LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
Faculty of Technology Management
Department of Industrial Management

Master's Thesis

# The Present State and a Development Plan of Cost Accounting in Batch Production of Wind Turbine Gears

Examiner: Professor Timo Kärri
Instructor: M.Sc. (Eng.), M.Sc. (Econ.) Sami Käppi

**ABSTRACT**

**Author:** Heikki Pänkäläinen

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**Keywords:** Activity-Based Costing, Time-Driven, Cost Accounting, OEE, Overall Equipment Efficiency, Idle Capacity, Wind Turbine Gears

The aim of this master's thesis was to document the present state and to create a development plan for Moventas Wind's cost accounting. The current cost accounting system was evaluated and most fundamental problems were chosen as areas of focus in development work. The development plan includes both short- and long-term development proposals for problems identified. This report presents two alternative models for product costing.

Benchmarking of cost accounting practices and modern cost accounting theories were used in development of cost accounting. It was found that the current cost accounting system functions quite well and the adjustments in unit cost rate calculation have only a minor influence on costs of goods sold. An OEE-based standard cycle concept was also developed and it was found that the implementation of this new system is worthwhile in the long-term.

**TIIVISTELMÄ**

**Tekijä:** Heikki Pänkäläinen

**Työn nimi: Kustannuslaskennnan nykytila ja kehittämissuunnitelma tuuliturbiinivaihteiden sarjavalmistuksessa**

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Tämän diplomityön tavoitteena oli dokumentoida Moventas Wind Oy:n kustannuslaskennan nykytila, sekä esittää lyhyen ja pitkän aikavälin kehittämisehdotuksia sisältävä kehittämissuunnitelma. Kehittämistyössä keskityttiin nykytilan kartoittamisen aikana havaittujen ongelmien ratkaisemiseen. Tässä raportissa esitellään kaksi vaihtoehtoista mallia näiden tuotekustannuslaskennan ongelmien ratkaisemiseksi.

Kehittämistyössä hyödynnettiin kustannuslaskennan uusimpien teorioiden lisäksi vertailuanalyysia. Tutkimuksessa havaittiin, että yrityksen nykyinen järjestelmä toimii melko hyvin, ja että yksikkökustannusten laskemistapaa kehittämällä saadaan aikaan vain pieniä parannuksia. Tutkimuksessa havaittiin myös, että kehitetyn OEE-perusteisen standardiaikamallin käyttöönotosta olisi yritykselle enemmän hyötyä.

ACKNOWLEDGEMENTS

Six months have passed since I started working with this master's thesis and I am relieved that the project is finally finished. The project included several ups and downs, but I am glad to say that I am quite satisfied with the outcome. I have learned a lot during this project and I hope that my work will also benefit the ordered of this study.

I would like to thank all personnel of Moventas Wind who have participated in this project for their constructive attitude toward my development work. Especially I would like to thank my instructor Sami Käppi for arranging time for this project despite his many other duties. I would also like to thank development engineer Niko Piispanen for his productional viewpoints and open-minded attitude in fruitful discussions we had. The examiner of this master's thesis, professor Timo Kärri, also deserves compliments for his guidance and contribution in revision of this report. Finally I would like to thank Tero for his proofreading work and Päivi for her patience and understanding attitude during this long-lasting project.

Jyväskylä, 8th April 2009

Heikki Pänkäläinen

CONTENTS

1 INTRODUCTION........................................................................1

1.1 Background........................................................................1

1.2 Objectives and Scope........................................................................1

1.3 Research Method and Structure of Study........................................................................2

1.4 Definitions........................................................................5

2 MOVENTAS WIND OY........................................................................8

2.1 Products and Customers........................................................................9

2.2 Competitive Environment and Capital Investment Programs........................................................................11

2.3 Manufacturing Processes, Equipment and Fixed Assets........................................................................12

3 PRESENT STATE OF COST ACCOUNTING........................................................................16

3.1 Resource Unit Cost Rates........................................................................16

3.2 Hour Reporting and Product Costing........................................................................19

3.3 Reporting and Cost Estimates........................................................................24

3.4 Problem Areas of Current Accounting System........................................................................25

3.5 Cost Accounting Practices in Comparison Companies........................................................................29

4 COST ACCOUNTING TODAY........................................................................32

4.1 Emergence of Activity-Based Costing and Management........................................................................33

4.2 Time-Driven Activity-Based Costing........................................................................38

4.3 Calculation of Unit Cost Rates........................................................................40

4.4 Capacity Measurement and Idle Capacity........................................................................42

5 PERSPECTIVES ON COST MANAGEMENT........................................................................49

5.1 Design of Cost Management Systems........................................................................50

5.2 Cost Information in Decision-Making........................................................................52

5.3 Support of Information Technology and Production Management........................................................................55

5.4 Emerging Cost Management Methodologies - Lean Accounting........................................................................60

6 DEVELOPMENT OF HOUR REPORTING ........................................ 64
6.1 Productivity Control and Cost of Idle Capacity ........................................ 64
6.2 Standard Cycle Times at Machining Workshops ........................................ 69
6.3 Standard Cycle Times at Hardening and Assembly Departments ..................... 71
6.4 Implementation and Maintenance of Standard Cycle Time System ................. 73
6.5 Assessment of Standard Cycle Time System ........................................ 75
7 DEVELOPMENT OF PRODUCT COSTING ........................................ 78
7.1 Principle of Process-Based Model ........................................ 79
7.2 Feasibility of Process-Based Model ........................................ 84
7.3 Introduction of Activity-Based Model ........................................ 87
7.4 Assessment of Activity-Based Model ........................................ 91
8 DEVELOPMENT PLAN ........................................ 94
8.1 Recommended Long-Term Solution ........................................ 94
8.2 Analysis on Unit Cost Rates ........................................ 95
8.3 Cost Effects and Relevance of Cost Information in Recommended Solution .. 98
8.4 Short-Term Development of Cost Accounting ........................................ 102
9 CONCLUSIONS ........................................ 105
10 REFERENCES ........................................ 109
APPENDICES

# 1 INTRODUCTION

## 1.1 Background

Gobal demand for wind energy has increased rapidly during the last few years with an annual growth rate of approximately 20-25 percent. Despite the recent economic recession the wind turbine gear markets are expected to grow. The increased cost competitiveness of wind energy has also benefited Finnish wind turbine gear manufacturer Moventas Wind Oy (later "Moventas Wind"). The company experiences rapid organic growth and the financial management feels that their current cost accounting system needs to be evaluated to make sure that it can produce cost information that supports the decision-making during the rapid growth. The company is in doubt about the rationality of its current hour reporting system and it wants its cost accounting system to be examined as a whole in a form of master's thesis.

## 1.2 Objectives and Scope

The aim of this study is to document the present state and to create a development plan for Moventas Wind's cost accounting. The development plan consists of short- and long-term development proposals. The development of recommended long-term solution has a major role in this study. Short-term development proposals can be carried out without any major changes to the current cost accounting system. After the evaluation and documentation of current cost accounting practices, some of the most significant problem areas are chosen as areas of focus of development work.

Moventas Wind has defined seven features that the recommended long-term solution should satisfy:

- sufficient accuracy of product costing
- cost accounting system should incur as little nonproductive work as possible
- relatively effortless updating
- possibility to estimate costs in advance
- guidance to improvements in productivity
- analogous terms within the data systems
- possibility to duplicate the recommended solution to other locations.

An inclusive reform of cost accounting is not possible to be carried out as a part of a master's thesis. Some minor issues of present cost accounting system that might be worth revising in the long term were ignored in this study. For example the allocation of R&D- and sales expenses is not examined in this study. The emphasis of this study is in identifying and presenting a solution to the most fundamental problems of company's current cost accounting costing system and thereby offering the biggest benefits to the orderer of this study. The documentation and evaluation of company's current cost accounting system identifies the most significant problem areas and it can also be used in internal communication. Recommended long-term solution enhances the functionality and relevance of company's cost accounting system.

## 1.3 Research Method and Structure of Study

This master's thesis is a constructive case study. The recommended long-term solution is the construction of this study. As a result of this study, Moventas Wind has a documentation of the present state of its current cost accounting system along with development plan that is composed of short- and long-term development proposals. This master's thesis provides practical solutions for specific problems of

Moventas Wind's current cost accounting system. Other companies with similar needs facing the same problems can review this study in order to find potential solutions for their problems and ideas for development of cost accounting.

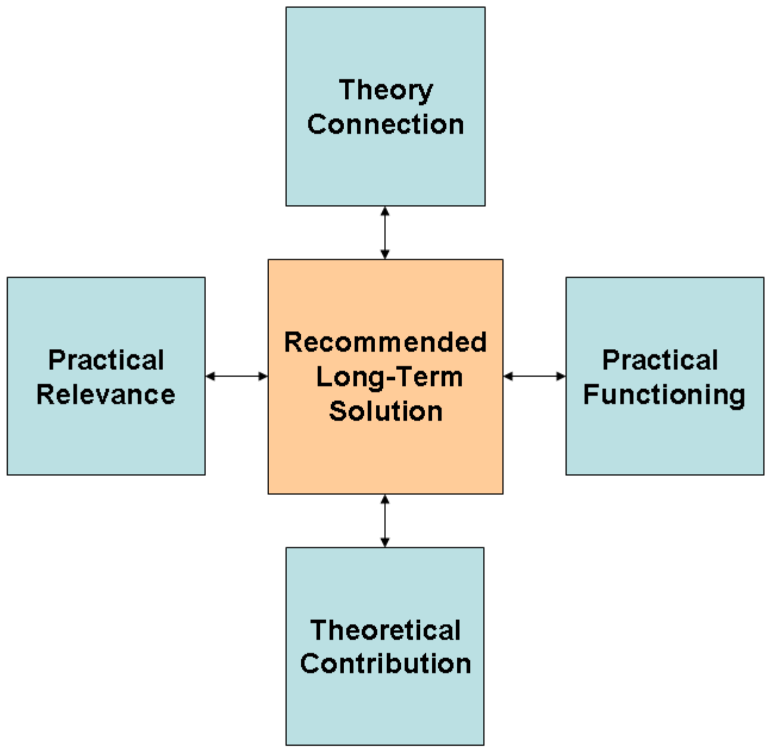



**Figure 1.** Components of Constructive Study (adapted from Kasanen et al. 1991, 306)

Moventas Wind's current cost accounting system is evaluated and relevant problem areas are identified and documented through theme interviews and discussions with key employees along with independent observation and application of modern cost accounting theories. This phase of the project equates to the first phase of a procedure presented by Kasanen et al. (1991).

Kasanen et al. (1991) propose the following phases of a constructive approach:

1. Find a practically relevant problem that has research potential.
2. Obtain a general and comprehensive understanding of the topic.
3. Innovate and construct a solution concept.

4. Demonstrate that the solution works.
5. Show the theoretical connections and the research contribution of the solution concept.
6. Examine the scope of applicability of the solution.

Company's internal documents, latest research results in the field of management accounting and empirical experiences in benchmarking companies are utilized in development of recommended long-term solution (phases two and three). Practices of benchmarking companies are revised in order to find imitable and functional models, and the practical functionality of recommended long-term solution is tested against the current cost accounting model of Moventas Wind (phase four). This study does not aim for implementation of new practices, so the functionality of recommended long-term solution cannot be tested in practice. The theoretical connections, findings and applicability of the solution are discussed in conclusions of this study.

The case company Moventas Wind Oy is introduced in the second chapter of this master's thesis. The chapter introduces the products, customers, equipment and manufacturing processes of the company in order to offer an extensive view of special characteristics affecting the design of cost accounting system. The third chapter describes the present state of case company's cost accounting and presents the most significant problem areas. The fourth chapter approaches the evolution, principles and methods of activity-based costing and -management systems. The second theoretical chapter, the fifth chapter, presents some perspectives on cost management. The chapter gives some guidelines for design of cost management systems, discusses the relevance of cost information, reviews the role of information technology and production management in cost accounting and introduces the principles of lean accounting.

The theories presented in fourth and fifth chapter are applied in the next two chapters. These two chapters introduce the models and concepts developed in this study. The models and concepts that are presented in sixth and seventh chapter are put together and recommended short- and long-term solutions are presented in the eight chapter. The eight chapter also evaluates the accuracy and benefits of recommended long-term solution. The accomplishment of objectives, research contribution, and applicability of findings are concluded in ninth chapter.

## 1.4 Definitions

Some of the most important terms of this master´s thesis are defined in this chapter. The terms are defined in one hand to clarify the meaning of most important terms of this study to the ones who are not familiar with them at Moventas Wind and on the other hand clarify the meaning of company's internal terms to the readers outside the company. The definitions of cost accounting terms are mainly picked up from Kaplan & Atkinson (1998).

**Activities and resources**

*Activity is for example a task, work cell or a group of machines with individual purpose of use and resource consumption. Single machines are called resources in this study.*

**Arrow Machine Track**

*Arrow Machine track is a software that is designed for measurement of productivity and utilization rates of machines.*

**Bottleneck and constraining activities**

*Both these terms mean an activity or a single resource that has less capacity than the other activities of a process have.*

**Cost allocation and assignment**

*Cost allocation is an approximation used to drive indirect costs to the cost objects with a certain inexact cost driver. The tracing of direct and indirect costs to the cost objects with verified and more precise method is called cost assignment.*

**Cost object**

*Cost object can be for example product, customer or area whose costs are calculated.*

***Flexible, committed and capacity costs***

*Flexible costs are incurred when the product is processed. Committed costs are incurred anyway because of an earlier decision. Capacity costs mean the same as committed costs in this study.*

**Flexim access control and bar-code reader**

*Flexim access control system is used in monitoring of presence hours and bar-code reader system is used in registering the actual working hours of each stage of each work.*

**Ikola**

*New production facility in Jyväskylä that was started during the fall 2008. All planet wheels are manufactured at Ikola and also hardening, assembly and test drive functions can be performed in Ikola.*

**Idle capacity, unused capacity**

*Idle or unused capacity is equal to the capacity that was available for use less the capacity that was used during a certain period of time. The cost of idle capacity is a cost of products that were not manufactured during a certain period and therefore it is a period cost like general administration costs and it should not be assigned to the products manufactured.*

**Lean System**

*Moventas' enterprise resource planning system.*

**OEE**

*Overall equipment efficiency is a measure of total machine performance that shows exactly where the time is lost.*

**Opex**

*Operational excellence –project that aims for implementation of Lean manufacturing principles.*

**Program time**

*The actual machining time of each item.*

**Rautpohja**

*Industrial area where all components except planet wheels are manufactured. Assembly, hardening and service functions are also performed at Rautpohja.*

**Practical capacity**

*Time available for working during a certain period of time. At Moventas, the practical capacity is usually 6100 hours a year in four-shift system for bottleneck resources.*

**Standard cycle time**

*Time needed to perform a certain stage of a manufacturing process on current level of efficiency.*

**Tourula machining**

*A separate machining unit few kilometers from Rautpohja.*

# 2 MOVENTAS WIND OY

Moventas Oy has long roots as a gearbox manufacturer, but the name of the company is not very well known even in Finland. The figure 2 describes how Moventas and its present wind and industrial gear businesses were born.

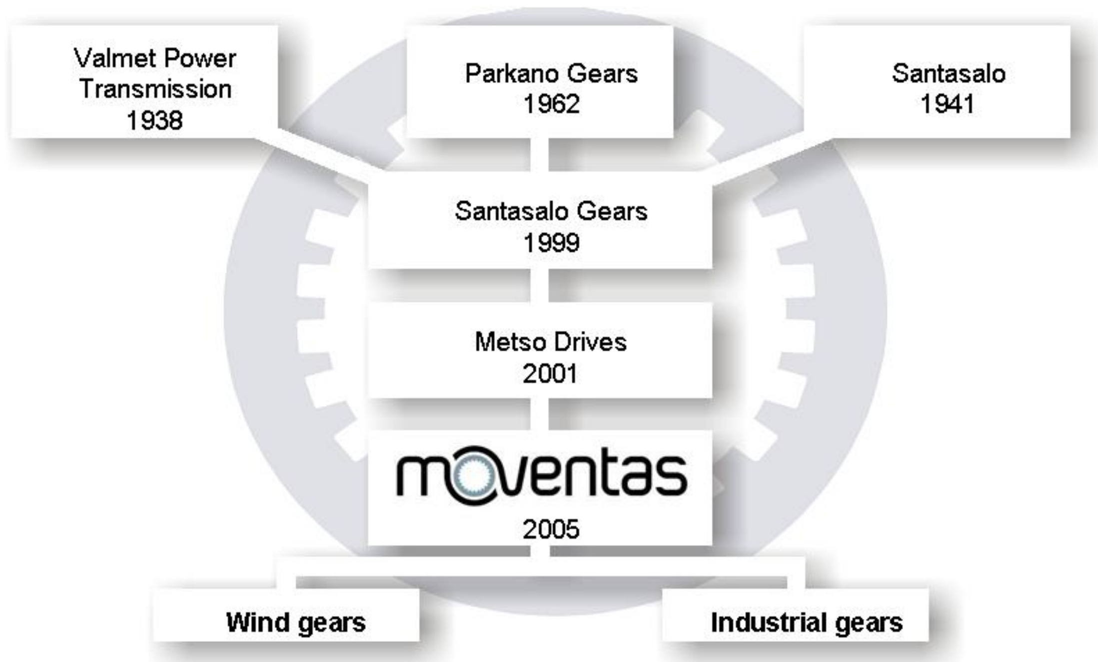



**Figure 2.** Predecessors of Moventas (Moventas 2007b)

Moventas' present wind and industrial gear businesses were part of Metso group until 2005 under company name Metso Drives. In 2005 Metso sold their gearbox-business to capital investment company Capman. Metso drives was then renamed as Moventas Oy and the company was shared into wind gear and industrial gear businesses. In the beginning of year 2008 capital investment company Industri Kapital bought a majority of Moventas´ shares, and it now owns 55 percent of Moventas group. The other owners are management of Moventas (25 percent), Capman (16 percent) and insurance company Varma (4 percent). (Moventas 2008a)

The strategy of Moventas is based on cash generating growth. The company aims for excellence in its business operations and focuses on:

- *Smart growth (double the net sales).*
- *World-class profitability (triple the profitability).*
- *Value creation to company´s stakeholders (four stakeholders – customers, personnel, partners and owners).*

Moventas has defined its mission and vision as follows:

- *Our mission is to provide mechanical power transmission expertise to create customer satisfaction.*
- *Our vision is to become the preferred brand in the market.*

The four values of Moventas are:

- *commitment*
- *openness*
- *reliability*
- *excellence.*

(Moventas 2008a)

### 2.1 Products and Customers

Moventas Wind has a relatively small variety of end products. At the moment Moventas Wind produces around 15 types of different gears. The same base frame can usually be used if gear needs to be modified in order to meet customers' demands. Wind gears can be classified into three main categories: kilowatt-, megawatt- and multimegawatt-classes. At the moment 1.5 MW wind gears have the highest volume in new equipment business and Moventas Wind has two high volume products in this class. Kilowatt –class gears have the highest potential in service business and multimegawatt –class gears are gradually increasing their market share in new equipment sales.

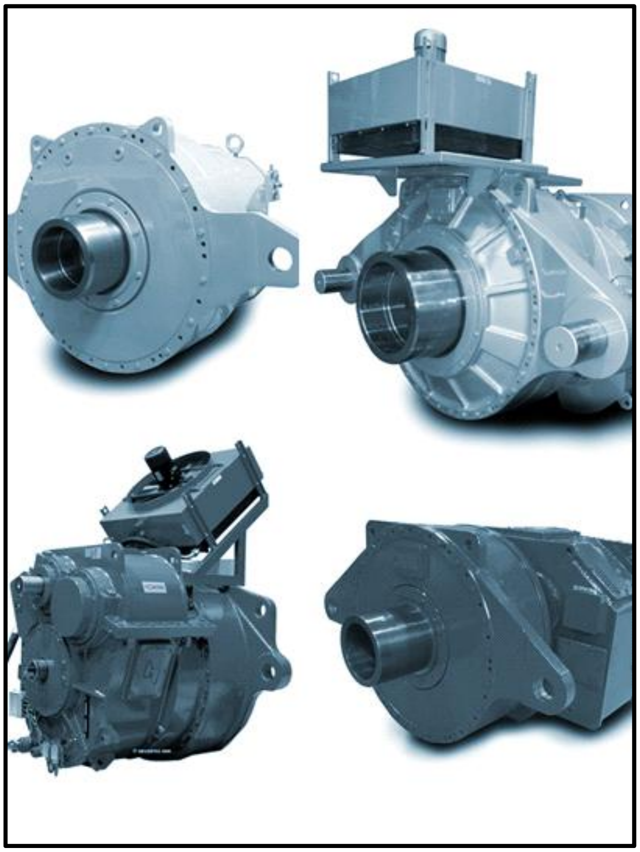


**Figure 3.** Wind Turbine Gears (Moventas 2007b)

Material costs dominate the cost structure of a gear unit with a share well over a half of the manufacturing costs. The overhead cost is the second highest cost factor and direct labor cost respectively the least significant cost factor in gear unit's manufacturing costs. The costs of material handling (purchase, quality assurance and logistics), freight costs of purchased components and freight costs of delivery to customer also involve a low level of significance in cost structure of a gear unit.

There are roughly 100-150 items in the bill of materials of a gear unit at assembly stage. Some of these items consist of several other items that are assembled at the earlier stages of a manufacturing process. Most gear units have six geared components that Moventas Wind produces. The main components are high speed shaft, intermediate shaft, hollow shaft, sun pinion, ring wheel and planet wheels. In addition to these components, the gear unit includes components like housing, bearings, sealings, piping, electric components and other body parts and smaller parts like bolts and nuts.

Wind turbine manufacturers are the main customers of Moventas Wind. Moventas Wind has most of the world's largest wind turbine manufacturers as its customers. Almost all gearboxes that Moventas Wind manufactures are exported to European and American customers.

## 2.2 Competitive Environment and Capital Investment Programs

The manufacturing of wind turbine gears was started at Rautpohja area in the 1980s by Moventas' predecessor Valmet Power Transmission (see figure 2). The manufacturing of wind turbine gears was project-based small-scale business until the rapid growth of last few years. By these days, over 8000 gear units have been installed by Moventas and its predecessors. (Moventas 2007b)

The wind turbine gear markets have growed rapidly with an annual growth rate of 20-25 percent during the last few years. A global economic recession has affected wind turbine gear business, but the markets are still expected to grow during the forthcoming years. All major wind turbine gear manufacturers except Moventas Wind are owned by a wind turbine manufacturer. The most important competitors of Moventas Wind are Winergy, Hansen and Bosch. Winergy has the highest market share and Hansen respectively the second highest (in 2008). Bosch's market share is approximately the same as Moventas Wind’s. Winergy is owned by wind turbine manufacturer Siemens and Hansen is owned by another wind turbine manufacturer Suzlon. In order to grow and sustain its strong position as a wind turbine gear supplier, Moventas has decided to make significant capital investments that aim to double the production capacity during the next few years. (Moventas 2008b)

In the first phase Moventas invested significantly in expansion of existing industrial halls at Rautpohja area. In the second phase the capital investments were 115 million euros, including the construction of new planet wheel and assembly factory Ikola and establishment of logistics center at Jyväskylä. The new Ikola factory at Etelä-Keljo industrial area in southern Jyväskylä started operating at the end of the year 2008 and it will be running at full rate in the beginning of year 2010. The third phase of the capital investment program is already planned in detail but it is frozen for the present.

### 2.3 Manufacturing Processes, Equipment and Fixed Assets

At the end of year 2008 Moventas Wind operates in three locations: in Jyväskylä in Finland and in Portland and Big Spring in the United States. Manufacturing operations are centralized to Jyväskylä and the units in the United States concentrate on service functions. In Jyväskylä there are three separate areas where the manufacturing takes place and a logistics center that supports all these facilities. Rautpohja industrial area is the traditional place where gear manufacturing began for over 70 years ago. All shafts, pinions, ring wheels and housings are currently produced at Rautpohja. Also hardening, assembly, test drive and service operations are performed at Rautpohja. At Tourula, which is located few kilometers from Rautpohja, there is a smaller pre-machining unit and the new planet wheel and assembly facility Ikola is placed at Etelä-Keljo -area. The new Etelä-Keljo factory concentrates on manufacturing of planet wheels and on assembly of megawatt –class gear units. The new facility also has its own hardening department, test drive benches and final fitting areas.

Because of the fast growth and rapid changes during the last few years, the manufacturing processes of Moventas Wind are going through a continuous change. Industrial gears are no longer produced in Jyväskylä and volumes of wind turbine gears have increased significantly. The following paragraphs describe the state of manufacturing processes at the end of the year 2008.

The manufacturing processes of shafts and pinions basically consist of soft machining, hardening and hard maching stages. Intermediate shafts and hollow shafts are also assembled from shaft and a gear wheel and finished as one. The soft machining of some shaft types is often performed by a subcontractor, but most shaft types are processed at Tourula machining or at pinions and service –workshop in Rautpohja. A significant share of housings are purchased half-finished and machined in house, but some are processed completely by a sub-contractor. Moventas Wind has decided to manufacture the two most critical components of a gear unit, ring wheel and planet wheels, almost completely in house. The hardening of geared components is performed mainly in house at either Rautpohja or Ikola.

The whole manufacturing process of planet wheels is performed at Ikola. The process also consists of soft machining, hardening and hard machining stages. Soft machining typically include stages like soft turning and hobbing and hard machining respectively includes stages like hard turning and various types of grinding. The manufacturing process of ring wheels also includes the same three main stages and the ring wheels are currently machined almost completely at Rautpohja. Only some of the first stages of certain gear types are sub-contracted.

The blue-collar workers usually work in four shifts at machining departments, and machines most often run 132 hours a week. At assembly departments, the test drive bench operators work in two shifts during the week and two ten-hour shifts during the weekend. The rest of the assembly workers work in two shifts and they work on weekends only when needed. At the end of the year 2008, Moventas Wind employed over 600 employees.

Moventas wind has around 90 different machine resources. Those resources include for example various hobbing machines, turning machines, grinding machines, test drive benches, machining centers for housings and hardening devices. The depreciation method used for machines is usually 12 years straight-line depreciation, and annual depreciation of a single machine varies from zero to 200 000 euros. Ikola factory is currently implementing Arrow Machine Track system for productivity control and measurement of utilization rates of machining centers and test benches.

Moventas Wind has its own HR-, IT-, R&D and sales functions, but the financial processes like handling of invoices are performed by corporate financial shared service center. The cost centers for year 2009 can be found in appendix 2. Moventas Wind sold all its real estates during the spring 2008. All production facilities are now rented and most of the vehicles like forklift trucks are leased. In addtion to machine resources, the property of workshops often consists of cranes, industrial washing machines, tools and various other pieces of equipment.

Moventas Wind started the implementation of lean manufacturing ideology through OPEX (OPerational EXcellence) –project in 2006. The aim of the project is to increase productivity and enhance long-term profitability. Opex includes various lean manufacturing tools that are currently being implemented. For example the efficiency of constraining or and expensive machines is monitored weekly with overall equipment effectiveness –percent (OEE-%, see chapter 5.3). An OEE-percent is defined and measured for most of the machines. Moventas has set a target that constraining machines should run 6100 hours a year in four-shift system with target OEE-percent. The target running time, 6100 hours, is the time that labor should be present annually in four-shift system when vacations and midweek holidays are deducted from planned presence time. (Moventas 2007a)

# 3 PRESENT STATE OF COST ACCOUNTING

Activity-based costing has long roots in cost accounting of gear production at Rautpohja. Moventas' predecessor's Valmet Power Transmission's gear manufacturing in Jyväskylä served as a pilot unit in implementation of activity-based costing among the first in Finland almost twenty years ago. The implementation of enterprise resource planning (ERP) and other data systems have changed the methods and practices of cost accounting greatly since those days, but activity-based costing still remains as a fundamental cost accounting approach of Moventas Wind.

## 3.1 Resource Unit Cost Rates

The resource unit cost rates are usually updated once a year with a simple Excel template. All costs in unit cost rate calculation (except depreciations) are budgeted estimates. Individual unit cost rates are calculated for every significant piece of production equipment that the company uses. For resources of Ikola planet wheel factory there is a different procedure. The unit cost rates are calculated for each activity, that is, for a group of substitutive machines. For example turning and hobbing of planet wheels are activities and thereby have a single resource id and unit cost rate. After the unit cost rates are calculated in Excel, they are manually input to the ERP as a standard unit cost of using the resource. The resource unit cost rate consists of three components: production administration surcharge, depreciation and department overhead cost.

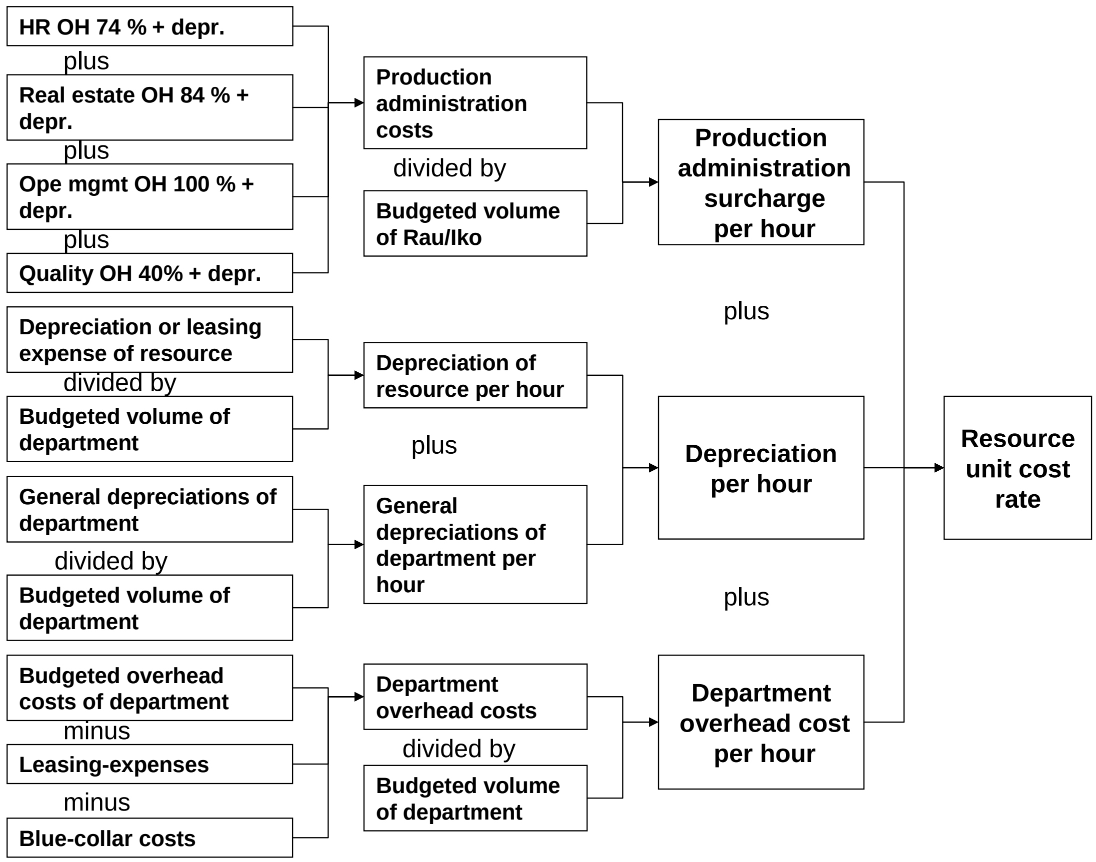



**Figure 4.** Calculation of Resource Unit Cost Rates in Present State

Production administration surcharge is defined by dividing the budgeted production administration costs by total amount of machine hours of whole production during the forthcoming year. The production administration costs consist of four different cost components: human resource, real estate, operation management and quality assurance costs. Production administration costs are divided between hardening department and other production departments according to the total sum of overhead budgets. The costs of human resources, real estate and quality assurance are allocated only partially for resources. The allocation is based on the following observations: approximately 74 percent of all employees work at the production departments, the production occupies roughly 84 percent of total area at Rautpohja and internal quality assurance costs are estimated to be 40 percent of all quality assurance costs. The costs of operative management are allocated to production administration costs as whole.

The depreciations of these four departments are also included in production administration costs. As the production halls are rented and human resources and operation management incur little or no depreciations, the depreciation of quality control resources is the most significant depreciation in production administration costs.

The second component of a resource unit cost rate is the depreciation. It consists of depreciation of resource and general depreciation of the department. The general depreciation includes the depreciation of cranes, industrial washing machines and all other equipment that the department possesses. The depreciation of a resource is calculated by dividing the depreciation or a leasing expense by budgeted level of activity of a resource. The budgeted level of activity for each resource is usually estimated by a workshop manager or development personnel. The general depreciation rate is calculated in the same way, with an exception that the budgeted level of activity of the resource is replaced with budgeted level of activity of whole department during the forthcoming year.

The last of the three components of a resource unit cost rate is the department overhead cost rate. Tools, equipment, accessory materials and repairs are by far the most significant sources of overhead cost at almost every department. The leasing expenses and blue-collar costs are subtracted from total overhead costs of a department to define the overhead costs that are to be allocated. That amount of overhead costs is then divided by the total budgeted level of activity of a department during the forthcoming year to define the department overhead cost per hour.

There is some variety in magnitude of these three cost components between different resources. The depreciation or leasing expense are usually the most expensive components of resource unit cost rate, but the product administration surcharge and department overhead cost rate can also be substantial especially for older resources. The department overhead rate is usually minor at assembly departments, but significant at most machining workshops. The production administration surcharge is the same for every department and resource. At hardening departments, the resource unit cost rate is calculated per kilogram hardened.

A department-specific blue-collar hour rate is calculated by adding up the budgeted blue-collar costs (including social costs) and budgeted overtime costs and then dividing the sum by estimated annual amount of blue-collar workers' presence hours (excluding training hours).

### 3.2 Hour Reporting and Product Costing

Moventas Wind's ERP, Lean system 5.3, is used for manufacturing control and management accounting purposes. This chapter describes how costs are generated into the Lean system. At the moment there are three alternative ways that are used to collect the actual duration of each stage of the manufacturing process. At some departments, the workers manually input the amount of hours they have used at each stage of a manufacturing process into the Lean system. If a blue-collar worker has operated for example two machines at a time, he then inputs only half of the labor hours but full machine hours for the resource id he operated. The blue-collar workers of hardening department report only kilograms they have hardened into the Lean system. A new practice for cost accounting is currently being tested at hardening departments. The weight of each component is already known in Lean system and in new concept the costs are automatically generated to the system after the work is finished.

Another practice is hour reporting with Flexim bar-code reader. When an employee arrives at his workplace, he must always sign in with Flexim terminal at entrance doors. The presence hour are gathered for purposes of payment of wages at each department. There are additional Flexim terminals placed nearby the machines or places of assembly at some departments. These terminals are used for productivity control and product costing purposes. When a blue-collar worker starts for example the turning of a shaft, he signs in to a specific work id with a bar-code wand attached into the Flexim terminal. After the work is finished, he signs into a new work number or into the department overhead work number. The department overhead number should be used when blue-collar worker does non-productive work, for example cleans up, participates in training or waits for the machine to be repaired.

There is an analogy between the functioning of Flexim bar-code system and a garden hose that starts squirting water (hours) from the moment an employee arrives at his department. There are several buckets (work ids) at the department, one for each unfinished work and one for nonproductive work such as waiting or training. An employee has to point out the hose to a certain bucket every time he starts working with a new work and if there is no work-in-process, the nonproductive bucket should be used. If an employee has left out the hose pointing at a certain bucket at the end of the day, the hours will flow for that work id from the moment he arrives in the next morning.

The third approach that is currently in use at Ikola and at one assembly department at Rautpohja uses standard cycle times instead of actual stage times. In this approach every stage of a manufacturing process has a predefined standard cycle time. When the work is closed, Lean system generates the costs of each stage by multiplying the standard cycle time by the unit cost. There is also an overhead work number that can be used with Flexim if production is interrupted for some reason. The Flexim and bar code reader wand is also used for collecting the reference data for definition of standard cycle times and productivity control. There are gear type- and stage-specific overhead work numbers for assembly and planet wheel processes. The employees report their working hours to these reference data work numbers, but the actual hours are not used in cost accounting.

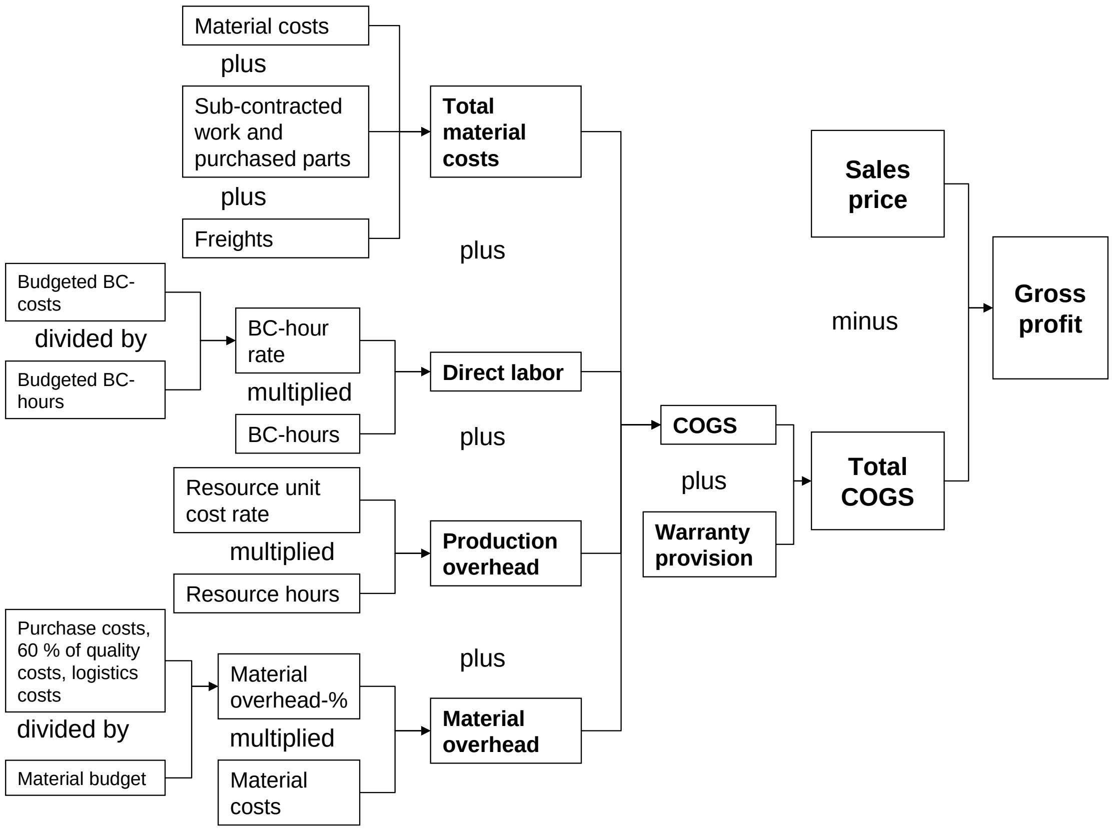



**Figure 5.** Calculation of Gross Profit in Present State

The costs are registered work id-specifically into the Lean system and each gear unit receives the costs by the procedure presented in figure 5. The assignment of material and material overhead costs is described in detail in the following paragraphs and the assignment of direct labor and production overhead costs is presented in the end of this chapter.

After a decision to manufacture a gear is made, the work planning team creates an assembly work into the Lean system. The system then automatically generates the manufacturing proposals and sends purchasing proposals to the personnel in charge for purchasing the components needed if the level of inventory requires manufacturing or purchasing of new components. The components in manufacture are not attached to any specific work id, but the manufacturing and purchasing proposals are generated to meet the forthcoming demand for components and to keep the inventory at desired level. Every item type in the inventory has a rolling weighted average cost that updates automatically every time an item with a different cost compared to the average cost is added into the inventory.

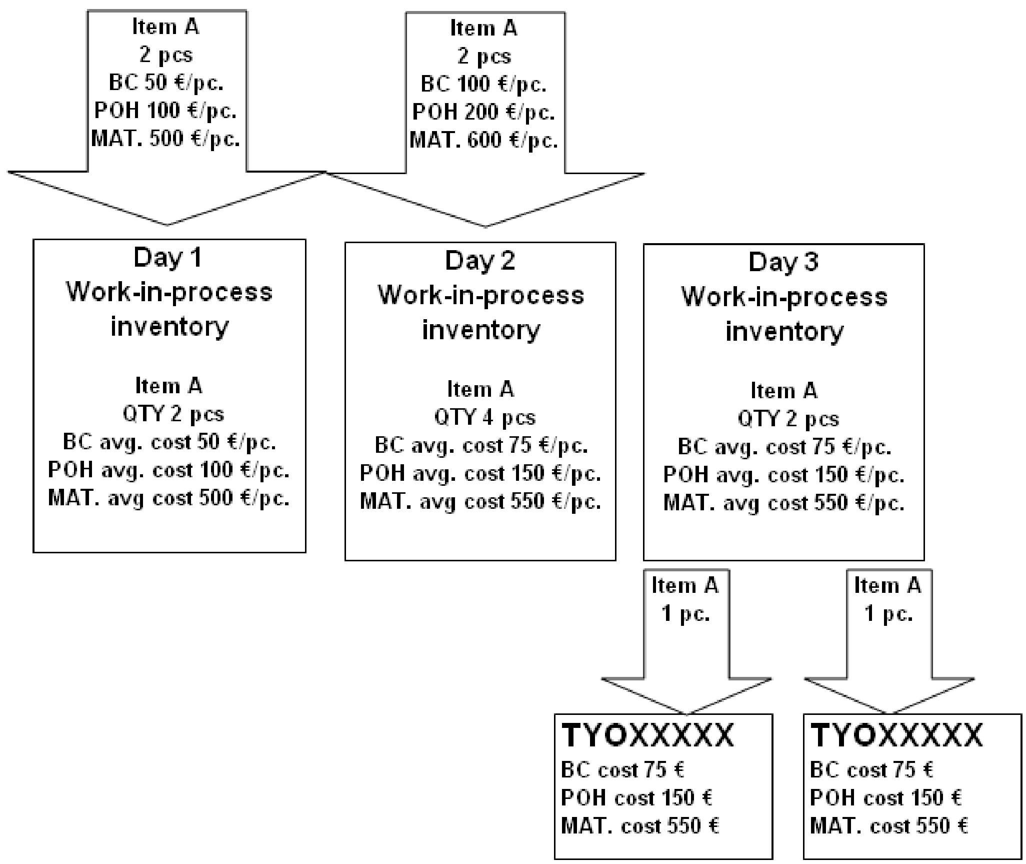
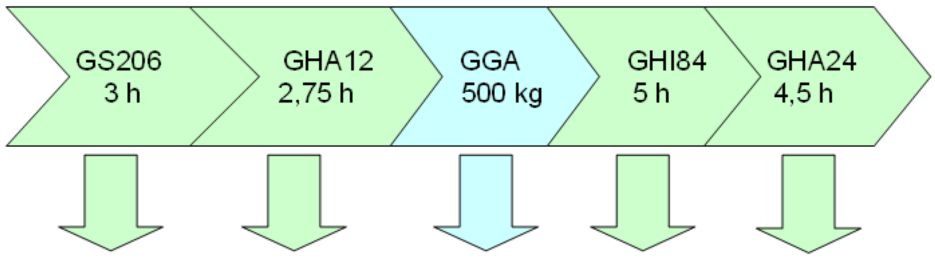



**Figure 6.** Principle of Weighted Rolling Average Price

When a half-finished item or purchased part is attached to certain work id, the work id automatically receives an item-specific average material, labor and production overhead costs (figure 6). This practice effectively levels out the fluctuations in costs of individual products and thereby improves the reliability of product cost information. After the work id receives a cost that is classified as a material transaction, the material surcharge is automatically added to the total costs according to the material surcharge –percent and amount of material costs registered. The warranty provision is added to the cost of goods sold according to warranty provision –percentage and sales price.




| | | | | | |
|---|---|---|---|---|---|
| **Direct labor (BC) cost** | 50 €/h x 3 h =150 € | 50 €/h x 2,75 h =137,5 € | 0,50 €/kg x 500 kg =250 € | 50 €/h x 5 h =250 € | 50 €/h x 4,5 h =225 € |
| **Production overhead cost** | 100 €/h x 3 h =300 € | 101 €/h x 2,75 h =277,75 € | 1 €/kg x 500 kg =500 € | 102 €/h x 5 h =510 € | 103 €/h x 4,5 h =463,5 € |

**Figure 7.** Principle of Current Product Costing System

Figure 7 illustrates how direct labor and production overhead costs are allocated to the products. Resources (GS206, GHA12 etc.) represent the machines that are used in manufacturing process and the duration below the resource id represents the actual duration that is reported to the Lean system. The resources used in manufacturing process are defined in routings of each item. Very few items need exatcly the same set of resources and thereby a large number of routings is needed. The cost accounting at hardening stage (GGA) is kilogram-based and there are three different direct labor and production overhead unit cost rates for different types of hardening.

### 3.3 Reporting and Cost Estimates

Separate reporting software, Business objects, is used to generate reports from Lean system databases. Business objects -based cost of goods sold -report is able to calculate customer-, gear type- or work id-specific gross profit by the procedure presented in figure 5 on page 21.

Moventas Wind has also created an Excel-based simulator for estimation of absorption costs of its products in advance. The simulator is usually updated once a year for the forthcoming year and it is used for many purposes. It assists in pricing and in make-or-buy decisions and it is also able to generate profit and lost estimates for forthcoming year.

The first part of the simulator estimates the costs of geared components. The workshop managers define the routings for each component. The workshop managers also estimate the time needed to complete each stage of a manufacturing process. The simulator uses average blue-collar hour rate and unit cost rates of each resource in calculation of total direct labor and production overhead cost for each component. The make-or-buy distribution of each component is input in percentage values. The purchase and work planning personnel estimate the costs of materials, half-finished products, the costs of regular subcontracting of specific stages of manufacturing process and the costs of finished components that the suppliers deliver.

The amount of direct labor hours and production overhead hours in machining of housings and assembly are estimated in the same way as the machining hours of geared components. The costs of purchased parts and freights are estimated in the last section of each sheet. The simulator summarizes the costs to the summary area of eah gear type. The materials costs include the costs of raw materials, half-finished products, sub-contracted work, purchased parts and freights. Material overhead and warranty provision –percentages can be defined in their own fields. Finally, the simulator sums up the total costs of a gear unit and the two bottom lines of the gearbox-specific cost sheet estimate the profitability of a gearbox type with absolute and relative gross profit.

### 3.4 Problem Areas of Current Accounting System

As a whole, the current accounting system seems to work fairly well, but some significant problems can be identified. An assessment of Moventas Wind's cost accounting system was carried out as a part of this master's thesis and the following topics were considered to incur the most fundamental problems.

The three alternative ways to report blue-collar and resource hours to the enterprise resource planning system were described in chapter 3.2. The reporting of actual hours is vital for companies manufacturing customized products for each customer as individual projects. As Moventas Wind these days pursues batch production with standardized products and manufacturing processes, the reporting of actual hours is not required anymore. There have been some problems with each of the three reporting methods, but the biggest errors are most often incurred because of erroneous use of Flexim bar-code reader. The use of rolling average cost in product costing often levels out the biggest variations in product costs, but the products still receive costs they have not incurred. There are some specific situations identified in conversations with workshop managers that are considered to be the most propable sources of errorneous hour registration.

Firstly, an employee might finish working with a machine that uses Flexim bar-code reader and start working with another machine that has no Flexim barcode reader. If the worker is ruled to register hours through Flexim barcodes, he cannot stop the registration of hours through Flexim at the earlier machine. The worker thereby registers double hours to the Lean system as he also registers his actual hours manually. In one occasion an assembly worker had moved from Rautpohja to Ikola in order to assist in construction of new test-drive bench. Because he was not able to sign in to any work id at Ikola construction site, the Flexim system automatically reported his hours for several months to the last work id he was signed in when he left Rautpohja. The workshop manager had to correct his hours to the Lean system every month. Several workshop managers also have stated that as long as the registration of hours to the work id:s is not connected with the payment of wages, it is hard to prevent the registration discipline to slacken. Very few people in the organization generally trust in the reported actual hours of single work ids.

The workshop foremen have to verify the hours that their employees or Flexim have input every week and there are often faults that have to be corrected. So the current hour reporting system incurs nonproductive workload for both blue- and white-collar workers. There has regularly been some deviation with the amount of hours that are registered to the Lean system compared to the amount of presence hours registered in Flexim access control at the entrance door. Based on the interviews with workshop foremen, it seems obvious that products constantly receive hours that should be registered as nonproductive work.

Appendix 1 exhibits the amount of hours that are gathered through Flexim access conrol system at the entrance doors compared to the hours that are registered into the Lean system from January 2008 until the end of September 2008 at hollow shaft workshop. The total amount of hours should be exactly the same, but the table proves that there is plenty of variance. Either the Flexim bar-code system is not functioning as desired or the reporting behaviour of employees incurs the variance. The comparison between Flexim presence hours and Lean system hours revealed that management accounting had lost around 20 000 hours during the first nine month of year 2008 on a company level. This means that annually over 25 000 hours are lost which equals to around six percent of all blue-collar hours worked during a year. The cost accounting system now almost always registers either too much or too little direct labor and production overhead cost. The small amount of nonproductive hours also suggests that the products regularly receive hours that should have been registered as nonproductive work.

The amount of resource hours in the Lean system is either not valid. Almost every resource that the company uses for production has an individual unit cost rate. In Lean system, there is a routing that defines the resource id used in every stage of a manufacturing process of the component in question. In reality the stages are quite often performed with a certain substitutive machine that is different to the one defined in routings. Even though the work is done with a different machine, the Flexim system automatically reports the hours to the resource id defined in routing. This fault can lead to a situation in which the Lean system reports that some resources have done over 9 000 hours a year.

A procedure of resource unit cost calculation was presented in figure 4 on page 17. At the moment, Moventas Wind uses budgeted capacity as a denominator value in calculation of resource unit cost rates. If the production encounters machine breakdowns or other problems, the actual level of activity can be for example 80 percent of the budgeted level. In occasions like this, the present cost accounting system only catches the 80 percent of actual overhead costs. Correspondingly, if the actual level of activity is higher than estimated at the beginning of the year, the current cost accounting system absorbs over 100 percent of the overhead costs in costs of goods sold and in value of inventory. The Finnish legislation demands, that the costs of underutilization of capacity should not be capitalized. At the present state the resource unit cost rates are defined according to the estimated budgeted level of activity and thereby there is a danger of over- or undercapitalization of overhead costs.

There are also some other dangers connected with the use of budgeted capacity. At the moment all costs of resources are absorbed to the products even though the resource could be capable of running more hours than it does. The cost of idle capacity is not reported. The costs of idle capacity can be classified as costs of those products that were not produced during the period rather than as a cost of goods manufactured. As the capacity is not completely utilized, the idle capacity raises the resource unit costs rates. As a result, the products seem to be more expensive to manufacture and the company may have pressure to raise the prices. An increase in price usually brings down the demand and the utilization rates may fall even more.

At the moment, the freight costs of purchased components are registered into a specific account, but they are not included in costs of goods sold even though the Finnish legislation allows the capitalization of these costs. Production administration surcharge also has some faults mainly in allocation of real estate costs. Real estate – cost center includes some significant cost items such as electricity costs and rents. The production administration surcharge is calculated per resource hour worked and all resources have the same production administration rate. It is obvious that the amount of electricity consumed at hardening furnaces is overwhelming compared to the amount consumed at assembly departments during one hour. The assembly departments also do more hours than most of the machining workshops, so the amount of electricity costs that are allocated to the assembly departments is by far too big. For example Laaksola assembly department annually charges products with an electricity cost that is 12 percent of whole department’s overhead budget. In present state, the production administration costs and thereby also the electricity costs are allocated between hardening departments and other production in relation to the overhead budgets and thereby the hardening department of Rautpohja receives an electricity cost that is 37 percent lower than the electricity cost of Laaksola assembly department. The facility costs are also allocated quite arbitrarily according to the number of machine hours of a resource. For example the facility costs of Laaksola assembly department are 6 percent higher than at Ring wheel workshop. The area of ring wheel workshop is however more than twice as big as the area of Laaksola.

There are several other accounting practices that are found to be in conflict with the principle of causality demanded by the doctrine of activity-based costing. The principle of causality is not strictly followed for example in allocation of logistics, purchase and quality assurance costs. The costs of research & development and sales departments are not allocated to products at all. However, these generalizations are considered to have so little influence on decision-making that the trade-off costs would probably exceed the advantage achieved from increased accuracy. Based on the assessment of present state of Moventas Wind's cost accounting, the following topics were chosen as areas of focus in development of cost accounting:

- development of hour reporting system
- development of product costing practices
    - adjustment of unit cost calculation
    - abandonment of budgeted capacity as only denominator value
    - abandonment of individual resource unit cost rates.

### 3.5 Cost Accounting Practices in Comparison Companies

Three companies were chosen for benchmarking of cost accounting practices in this study. The benchmarking events were performed one at a time in comparison companies in theme interviews with people in charge for cost accounting. This chapter describes how comparison companies approach the problem areas of Moventas Wind that were identified in the previous chapter.

By the basic guideline of benchmarking the practices should be compared with best in class companies. This was challenging because of scarce knowledge available about the level of cost accounting in potential comparison companies. It was also found that the share of material costs is often dominant in companies of mechanical engineering and thereby some companies have devoted quite little effort on cost accounting. As a whole, the level of cost accounting costing systems was a bit of a disappointment in two out of three comparison companies examined and therefore the results of benchmarking events were not very fruitful.

Moventas Wind does not have direct competitors in Finland and therefore three companies from different sectors of industry with similarities in size, products and in ways of action had to be chosen for benchmarking. The first of the three comparison companies (company A) is part of a global manufacturer of agricultural machinery. The company A itself produces diesel engines, generators, pumps, gearwheels and transmissions and employs over 700 personnel. The company A was chosen as a comparison company because of its similarities in products and benchmarking was carried out at the halfway of this master's thesis project. Company B is a listed Finnish forest machine manufacturer that is approximately same sized as Moventas Wind. The company B was chosen as a comparison company because of its rapid growth and similarities in manufacturing processes. This benchmarking was also conducted at the halfway of this study.  The last of the three comparison companies (company C) is a listed company that operates on global marine and energy markets. The company is significantly larger than Moventas Wind with around 17 000 employees. The company C was chosen as comparison company because of its substantial resources in process development, along with similar manufacturing processes and service business. The benchmarking was carried out during the third quarter of this study.

All three companies used standard cycle time –based system in product costing. One of the three companies had foreign units that gather actual working hours, but in Finland they have used standard cycle times for decades. Two out of three comparison companies used Arrow Machine Track in productivity control. Both companies praised the system to be very functional in its purpose.

One company used job-costing –based product costing system and the another one was currently developing its ABC system. These two companies did not have advanced ERP systems and their data systems focused mainly on production management. The third company had a proper ERP with some ABC features and its product costing procedures were very similar to Moventas Wind's procedure presented in chapter figure 4 on page 17. That company also had intentions to aggregate activities and define one common unit cost rate for wider group of activities, but this is not carried out yet because the manufacturing processes were not stable enough. None of the three companies actually separated idle capacity, but the causes were examined if costs of goods sold were not on a level they should be on a certain period of time. As a whole, it can be stated, that Moventas Wind's cost accounting is on a pretty good level even in the present state compared to many other companies in Finnish metal industry. The best offering of the benchmarks performed were the experiences on use of Arrow Machine Track in productivity control and an improved general view on the state of Moventas Wind's cost accounting system.

# 4 COST ACCOUNTING TODAY

The main purpose of accounting can be defined in many ways. American accounting association defines accounting as follows: “Accounting is the process of identifying, measuring, and communicating economic information to permit informed judgements and decisions by users of the information” (AAA 1966, 1).

Accounting has four main problems: the problem of scope, valuation problem, allocation problem and measurement problem. Understanding of these four main problems assists in interpretation of financial reports and leads on to better decision-making. Most Finnish cost accounting studies of 1990s (Lukka & Granlund 1993; Hyvönen 2000) suggest that three most often faced problems in management accounting of Finnish companies are the problem of collecting the data needed, the problem of assigning the costs of administration to products and the problem of assigning sales and marketing costs to products and customers. However, all these problems have faded slightly in companies that have implemented modern information systems and adopted advanced cost accounting procedures. (Neilimo&Uusi-Rauva 2002, 38-39; Hyvönen 2000, 36-37)

Accounting is usually divided into financial accounting and management accounting. The main objective of financial accounting is to collect and register key figures that describe the economical state of a company. Financial accounting usually offers information for interest groups and stakeholders of the company and management accounting principally aims for producing information that supports the decision-making. Cost accounting is an essential part of management accounting. The cost information is usually used for diverse different purposes. Companies have designed various cost accounting systems to satisfy the individual information needs they have.

The first theoretical frameworks of cost accounting, variable-cost calculation and full costing accounting principles, were mainly developed as early as in the 1920s. After the development of those theories the field of cost accounting received little or no attention until the mid 1980s when Professors Kaplan and Johnson published their famous book *Relevance lost – The rise and fall of management accounting*. They claimed that management accounting had separated out from reality and no longer produced relevant information for decision-making. Management accounting was originally developed to assist managerial decisions, but during the years it had emphasized in fulfilling the needs of financial accounting (Johnson & Kaplan 1987, 13). Johnson and Kaplan presented activity-based costing as a tool for better assignment of indirect costs. Management accounting had come to life again and an intense discussion about the future of management accounting and a series of articles followed in the late 1980s.

### 4.1 Emergence of Activity-Based Costing and Management

Activity-based costing (ABC) was developed as a tool for more accurate assignment of indirect costs. The goal of ABC is to offer a unit price for each activity performed in a company.

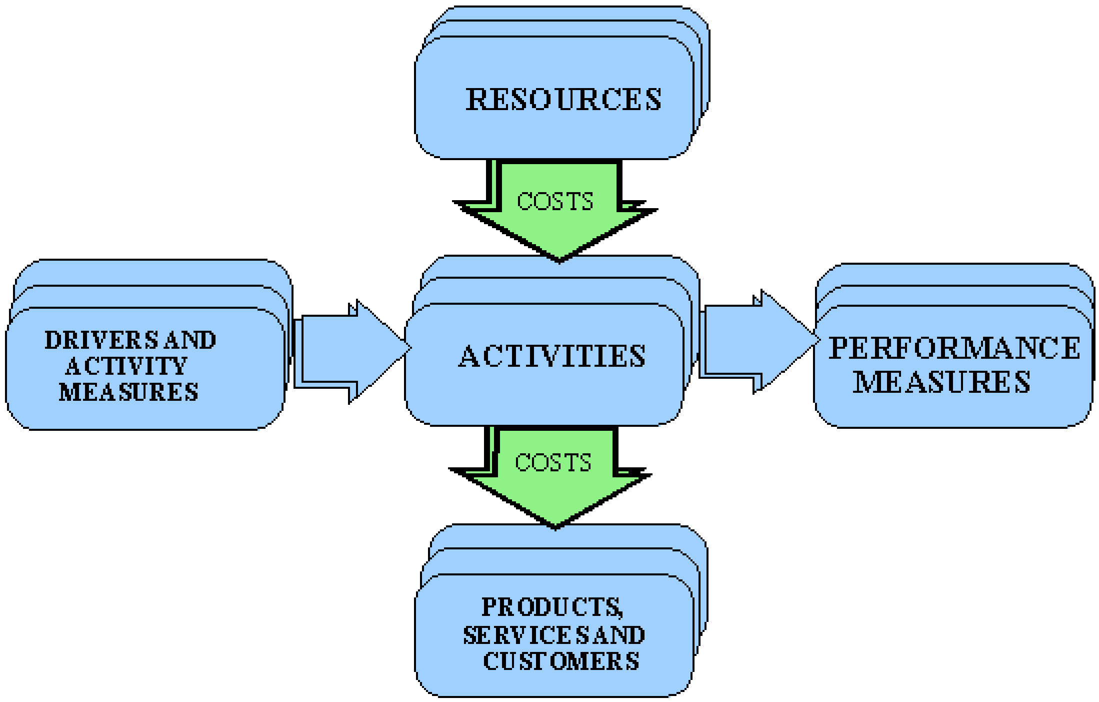



**Figure 8.** Activity-Based Costing and –Management (Martin 2008b)

There are two phases in calculating the costs of a cost object. In the first phase the expenses of resource usage are traced to the activities in order to find out the total expense of performing each activity (figure 8). Resource drivers such as power consumption or floor space occupied are used in allocation of costs from general ledger. In the second phase the costs of activities are traced to the cost objects by defining a cost driver for each activity (e.g. number of setups or machining time), by calculating a cost driver rate and using this rate to drive activity costs to cost objects. (Kaplan & Atkinson 1998, 97)

Despite the broad attention and interest that the ABC theory has received, several surveys have continuously proved that the adoption rate of ABC has remained surprisingly low in Finland but also globally (Lukka & Granlund 1993; Malmi 1996; Hyvönen 2000; Innes et al. 2000). Lukka and Granlund (1993) found that none of the 135 Finnish large and medium-size industrial companies studied used ABC in 1993, but a third of those companies were implementing or planning to implement ABC.

The companies often faced a problem of obtaining transaction information effectively.

Malmi (1996) found some improvement in adoption of ABC with an implementation rate of 13,7 percent among the 287 large or medium-size metal industry companies studied. By the end of a century, the portion of ABC adopters had increased into 24 percent among the 99 large and middle-size Finnish manufacturing units studied in 2000 by Hyvönen. Hyvönen (2000) also found that most of the respondents (40 percent) were applying full costing procedures while variable costing was the most popular procedure in the beginning of the 1990s. Traditional cost accounting techniques were still used in most of the units as half of the respondents used job-costing and 47 percent used process costing even though the ABC was implemented. Most of the newish cost accounting methods such as target costing and life cycle costing were rarely adopted in Finnish companies with adoption rates of 8 and 5 percent at the end of the century.

Three comparison companies were benchmarked in this study and the findings correlate well with larger studies presented above. One of the three companies had an advanced enterprise resource planning system and it used activity-based costing in product costing, but did not separate the cost of unused capacity systematically. The two other companies had very limited applications of activity-based costing. Lack of extensive enterprise resource planning system may affect the level of activity-based costing in these companies. The another of these two companies was however developing their cost accounting towards activity-based costing during this study, but the another still used job-costing and overhead cost increments in product costing.

Large number of companies that implemented an activity-based costing during the 1990s faced the weak points of ABC theory in practice. The data processing systems were not mature enough to be able to produce the huge amount of input data that the system needed and some of the early adopters even rejected their ABC system (Innes et al. 2000). Innes (2000) also suggests that the implementation rate and general interest towards ABC systems has declined during the 1990s in the large British companies of all sectors.

The implementation of ABC should also lead to adoption of activity-based management (ABM, horizontal view in figure 8 on page 34). Cooper and Kaplan (1999) state that ABM refers to the set of managerial actions that can be taken on a better informed basis of activity-based costing. ABM aims for analysis and continuous development of activities and processes based on information from ABC system. ABM enables a company to achieve its outcomes with fewer demands on organizational resources. (Cooper & Kaplan 1999, 277)

Operational activity-based management outlines the actions that increase efficiency, lower costs and enhance the utilization of assets. In other words, it gives guidance how to do things right. Operational ABM treats the demand for activities as given and attempts to meet this demand with fewer organizational resources. At its best this may lead to reduced costs through lower spending on resources, higher revenues through better resource utilization and cost avoidance because lower resource consumption obviate the need for additional investments in capital and people. (Cooper & Kaplan 1999, 277)

Strategic activity-based management attempts to alter the demand for activities as a way to increase profitability while activity efficiency remains constant. In other words, it gives guidance how to do right things. Strategic ABM encompasses actions that reduce the cost driver quantities demanded by unprofitable activities, but it also encompasses decisions about product mix, pricing, product design, product development and supplier relationships that reduce the demand for organizational activities. Strategic activity-based management generally require relatively few activities (often 20-60), while operational ABM systems might require several hundred activities to provide a view of the processes that underlie production and customer service. (Cooper & Kaplan 1999, 277-282)

For example the actions listed below are actions of activity-based management as they refer to managers' decision-making using information about activities (Kaplan & Atkinson 1998, 151):

- reprice products
- substitute products with more profitable products
- redesign products
- eliminate products
- improve processes and operations strategy.

Companies in which overhead and direct labor costs form a dominant share of total costs benefit most from ABC and ABM. Material costs usually dominate the cost structure of metal industry companies like Moventas Wind and production overhead and direct labor costs are often less significant. This diminishes the biggest benefits of ABC and ABM. These companies also often have little discretion in product pricing, little potential in elimination of activities and they often have a small number of products. This means that the biggest benefits of ABC and ABM for companies like Moventas Wind lie in profitability analysis, outsourcing decisions and product and process improvements. (Kaplan & Atkinson 1998, 151)

Swenson (1997) studied the best practices in implementation and using of activity-based management in 166 companies in manufacturing, process manufacturing and service industries. The study revealed that five most common applications of ABM among the companies surveyed were product costing, cost reduction, profitability analysis, process improvement and cost estimation. The study also presented that many companies used pieces of ABM system, but very few had a fully developed system. The research team chose 15 companies out of 166 as best practice companies and examined them more carefully. The findings of their study state that in best practice ABM system the organization must be willing to accept the validity of activity performance measures and utilize them for benchmarking and performance measurement. The best practice companies also use a process view of their organization, employ solid ABM practices and tie ABM to other corporate plans. The research team also states that the emphasis of managers' should not solely be in costs of designing and making the product but in total costs that include distribution and support costs among others. (Swenson 1997)

### 4.2 Time-Driven Activity-Based Costing

In 2004 Robert S. Kaplan and Steven R. Anderson introduced an alternative approach that was touted to be simpler, more powerful and accurate way to drive costs of resource usage to cost objects than the traditional ABC. The new model is called time-driven activity-based costing (TDABC). (Kaplan & Anderson 2007b)

Time-driven activity-based costing uses time as a primary cost driver since the capacity of most resources is already measured by the time they are able to work. Other capacity measures, such as cubic meters, kilograms or gigabytes, can also be used for resources like warehouse space, vehicle capacity and data storage capacity. The traditional ABC systems often use multiple transactional cost drivers such as number of production runs or number of setups. The original ABC theory also has the ability to use time as a duration driver in driving the costs from activities to cost objects based on the time they consumed. The main innovation of this new approach is to drive costs directly from resources to the cost objects without a need to calculate the costs of performing each activity. The annual costs of five clerks might be for example 175 000 euros a year and if the practical capacity of these five clerks is 8 500 hours a year, the capacity cost rate is acquired simply by dividing the 175 000 euros by the 8500 hours. The only input information needed in TDABC system is the unit cost rate of supplying resources and the time it takes to carry out activities. (Kaplan & Anderson 2007a, 23-24; Kaplan & Anderson 2007b)

The standard cycle time required to perform each activity is a key input for a TDABC model. The industrial engineers have estimated standard cycle times for the work performed by employees and equipment for over a century, but the TDABC model requires that the standard cycle times has to be estimated in a larger scale. The good news is that TDABC system used for strategic costing purposes does not need exact time measures. Professors Kaplan and Anderson emphasize that "Knowing the first digit accurately, being close on the second digit and then placing the number of zeros and decimal point correctly are more that adequate for TDABC". (Kaplan & Anderson 2007a, 23-24)

There are multiple methods for obtaining the standard cycle times: direct observation (stopwatch and clipboard approach), accumulating the time required to process fifty to one hundred similar transactions and calculating the average time, interviewing or surveying employees, utilizing existing process maps or colleting time estimates elsewhere from company or industry. In conventional ABC, the project team asks employees to specify how they spread their time (or equipment time) across multiple types of activities. The TDABC approach for time estimation, in which the employees are asked to define a time needed to perform each activity, is a lot smoother process for both employees and project team. (Kaplan & Anderson 2007a, 23-24)

Cardinaels and Labro (2008) recently studied the factors affecting the accuracy of time estimates. The first observation of their study suggests that increased aggregation in definition of activities leads to lower measurement error. An employee can often for example estimate that the time he needs to make the setups is 2.5 hours, but an employee is often unable to break down the 2,5 hours elapsed time into the time required to perform 10 separate micro activities. The second finding of the study is that the employees should be informed in advance that they will be asked to estimate the time they need to perform specific activities. The notification had strongest influence on measurement error when employees estimate the time they need to perform incoherent tasks that are often completed in discrete periods. Thirdly, Cardinaels and Labro found a strong overestimation bias when participants provide the time estimates in minutes as TDABC advocates. Despite the findings of this study, it is unclear whether these findings can be generalized for alternative tasks and experience levels. The gaming behaviour of participants and the accuracy of managers´ estimates compared to the employees’ estimates are either not examined. These findings can best be utilized in estimation of time needed by an employee to perform a specific activity in service companies like accounting or insurance companies. Even though many similarities exist, the standard time estimation for equipment is different in many respects. (Cardinaels & Labro 2008)

## 4.3 Calculation of Unit Cost Rates

Another crucial factor affecting the reliability of activity-based costing systems is the calculation of activity unit cost rates. In TDABC, the resource unit cost rate is usually calculated as a cost per hour and the process of calculating the cost of resource usage differ only little between conventional ABC and TDABC. The basic procedure for calculating the cost rates is reviewed in the following.

The basic equation for calculation of capacity cost rate is defined as follows: (Kaplan & Anderson 2007b)

$$\text{Capacity cost rate} = \frac{\text{Cost of capacity supplied}}{\text{Practical capacity of resources supplied}} \tag{1}$$

The cost of capacity supplied consists of following elements: (adapted from Kaplan and Anderson 2007a, 42)

- *Equipment and technology:* cost of equipment including depreciations or leasing expenses.
- Blue-collar workers: wages, salaries, overtime work and social costs of employees.
- *White-collar workers:* salaries and social costs of supervisors and supporting personnel.
- *Facility:* cost of supplying space for employees and their equipment and supervisors.
- *Other indirect and support resources:* assigned expenses from support departments.

Equipment and technology costs include operating expenses such as depreciation or leasing expense. The depreciation cost is usually based on straight-line depreciation or replacement cost depreciation and the cost of capital can also be included in annual equipment expense. If a company uses same cost accounting system in valuation of inventories, it must be noted that in Finland it is not allowable to capitalize the cost of capital in most cases. (Kaplan and Anderson 2007a, 43; Finnish Accounting Board 2006)

The social costs and overtime costs have to be included in white- and blue-collar personnel costs. The costs of indirect and support resources include all the functions (often corporate-sustaining) that are not directly involved in manufacturing, but provide the infrastructure required by frontline people or equipment to perform their work. (Kaplan and Anderson 2007a, 45)

The facility costs represent the cost of supplying workspace for equipment and employees. The facility cost per square meter might include costs like rent or depreciation, maintenance, cleaning and insurances. The departments that use more expensive space, such as clean rooms, should be charged a higher facility cost per square meter. The other indirect and support resources respectivey include internal services that are needed to sustain the capacity. (Kaplan and Anderson 2007a, 44)

An essential question in design of TDABC model is the level on which the capacity cost rates are calculated. A department level is the fastest and simplest approach, but it requires that all resources on a departmen level are able to perform all activities equally well. This assumption is violated if activities of a department use different resources. In case of Moventas Wind this would mean that only one activity (for example gear grinding) could be performed within a department if department-level capacity cost rate would be used. This means that separate capacity cost rates have to be calculated for each activity performed within a department and the greatest simplicity of TDABC is unfortunately lost. Another option is to accumulate the costs of certain processes performed within the department and define the practical capacity and cost rates on a process-level. This, for one’s part, requires that the practical capacity of a process should be relatively constant and not affected by for example changes in product mix. The resource consumption might also be two-dimensional. For example in warehouse services, the cost object on one hand incurs a time-based labor cost for handling the cost object and on the other hand it incurs a facility cost according to the floor space occupied. This requires that two separate capacity cost rates have to be calculated. The first process of handling an item could use time as a cost driver and the another could drive the costs to the cost object according to the floor space occupied. (Kaplan and Anderson 2007a, 49-52)

### 4.4 Capacity Measurement and Idle Capacity

Capacity and the level of activity are one of the most fundamental concepts in management accounting. Some basic concepts of capacity measurement and classification are presented in the following.

American Production and Inventory Control Society Dictionary defines capacity as "highest reasonable output rate which can be achieved with current product specifications, product mix, work force, plant and equipment". The capacity of a plant is relatively easy to define in process industry, but in discrete manufacturing the capacity is most often a guess. Production capacity in a discrete factory depends on bottlenecks, which, in turn, depend on the product mix. Capacity is rarely constant over time and contingencies like absenteeism and scrap affect the actual capacity of a plant. The equipment can extremely rarely be utilized with one hundred percent because real life issues like varying processing times generate idle time (process balance). Capacity is not solely a function of capital equipment but it is also influenced by operating procedures: engineers create capacity through their designs and managers allocate capacity through their decisions. (Paranko 1996)

Capacity can be measured in units of output, but it is difficult to find a common unit of output with diverse product mix. Therefore the capacity of equipment is often expressed in terms of input measures (usually hours). Load is the amount of work scheduled to be done by a resource. Load is often expressed as hours or units and the capacity of a resource determines how much time is needed to complete the work. The facility layout also affects the capacity measurement. Four major layout patterns are used in manufacturing process design: process layout, group layout, functional layout and product layout. If machines are for example mounted as cells as in the group layout and every piece goes through the whole cell, the cell can be considered as a single machine and it does not make sense to report the idle capacity of each machine in the cell. Functional layout is the most flexible layout and individual unit cost rates are usually defined for each resource. In product layout, a certain independent unit of factory is responsible for manufacturing of a certain product or component and in process layout the machines or activities of a manufacturing process are also usually placed one after another. If all products go through the same stages of a process in the same order and constraining activity is relatively constant, the aggregation of resources might be possible. (Paranko 1996; Haverila et al. 2005, 475-479)

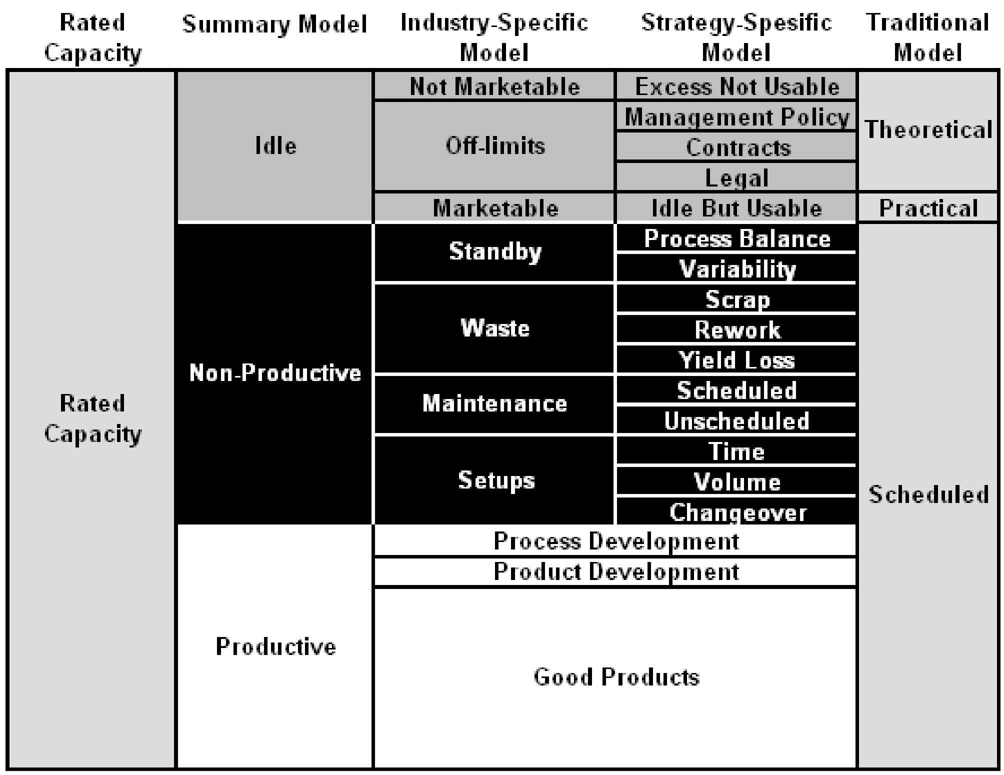



**Figure 9.** CAM-I Capacity Model (Klammer 1996, 17)

In 1995 the consortium of advanced management international (CAM-I) introduced a capacity model that aims for clarifying the concepts of capacity of a process and that offers a common language for both management and operations team.

- Idle capacity consists of marketable, not marketable and idle off-limits capacity.
  - Idle marketable: a market exists but capacity is idle because of competition, product substitutes or distribution constraints. Business team is responsible for idle marketable capacity.
  - Idle not marketable: a market does not exist or management has decided not to participate in the market. This capacity should be minimized.

  - Idle off-limits: capacity that is unavailable because of holidays, contracts or management policies. It remains off-limits until management decides that it is marketable.
- Nonproductive capacity is capacity that is not in a productive state or in any of the defined idle states. The amount of nonproductive capacity is industry-specific.
  - Standby is nonproductive because of variability caused by suppliers, customers or business operations. Standby is a capacity buffer that helps the company deal with this variability. Standby results from waiting or because some operation has more capacity than the factory constraint (process balance).
  - Waste may be for example scrap, rework and yield loss. There are multiple sources of waste.
  - Setups and maintenance may occur for several reasons but all time spend with these activities is considered nonproductive.
- Productive capacity is capacity that is used to process a product or provide a service. Productive use of capacity provides tangible changes in the product in a way that the customer values. Turning, grinding, painting and assembly are examples of productive capacity. Productive capacity results in manufacturing of good products. The use of capacity for process or product development is also considered productive. (Klammer 1996, 16)

The template assists in understanding and communicating the capacity issues and the focus of the capacity model presented is an entire process. A process consists of pieces of equipment that can be classified as contraints or nonconstraints. A process contraint defines the throughput of entire process and the amount of idle marketable capacity. The process constraint can sometimes be difficult to recognize. If a company continuously introduces new products, processes and product mix changes, the constraint constantly changes. (Klammer 1996, 73)

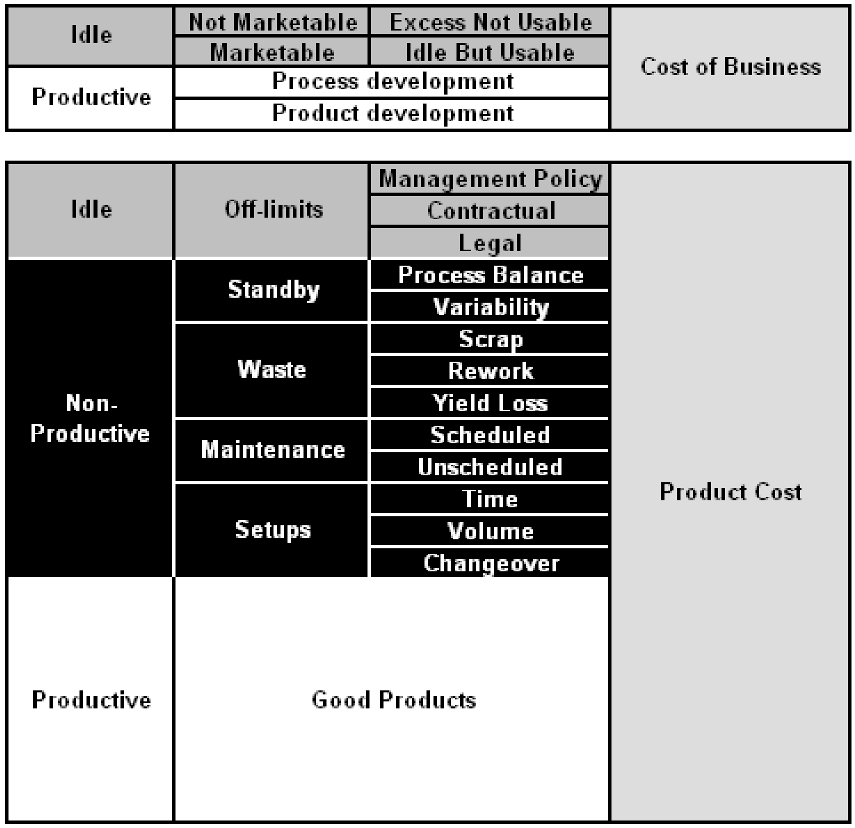



**Figure 10.** Detailed Product Cost Template (Klammer 1996, 72)

The figure 10 presents CAM-I product cost template. This template suggests that only off-limits idle capacity (capacity unavailable because of holidays, contracts or management policies) should be included in product costs. Different elements of product cost template like setups or maintenance can be included in product costs either by reducing the annual capacity by the time needed for setups annually or by including the setup and maintenance time in standard cycle times. The latter option is often easier to execute. It must also be noted that the pracical capacity used in quantification of idle capacity must equal to the capacity used in calculation of unit cost rates.

The denominator capacity is a crucial component in calculation of capacity cost rates. Most experts emphasize that practical capacity should be used as a denominator value. However, at the moment the surveys indicate that budgeted volume is the most popular denominator capacity. The third denominator capacity used is a normal capacity. Normal capacity is the level of capacity utilization that will satisfy the average customer demand over a span of time (often five years) that includes seasonal, cyclical and trend factors. (Paranko 1996)

Hyvönen (2000) found that 42 percent of 99 Finnish companies companies studied used actual or budgeted level of activity, 31 percent used practical capacity and 23 percent used long-term normal capacity as a denominator value. In general, the resource consumption was rarely observed as only seven percent of all respondents reported idle capacity. Anyway, among the companies that had implemented ABC the rate was a little bit higher, 20 percent. (Hyvönen 2000, 53)

The following simplified example illustrates the faults of using budgeted capacity as a denominator value in calculation of capacity cost rate. Consider a scenario in which Moventas Wind manufactures all components of wind turbine gears with equal capacity costs in three locations: Rautpohja, Ikola and Faribault. As the demand for wind turbine gears is high, all factories are operating at full running rate. Next year the demand for gears collapses, and Rautpohja factory is able to fulfill the whole demand and Ikola and Faribault stop the production. The capacity costs of Ikola and Faribault factories would be assigned to gear units manufactured at Rautpohja if budgeted level of activity would be used of a company level. The result would be that none of the gears produced at Rautpohja would be reported profitable even though the same gears were profitable during the good years. This cost information also encourages managers to stop the production also at Rautpohja. The same concept can be used also in a smaller scale. The practical capacity of a single turning machine is 6 000 hours. If the turning machine is used only for 2 000 hours, all capacity costs should not be assigned to those 2 000 hours that were used. If practical capacity would be used as denominator value, the products of Rautpohja would only receive the capacity costs of Rautpohja factory and the capacity costs of Ikola and Faribault would be costs of idle capacity. Correspondingly the products that the turning machine manufactures would only receive the capacity costs of 2 000 hours of processing and the remaining 4 000 hours would incur cost of idle capacity.

# 5 PERSPECTIVES ON COST MANAGEMENT

Several management accounting authorities state that most cost accounting systems have too many ties with financial accounting and they involve a relatively low level of innovation. They also state that the attention of managers should be moved from costs to the value added to the customer (figure 11). (Maskell & Baggaley 2001)

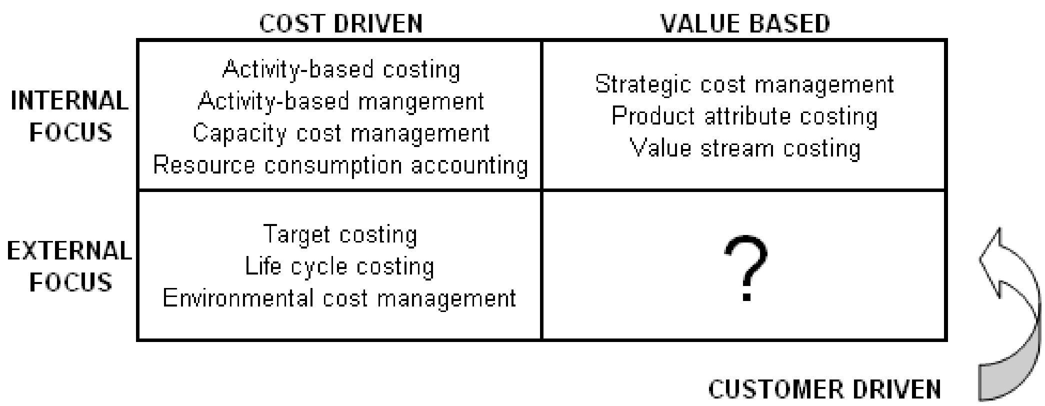



**Figure 11.** Cost Management Perspectives (McNair et al. 2006)

Numerous new cost management methodologies have arisen during the last decades. Activity-based costing has been in focus for some twenty years, but emerging methodologies like resource consumption accounting and value stream costing are continuously receiving more and more attention. Time will show which of these new methodologies will earn a permanent place in cost management practice and which will leave in history as momentary trends of cost management. This chapter discusses the perspectives of cost management and shortly introduces value-stream costing as part of lean accounting.

## 5.1 Design of Cost Management Systems

Unlike finacial accounting, the management accounting is not dependent on any rules or regulations from authorities. If the cost accounting system is however used for purposes of financial accounting for example in periodic allocation of production costs between costs of goods sold and inventory, some regulations exist. Finnish legislation presents the following terms as requirements for capitalization of fixed purchase and manufacturing costs.

1. The amount of fixed manufacturing costs has to be substantial compared to the amount of variable costs.
2. A company must have working and systematic product-specific cost accounting system that can be verified with book-keeping.
3. A company must follow the principle of continuity in determination of acquisition costs. (Finnish Accounting Board 2006)

Within these regulations, the cost accounting system can produce cost information according to any rules defined. The purpose of use defines the quality and form of cost information that the cost accounting provides. Kaplan & Cooper (1998, 2) present that the cost accounting systems are primary used for following three functions:

- valuation of inventory and measurement of cost of goods sold for financial reporting
- estimation of costs of activities, products, services and customers
- providing economic feedback to managers and operators about process efficiency.

The first of the three functions is usually easiest to put into practice, but it also has the lowest importance in managerial decision-making. The second function of a cost system equals to the cost assignment view of the ABM -model presented in figure 8 on page 33. The cost structure of a company is an essential factor in design of cost accounting system for costing of activities, products, services and customers. Activity-based costing systems are generally most effective if production overhead and overhead costs of supporting departments incur a major share of company's costs. Time-driven activity-based costing systems perform best in labor intensive companies like accounting companies. Traditional costing methods like job-costing or process costing may also be well adequate if material costs dominate and labor and overhead costs form only a minor share of total costs or if company has only one product in manufacture. The third function of a cost accounting system equals to the process view of the ABM model presented in figure 8 on page 33. The cost accounting system should also provide economic feedback to managers and operators about process efficiency to illustrate the effects of process development and to support continuous improvement.

Kaplan (1988) states in his article *One Cost System Isn't Enough* that one cost system cannot provide all relevant information needed in informed decision-making. The cost information needed for process improvement has to be much more precise than the strategic cost information used in for example product costing. The cost accounting system designed for operational purposes like process development requires a large number of activities and is thereby often heavy to maintain. (Kaplan 1988; Sievänen & Tornberg 2002)

Despite some studies performed (e.g. Abernethy et al. 2001) the researchers still have not found generic recommendations about what is the most suitable costing system for companies with different charasteristics. However, some signs that signal that the cost accounting system of a company might be obsolete are presented.

Cooper (1989) and Oliver (2004) present the following internal and external symptoms as signals of costing system that needs updating:

Internal warning signs:

1. Users complain that the financial reports are inaccurate or do not reflect the reality of the business operations.
2. Managers cannot explain the financial results.
3. Managers do not use financial reports.
4. Managers develop their own cost models.
5. Managers want to drop seemingly profitable products or services.
6. Accountants spend a lot of time on special analyses or requests.
7. Inconsistency in reported data.
8. Managers engage in suboptimal decision-making.

External warning signs:

1. Customers accept price increases without complaint.
2. Competitor prices are equal to your costs.
3. Supplier bids are lower than expected.
4. You have no competitors in a particular market niche.

Redesign of a cost system always takes time and requires considerable effort. If only one or two of these symptoms are observed, the cost accounting system might still be adequate. However, a pilot project can be launched with reasonable costs in order to examine whether the updating of costing system is needed. (Cooper 1989)

## 5.2 Cost Information in Decision-Making

Accountants usually define cost as a resource sacrificed to achieve a certain object (Paranko 1996). The field of cost accounting knows numerous different methods for calculating the costs of certain cost object and almost all of them end up in different results. Thereby the relevance of cost information in decision-making is an essential question in today's cost accounting. The relevance of costs is always connected with time perspective taken. Two cost accounting theories, theory of constraints and activity-based costing, are compared in this chapter from viewpoint of decision-making. (Paranko 1996)

Theory of constraints (TOC) was presented in the 1980s by Dr. Eliyahu M Goldratt in his book called *The Goal*. Goldratt states that the goal of a company is to make money now and in the future and the way to make money is to maximize the throughput and minimize inventory and operating expenses. Goldratt's TOC concentrates on reliefing the constraints of current equipment to increase the throughput. Throughput is defined as sales less truly direct costs (usually materials and energy) and it can also be defined as amount of money flowing into the company. Product inventory includes only the costs of direct materials that remain unsold as raw material, work in process and finished goods in TOC. Operating expenses are the costs of converting the inventory into throughput, that is, the money that flows out of the company is considered operating expense in TOC. (Kaplan & Atkinson 1998, 38; Sheu et al. 2003; Martin 2008)

The consumption of constraining activity is an essential factor in optimizing the use of short-term resources if capacity is fully employed. The flexibility of product mix and pricing affects the possibilities of choosing an optimal production plan. Products that generate high profits compared with their consumption of constraining activity should to be favored to maximize the profits in the short term. TOC states that constraining activity incurs an opportunity cost that is equal to the increase in profits that could be achieved without a constraint. Goldratt also states that capacity expansion is justified as long as the increase in capacity costs (costs of new machines or outsourcing) is less than opportunity costs that are avoided by further expansion. (Kaplan & Atkinson 1998, 38)

The definitions of fixed and variable costs are often indefinite and highly dependent on the time horizon chosen. In short-term decisions, most costs become fixed and therefore the relevant product costs are the costs advocated by Goldratt's TOC. For example the use of full absorption costs of ABC in very short-term decision-making is not reasonable. If company has unused and it considers whether to make or buy a certain product or whether to accept a one-time order, only truly direct costs are relevant. In these situations most of the costs are sunk (incurred because of earlier decision) and therefore irrelevant in decision-making. For example depreciation and facility costs will be incurred whether or not the product product will be manufactured and therefore full costing should not be used in cases like this. (Fritzsch 1998)

However, the theory of constraints does not take into account the long term resource consumption that the product incurs. The theory also disregards the fact that every fixed cost becomes variable if the time horizon is long enough and even the supply of machine resources can be altered. It might be reasonable to manufacture a product in house in situation described earlier, but if the same product is manufactured constantly and if the company does not have unused capacity, the full absorption costs of ABC should be used. ABC system better reflects products demand for resources in the long term. There is also a difference in treatment of capacity between these two philosophies. TOC concentrates on maximizing the throughput through careful planning at constraining activity while ABC emphasizes the elimination of idle capacity and thereby reduction of costs. (Fritzsch 1998; Sheu et al. 2003)

| | |
|---|---|
| **Practical capacity** | 6 100 h |
| **Budgeted level of activity** | 4 000 h |
| **Idle capacity** | 2 100 h |

**Budgeted level of activity**

| | |
|---|---|
| Capacity costs | 122 000 € |
| Unit cost rate | 30,50 €/h |
| | |
| Sales | 120 000 € |
| COGS | 122 000 € |
| **Gross profit** | **-2 000 €** |

**Practical capacity**

| | |
|---|---|
| Capacity costs | 122 000 € |
| Unit cost rate | 20 €/h |
| | |
| Sales | 120 000 € |
| COGS | 80 000 € |
| **Gross profit** | **40 000 €** |
| **Cost of idle capacit** | **42 000 €** |

**Figure 12.** Idle Capacity in Decision-Making

The example above illustrates the meaning of idle capacity. In this simplified example, only one machine is needed to produce product A. According to the budgeted level of activity, 100 units are processed in 4 500 hours. Annual costs of supplying the capacity are 122 000 € and the unit cost rate is 30.50 €/h if budgeted level of activity is used as a denominator value and 20 €/h if practical capacity is used as a denominator value. If we use budgeted level of activity in definition of unit cost rate, the processing of product A seems unprofitable and the costing system incites to stop the manufacturing of the product. If practical capacity of 6 100 hours are however used as a denominator value, we the real profitability of a product is revealed. The use of practical capacity and reporting of idle capacity avoids all these fluctuations and the gross profit of certain product is constant regardless of the level of activity.

### 5.3 Support of Information Technology and Production Management

Information technology has developed significantly during the last decades. Modern enterprise resource planning systems integrate production planning, materials management, and cost and management accounting. Hyvönen (2000, 44) studied 99 Finnish companies and found that for cost accounting, the biggest benefits of new data system are the timelyness (78.2 percent of responders) and accuracy (65.0 percent of responders) of reporting.

Spathis & Constatinides (2004) studied the effects of implementing ERP to the accounting processes in Greek companies. The companies studied were quite recent ERP adopters (18 months of use on average) and thereby the full potential of their ERP systems may not be fully utilized. The study however reveals that the most important benefits of implementation of ERP are increased flexibility in information generation, increased integration of accounting applications and improved quality of reports. The accounting functions and practices that were most affected by the implementation of ERP were internal audit function, the use of non-financial performance indicators and profitability analysis at segmental and product level. (Spathis & Constatinides 2004)

Lahikainen et al. (2000) studied the possibility to perform activity-based costing in traditional enterprise resource planning system and compared separate ABC softwares with ERP-integrated solution. They found that ABC can be performed also in traditional ERP system with some limitations compared to separate ABC softwares or ABC modules of extensive ERP systems. Some other observations and findings of their study are presented in the following. In traditional ERP systems, the allocation of service department costs like costs of sales function is more complicated and the cost object is usually only the product. ABC softwares are used to model company's processes and activities in logical order and cost objects may include products, customers and suppliers. Most of ABC softwares are able to measure performance, efficiency, quality, customer and product profitability, increase organizational profitability and eliminate non-value added work. In ABC systems, the costs are allocated with resource drivers and the drivers can usually be defined separately. Activity drivers can also be defined separately and individual allocation rules can be defined. In ABC softwares, the unit cost rates of resources can be calculated inside the software, and they are not tied into hours as in most ERP systems. The strenght of

ERP system in cost accounting is up-to-date information, for example in recording material prices. Lahikainen et al. (2000) however suggest that separate ABC software is needed to support the ERP in definition of unit cost rates. (Lahikainen et al. 2000)

There are also various softwares available for productivity control of machining centers. Arrow Machine Track is an example of software that can be used with almost any industrial machine. The software also produces information on capacity utilization so it can support also cost accounting. It continuously records the running history and performance and availability rates for each machine. The system also separates machining time, waiting time, reduced speed time and breakdown time for each machine (see appendix 4). If a machine faces a breakdown, the system automatically starts recording breakdown time with red colour code and the worker can comment the reason for down time. Arrow Machine Track is able to follow the level of productivity of equipment on item, work id, machine, workshop, and company level and it can be configured to obtain the information on work ids from ERP or the operator of a machine can input it to the system manually. (Arrow Engineering 2008)

As competition is keen in almost every industrial sector, the companies are forced to develop their operations and processes in order to sustain their market share. A careful assessment and standardization of business processes can provide valuable information on cycle times, capacities and capacity utilization rates also for cost accountants. Lean manufacturing is an example of production philosophies that often provides plenty of valuable information on manufacturing processes. Principles of lean manufacturing and some connections to the cost accounting are described in the following paragraphs.

Womack (2002, adapted) identifies five principles of lean manufacturing as follows:

- Specify the value desired by the customer.

- Identify all steps in the value stream for each product family and eliminate every step and every action that does not create value from the standpoint of a customer.
- Make the product flow continuously through the remaining, value-creating steps.
- Introduce pull between all steps where continuous flow is not possible.
- Manage towards perfection so that the number of steps and the amount of time and information needed to create value falls continuously.

Lean manufacturing is a production philosophy that aims to shorten the period of time between customer's order and delivery by eliminating the waste included in order-delivery process from standpoint of a customer (Ohno 1988). There are several tools that are used in elimination of waste. Some of the tools that Moventas Wind has utilized are presented in the following paragraphs.

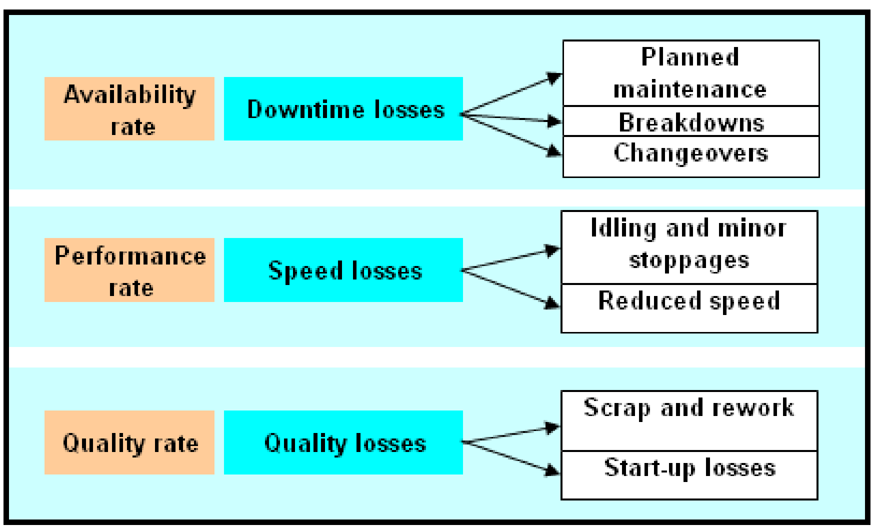



**Figure 13.** Overall Equipment Efficiency (Moventas 2007a)

Overall equipment efficiency (OEE, figure 13) is a measure of total machine performance that shows exactly where the time is lost. It categorizes time losses and assists in improvement actions. Availability rate describes the time machine is available to run, performance rate describes the amount of time that the machine runs at optimal speed and quality rate measures how many defective parts the machine produces. The OEE percent can be calculated by multiplying the availability rate by performance rate and by quality rate. At Moventas Wind, the OEE-percent is calculated weekly by formula two. (Moventas 2007a)

$$\text{OEE-\%} = \frac{\text{Finished pieces x processing time per unit}}{\text{Practical capacity}} \tag{2}$$

The higher the OEE-percent is the more good products the machine produces in given time. One has to remember the fact that if you cannot measure something, you do not understand it, if you do not understand it, you cannot control it and if you cannot control it, you cannot improve it. World-class OEE is generally considered to be 85 percent. (Kocakulah et al. 2008)

The changeover times affect the OEE-percent considerably and they can be measured and shortened with single minute exchange of a die (SMED) -methods. Value-stream mapping (VSM), for one’s part, is a visual method for illustrating the flow of information and materials. VSM offers managers a simple way to see the flow of value and unnecessary activities. A careful documentation of company’s processes also assists in design of activity structure for cost accounting system. (Kocakulah et al. 2008)

### 5.4 Emerging Cost Management Methodologies - Lean Accounting

In addition to the methods described in fourth chapter, several other accounting theories have emerged during the 21st century. For example recource consumption accounting and contribution-based accounting have received attention in the field of management accounting. This chapter shortly reviews the principles of lean accounting.

Lean organizations manage their business by value streams. The value is created and the waste is eliminated within the value stream. Lean accounting focuses on measuring and understanding the value delivered to the customer and it uses this information in product design, pricing and lean improvement. The measurements and reports like labor efficiency and overhead absorption rates that are usually provided by standard and activity-based costing systems are said to motivate non-lean behaviour such as use of large batch quantities and inventory building to reach a high utilization rate of capacity. The following features of traditional accounting systems are also considered harmful for company pursuing lean thinking: (Maskell & Baggaley 2006)

- Current cost accounting systems provide measurements and reports that motivate non lean-lean behavior such as large batch production and inventory building.
- Current cost accounting systems do not show the financial effects of the lean improvements made and often suggest that lean improvements have a negative impact on financial performance.
- Large and complex processes of traditional accounting systems generate non-value work that can be classified as a waste.
- People in the organization often do not fully understand the cost information provided.
- Standard costs are often misleading when making decisions related to outsourcing, pricing and product mix.

Thomas Johnson who was involved in development of activity-based costing some twenty years ago has even stated that: “Accounting control systems have been the number one enemy of sound operations management in American business for at least fifty years.” Heavy accounting systems with large amount of transactions are also completely contrary to the ideology of lean manufacturing. (Johnson 2006)

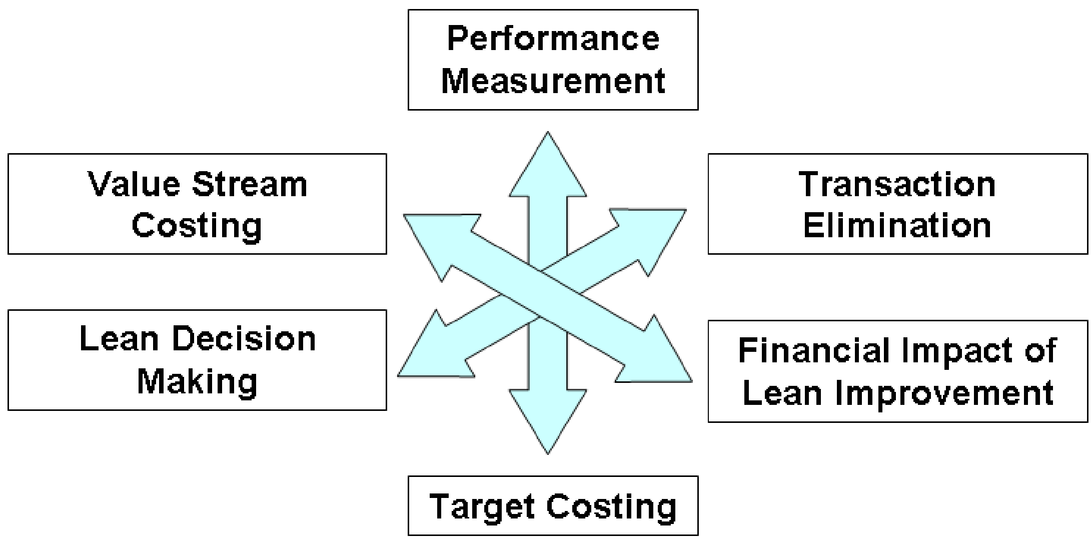



**Figure 14.** Elements of Lean Accounting (BMA Inc. 2005)

The whole ideology of lean accounting cannot be introduced (figure 14), but this chapter presents the principles of one important lean accounting tool: value stream costing. Value stream costing is an example of strategic accounting method for companies that pursue mature lean manufacturing. Generally praised cost accounting methods like activity-based costing and resource consumption accounting are said to be unsuitable and even harmful for lean companies. Lean manufacturing pioneers like Toyota have always shunned these elsewhere popular cost accounting methods and accounting control systems play no role in Toyota’s operations. (Johnson 2006; Maskell 2006)

Value stream costing supports the following principles of lean manufacturing (Maskell 2006):

- Interest toward the cost of production rather than cost of a specific product.
- Overhead costs are related to the value stream as a whole with little or no allocation.
- Maximum profitability comes from creating a maximum flow of product through the value stream with a pull of a customer.
- The cost of a particular product is primarily dependent upon how quickly it flows through bottleneck operations within the value stream.

Value stream costing ignores individual product costs, because lean organizations never make pricing decisions with reference to the cost of product. The right procedure for answering the question "Are we making profit or not if we sell at this price?" is to find out the effects of new order on the profitability of value stream taking into account any additional costs that will be associated with this new order. In effectively operating lean organizations, the inventory levels are low. The inventory can be valued according to average costs or direct material costs that are adjusted for the labor and overhead to bring the full absorption costs to inventory valuation. (Maskell 2006, 33)

A company must have a certain level of lean maturity in order to implement value-stream costing effectively. At least the following properties must be in place (Maskell 2006):

- Reporting has to be made by value streams and not by departments.
- People in the organisation must be assigned to value streams with minimum overlap.
- Few shared services departments exist.
- Production processes must be defined and under control with low variability.
- There must be a thorough tracking of exceptions like scrap and rework.

- Inventory must be reasonably controlled, relatively low and consistent.

Lean accounting was introduced in this chapter as a developing accounting model of 21st century. It is obvious that the maturity level of lean manufacturing is not adequate at Moventas Wind for implementation of lean accounting. The purpose of this chapter was to introduce some fresh and innovative methods for controlling lean organization. New accounting theories like lean accounting have recently received growing attention in the field of management accounting and the focus of new accounting theories is more and more in customer delivered value rather than in costs.

# 6 DEVELOPMENT OF HOUR REPORTING

The aim of the sixth chapter is to introduce a plan of action for implementation of standard cycle time system. The recommended solution for hour reporting is presented and evaluated in the end of this chapter.

## 6.1 Productivity Control and Cost of Idle Capacity

Despite all faults that the current hour reporting system has, it produces approximate information on present state of productivity. If standard cycle time system is implemented and current hour reporting is eliminated, a new method for productivity control is needed. Two methods are identified for this purpose: use of current hour reporting system for productivity control and use of productivity control software. The existing hour reporting system can be used in collection of reference data even thought the hour reporting system would not be used for cost accounting. Another option is to extend the use of Arrow Machine Track to Rautpohja. Although Arrow Machine Track would be used, the Flexim bar-code reader system is still needed in productivity control of assembly departments.

The implementation of Arrow Machine Track at Ikola gives good experience about the functionality of the system. A representative of business control function might be needed in implementation of Arrow Machine Track at Ikola to make sure that the system serves also purposes of management accounting. The system must be able to report the productive and nonproductive time at resource id, item-id and department level. If Arrow Machine Track functions as desired, the recommended concept is to implement the system also at Rautpohja. At machining departments the hour reporting can then be stopped, but in productivity control of assembly departments the reporting of hours through Flexim bar-code reader is however the most suitable concept.

Standard cycle times are used to assign the costs of machining or assembly work to the products according to predetermined load instead of using actual duration. However, these standard cycle times are sometimes exceeded or there simply is not enough work to employ the full capacity. In these situations the cost of idle capacity should be distinguished and reported separately as a period cost. While the reporting of idle capacity is not absolutely obligatory in standard cycle time system, there are numerous undoubted managerial benefits identified if the amount of idle capacity is known (see chapter 4.4).

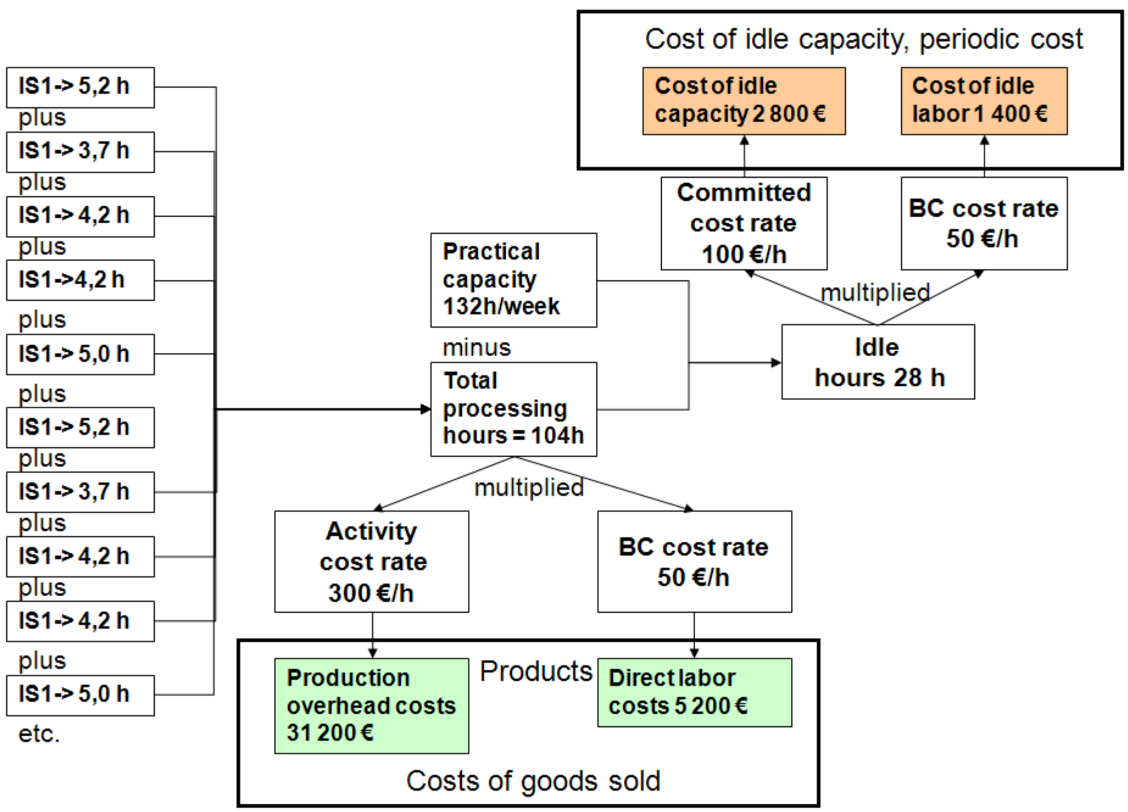



**Figure 15.** Reporting of Idle Capacity in Standard Cycle Time System

Figure 15 introduces the concept of standard cycle time system and reporting of idle capacity. The figure uses Ikola planet wheel production as an example. The activity

(IS1, turning of planet wheels) reports processing hours to work ids according to the standard cycle times and unit prices defined in routings. The total processing hours reported by a certain activity during a certain period of time are subtracted from practical capacity of an activity to define the idle hours. The cost of idle capacity during a certain period of time is equal to the amount of idle hours multiplied by committed cost rate of an activity (or BC hour rate of department). The amount of idle capacity of activities can be observed department-, activity- or item id-specifically. The idle capacity of blue-collar workers can be observed on department or item level.

There are three alternatives indentified for reporting of idle capacity costs in company’s data systems in practice. The first alternative is a modification of Lean system, the second option is development of new report and the last option is to use manual Flexim hour reporting in determination of idle time. The three alternatives are presented in detail in the next paragraphs.

The amount of idle capacity can be determined by the following procedure if Lean system is modificated. Lean System runs calculation of idle capacity as a background processing for example every Sunday evening. In order to calculate the idle capacity of a specific week, Lean system must read practical capacity from *Lean calendar* of an activity (RESID) in question. The amount of idle capacity can also be calculated for example daily. The amount of hours or kilograms registered to an activity under the time period given is acquired from *REP_TRANSACTION - Tapahtumat* –sheet from column *määrä* (QTY). Lean System then multiplies the amount of total idle hours by the committed cost rate of an activity (RESID) and allocates the total amount of idle capacity evenly to the work ids (WORKID) finished during the given time period. There are two columns for two different resource unit prices in Lean system. At the moment only one unit price is needed. The unit cost price of first column can be used in product costing and the committed cost rate can be input to the second column and it can be used in generation of idle capacity transactions. Idle capacity cost transactions can be identified as idle capacity transaction with a unique transaction type (TRANSACTTYPE). The cost of idle capacity is calculated for each activity that has received hours during the time period in question. The cost of idle capacity can also be calculated for each activity that has a unit price in Lean system.

The cost of goods sold –report in Business objects also has to be modificated in this option in order to enable the reporting of cost of idle capacity. The report should identify the transactions of idle capacity by their unique transaction type. The user has to be able to define whether or not he wants the costs of idle capacity to be included in costs of goods sold. As Lean system has information on which department each activity is performed, it is able to present the amount of idle capacity incurred at each department activity-specifically. The system can also list the items that were in production during the time period that the idle capacity was incurred. As Lean system possesses all information on idle capacity, the reports can then relatively easily be modificated to give any piece of information desired.

Another option is to develop a new Business objects -report. The basic operational principle of report is similar to the procedure described above. However, the report does not create transactions but only presents the amount of idle capacity during the defined time period with given parameters. The problem with this approach is the reporting of idle capacity from previous months or years. Nobody actually knows what the practical capacity at certain department was for example ten months ago if idle capacity transactions are not made to the Lean system.

The third option is to use certain overhead work numbers at each department for reporting of idle hours. In this concept the blue-collar workers sign in to an overhead work number with Flexim if they have idle time. This option is very similar to the current system and it does not solve the problems associated in Flexim hour reporting that were presented in chapter 3.4. Three alternative concepts were developed for practical implementation of reporting of idle capacity costs in data systems. Because of the significant faults of two other concepts, the modification of Lean system is the recommended concept.

A critical phase in reporting of idle capacity is the definition and maintaining of practical capacities of activities (RESIDs). The following paragraphs discuss the issues connected with technical acquiring of practical capacity in data systems, while chapters 7.1 and 7.3 discuss the determination of practical capacity in unit rate cost calculation.

The practical capacity of machining activities has to be defined in Lean calendar. The annual capacity in Lean calendars must be equal to the denominator capacity in committed cost rate calculation. If calendar-structure is changed, it has to be noted that work planners need current resource-specific calendars in follow-up of loads of machines. This, however, is not a problem because loads of machines could also be observed on activity-level or old resource-specific calendars can remain in Lean system along with new activity-level calendars. The capacities in Lean calendars should be correct on week-level or at least on month-level, because one week is the shortest period of time for rational reporting of idle capacity.

There are two options for acquiring the practical capacity of blue-collar workers. The first option is to create and maintain department-specific blue-collar work force – calendars in Lean system according to the work force available. The second option is to acquire department-specific presence hours from Flexim access control system. In this concept, Lean system automatically starts to report the hours of blue-collar workers to certain work number as they arrive at work and sign in at Flexim terminal. The hours are reported to certain department work number until they sign out at the end of the day. These work numbers represent departments and Lean system acquires the practical capacity of each department according to the amount of hours registered to each work number during a certain period of time.

The maintaining of Lean calendars was the only concept identified for supplying the information on practical capacities of activities. The Flexim system could also be used in determination of practical capacity for blue-collar workers. However, if two different procedures are created for acquiring of practical capacities, it would result in huge complexity in programming of Lean system. Thereby the recommended concept for acquiring the practical capacity is the concept of Lean calendars for both activities and blue-collar workers.

### 6.2 Standard Cycle Times at Machining Workshops

Third step in an implementation process of standard time system is the determination of standard cycle times for components in manufacture. The determination procedure at each department is presented in detail in the next two chapters. This chapter focuses on determination of standard cycle times and direct labor times for geared components manufactured at machining departments.

The standard cycle times have to be achievable and they must reflect the current state of productivity. The development engineers have a vital role in defining the standard cycle times. Professors Kaplan and Anderson (2007a) give a rule of thumb for standard cycle time estimation: "Knowing the first digit accurately, being close on the second digit and then placing the number of zeros and decimal point correctly are more that adequate for TDABC".

$$\textbf{Standard Cycle Time 1} = \frac{\text{Processing Time}}{\text{Activity OEE-\%}} \tag{3}$$

The standard cycle times for geared components are calculated by formula presented above for each item manufactured. The standard cycle times for housings are also defined with similar procedure. The processing times (program-times) can be obtained from machining programs and the development engineers already follow these times for purposes of OEE -follow-up. The processing times are often verified with stopwatch method for high volume products and for lower volume products the processing time can be defined by multiplying the verified processing time of a high-volume product by an empirical processing time factor. (Moventas 2007a)

If an activity has machines whose target OEE-percents are not the same, a weighted average has to be calculated. The OEE-percent must reflect the current state of productivity and therefore it might differ from the target OEE. The reference data of actual OEE follow-up can be used in OEE-percent estimation. As the standard cycle times are calculated by OEE-based procedure described above, the standard cycle times include the following components:

- processing time
- changeover time
- set-up time
- measurement and break-down time
- quality and speed losses.

Standard direct labor times are built up from two elements. The standard cycle time defines the basis for direct labor time and the number of machines normally controlled concurrently possibly divides that time. If two machines are normally controlled by one blue-collar worker, the standard cycle times of components these machines produce are divided by two.

The standard cycle times for new products and prototypes have to be estimated according to the program time or known standard cycle time of a similar product. The standard cycle time estimates of new components have to be verified after the actual production has started especially if considerable volumes are expected to be produced.

## 6.3 Standard Cycle Times at Hardening and Assembly Departments

The hardening departments use kilogram –based reporting in product costing at the moment. The hardening process incurs two-dimensional resource consumption. On the one hand the component occupies a certain space in a furnace and on the other hand it occupies the furnace for certain period of time. This two-dimensional resource consumption is handled quite well with current kilogram-based system, but it can also be handled by defining the standard hardening times. The following paragraphs describe how standard cycle times could be used also at hardening departments.

Almost all components hardened at Moventas Wind are fitted into standardized batches. Most of the costs at hardening departments are batch-level costs. There are two options identified for determination of standard hardening times that could be used in assignment of these batch-level costs for single products. In first option the standard cycle time for each item is calculated by dividing the hardening time (including the duration of both hardening and auxiliary stages) of a batch by the maximum number of components in a batch. The duration of hardening process is often dozens of hours, so for example precise estimation of changeover times is not crucial in this case.

$$\textbf{Standard Cycle Time}_{z} = \frac{\text{Duration of Hardening Process}}{\text{Number of Pieces in Standard Batch}} \qquad (4)$$

The direct labor times at hardening departments can be determined according to the time needed to assemble, harden, disassemble and finish the batch. The standard labor time is a sum of component handling time and hardening (processing) time. The handling and finishing time can be set as constant based on average duration of these stages but the hardening time has to be determined item-specifically.

If hardening time is for example 72 hours and the standard planet wheel batch size is 24 pieces, the standard hardening time for assignment of production overhead is three hours. The standard labor times has to be estimated separately. The workshop managers must estimate the correlation between hardening time and blue-collar work needed. The hardening time can be for example multiplied with a certain factor to estimate the amount of blue-collar work needed. It is important to assess and revise the direct labor times few months after the implementation of standard time system if standard hardening times are used at hardening departments. The workshop managers' knowledge of real blue-collar utilization rate during a specific time period and reported idle (or under) capacity can used in adjustment of direct labor times.

Another option is to determine the standard hardening times for hardening by using hardening depth as a determinant for standard hardening time. In this concept, a standard hardening time is defined for each hardening depth regardless of the batch sizes used and a constant handling time is added to the hardening time in the same way as in the concept described above. The standard direct labor times are also estimated according to the hardening time with a procedure described earlier.

There is plenty of uncertainty and complexity connected with use of standard cycle times at hardening departments. For example the different-sized hardening furnaces and batches at Rautpohja make difficult the estimation of standard hardening times. Thereby the recommended practice is to maintain the current kilogram-based system in costing of hardening departments. The accuracy of current system is evaluated in chapter 8.2.

Standard times at assembly departments are easier to define than at the hardening department. The standard assembly times consist of the following components:

- assembly time
- normal time needed for washing of components
- normal level of interruptions in assembly

- normal level of disassembly and reassembly.

The assembly times and washing times are determined according to the development engineers’ measurements and reference data from Flexim. At the moment the amount of hours lost and root causes for interruptions at Laaksola assembly department are documented weekly to the Opex week report in company’s internal Lean manufacturing -database. This data can be used in estimation of normal level of interuptions. At the service assembly department the standard assembly times are estimated according to the reference data from Flexim and workshop managers' estimates.

Standard cycle times for test benches include the following components:

- test drive time
- changeover time
- set-up time
- measurement and break-down time
- speed losses.

The cycle times, set-up times and changeover times of test drive benches are also carefully measured within OEE-follow up and the test benches are similar to the machining centers in many respects. The test benches also have a target OEE-percent and the determination of standard cycle times for test drive follows the procedure described in chapter 6.2.

## 6.4 Implementation and Maintenance of Standard Cycle Time System

After the people in charge for updating the standard time system have been chosen and standard cycle times are collected, the actual implementation of the system can be executed. A proper maintenance of standard cycle times and practical capacities is a definite prerequisite for a functional standard cycle time-based model.

At this point of the implementation process the workshop managers must be well aware of the date when the hour reporting should be ended in order to avoid a situation in which double costs are reported to the products. The management and other people using the cost information also should be aware of the pieces of information available through separation of idle capacity. The relevance and meaning of cost information is discussed more closely in chapter 8.3. After all these steps are executed, the routings can be modified into a state in which they create the costs according to standard cycle times.

The capacities of activities and calendars presented in chapter 6.1 need to be revised annually and always when changes in capacity occur. For example work planners can be chosen as people in charge for updating the calendars. If Lean calendars are used in cost accounting, only a strictly limited group of people should have rights to modify these calendars.

The responsibilities of maintenance have to be defined clearly to make sure that the system is up to date. It is important that no changes will be made to the standard cycle times without informing the business control function. Controller cannot understand the cost information and information on idle capacity if significant changes are made without communicating them.

Especially the standard cycle times of high-volume products has to be updated immediately after significant changes, for example process improvements, are made. Some of the direct labor times have to be revised if for example an extra worker is added to a machine cell permanently. The Finnish Accounting Board (2006) demands that standard cycle times and cost rates has to be revised at least once a year. It might be reasonable to revise the standard cycle times of all products for example at the beginning of a year and go through the standard cycle times of high-volume and new products also at the halfway of a year. The standard cycle times of assembly departments are adjusted based on the follow-up of current productivity. This reference data can be acquired from development engineers or from Flexim. The standard cycle times should be evaluated few months after the implementation in order to verify the estimates. If system reports under capacity or inordinate amount of idle capacity without a proper reason, the causes has to be clarified in cooperation with workshop managers and standard cycle time team.

### 6.5 Assessment of Standard Cycle Time System

Table 1 summarizes some of the critical issues of standard cycle time system and lists the practical options presented. The recommended concepts are highlighted in table below. This chapter evaluates the strenghts and weaknesses of recommended standard cycle time solution.

**Table 1.** Summary of Recommended Concepts of Standard Cycle Time System

| | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| **Productivity control** | Current Flexim-based system | Arrow Machine Track | |
| **Reporting of idle capacity** | Modification of Lean system | New Business Objects -report | Current Flexim-based system |
| **Practical capacity of machines in data systems** | Activity calendars in Lean system | | |
| **Practical capacity of work force in data systems** | Blue-collar calendars in Lean system | From Flexim access control | |
| **Reporting of production overhead costs at hardening departments** | Batch-based standard cycle times | Hardening depth-based standard cycle times | Kilogram-based reporting |
| **Reporting of direct labor costs at hardening departments** | Estimated | Kilogram-based reporting | |

Following features are seen as strengths of the standard cycle time system:

- no need for nonproductive hour reporting at machining departments
- unaffected by reporting behavior
- reporting of idle capacity
- costs of idle capacity not buried in product costs
- homogenous terms with Opex-project
- utilization of existing OEE-data.

The use of standard cycle times dramatically reduces the time needed for hour reporting. Only assembly departments need to report their actual hours in order to provide reference data for productivity control and standard cycle time estimation. The workload of white-collar workers is also lightened, because the hour registrations of blue-collar workers need not to be revised anymore. The varying reporting discipline also will not affect the accuracy of product costing if standard cycle times are used. The reporting of idle capacity is difficult to implement without using a standard cycle time system. In current model, the costs of underutilization of capacity are buried in product costs instead of reporting these costs separately. These costs may be significant especially in economic downturns and on the other hand slack capacity may be found during the boom times. At the moment, the product costs rise if utilization of capacity decreases. The recommended practice would be to keep product costs constant and report the cost of idle capacity. In standard cycle time based concept, the cost accounting uses homogenous terms as the production personnel do and most of the information needed in product costing is already acquired by development engineers within the OEE-project.

The following features are seen as weaknesses of standard cycle time solution:

- inaccuracy in small-scale production
- effort needed in maintenance of standard cycle times
- delay in registration of costs

- control issues.

It is obvious that standard cycle time system cannot be as accurate as reporting of actual time in small-scale production and in processing of prototypes. However, the significance of these small-scale batches is very low as long as the costs of these batches are registered roughly right. For other purposes like R&D or pricing the significance of for example the costs of a prototype may be more important. The processing time of these very low volume products can however be acquired otherwise. Arrow Machine Track, direct observing and use of specific Flexim R&D work number are the methods that can be used in follow-up of actual processing time of a certain component under the standard cycle time system. The updating of system needs some effort, but most of the processing times and OEE-percents are known already. The maintenance of Lean calendars also requires some effort depending on the product costing model chosen. The amount of calendars needed is however controllable and the updating of calendars can be carried out concentratedly at the turn of the year. There are some other issues that need to be considered before the standard cycle time system is implemented. For example the trigger for generation of cost transaction should be discussed with system developers in order to make sure that the costs will be generated into Lean system with an acceptable delay. Some people in wind gear service business also follow the state of certain work ids to see when the machining of component they need has begun. It should be considered how work ids can transfer for example to state *started* if stages of work are not signed as finished manually or with Flexim barcode reader as in current system.

# 7 DEVELOPMENT OF PRODUCT COSTING

This chapter introduces two alternative product costing models. These two models present an alternative way to assign production overhead costs to the products. In both models, material, material overhead and direct labor costs are assigned to the products in the same way as in the present state described in chapters 3.1 and 3.2. Substitutive machines are also grouped into activities instead of having unique resource cost rates for each machine in both of the new models.

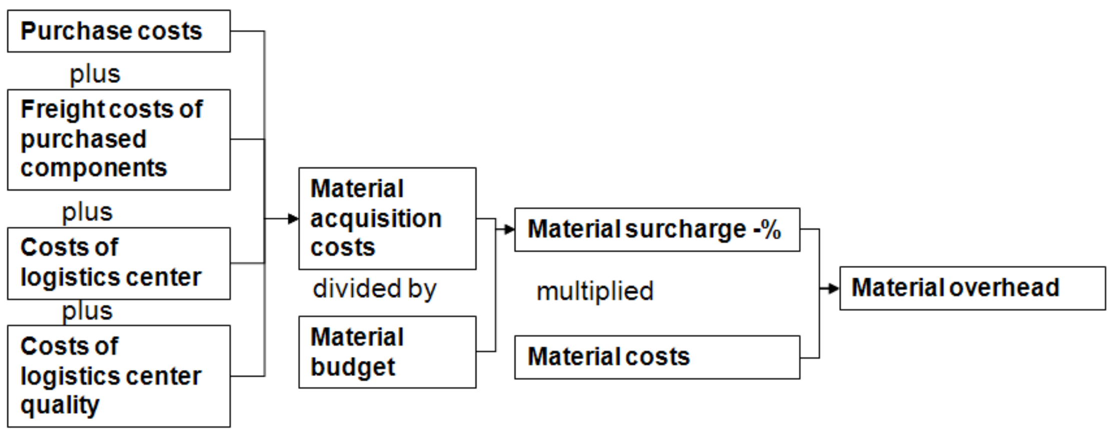



**Figure 16.** New Procedure for Material Overhead Calculation

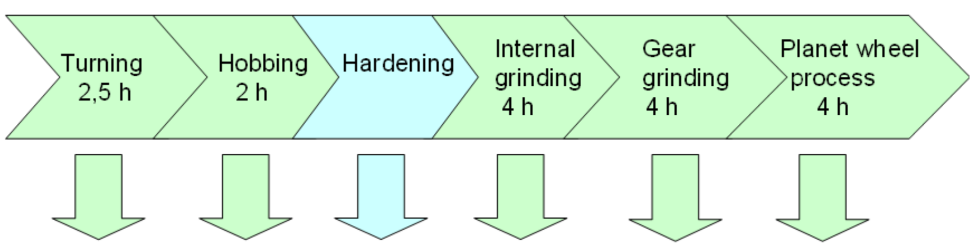
A similar material surcharge is used in both models, but the content of the surcharge is updated compared to the present state (figure 5 on page 21). The material budget is used as a denominator value in calculation of material surcharge as earlier, but the material acquisition costs now include the budgeted costs of purchase department, budgeted freight costs of purchased components, costs of Seppälä logistics center and costs of quality function at logistics center. Only one generic material surcharge percent is calculated for each budget period. Historical data (percent of material costs) from previous years can be used in estimation of freight costs for forthcoming year.

Both models developed group resources as activities. This requires some modifications to the resource (RESID) structure in Lean system. Activities established must have their own resource ids and activities needed in manufacturing of each item have to be defined in routings. A proposal for activity structure was developed with manager of production of geared components in this study. All these activities should have new, analogously named resource ids.

The main difference between these two alternative product costing models is in the level of aggregation of activities in calculation of resource unit cost rates. The first model is based on processes and constraints (*process-based model*) while another model is more traditional approach with several activities and activity unit cost rates (*activity-based model*).

### 7.1 Principle of Process-Based Model

In process-based model, the manufacturing processes, constraining activities and resources used in each process have to be defined carefully. Process-based model assigns the costs of whole process to the cost objects according to the use of constraining activity.




| | | | | | | |
|---|---|---|---|---|---|---|
| **Direct labor (BC) cost** | 50 €/h x 2,5 h =125 € | 50 €/h x 2 h =100 € | Duration- or kilogram-based allocation | 50 €/h x 4 h =200 € | 50 €/h x 4 h =200 € | |
| **Production overhead cost** | | | Duration- or kilogram-based allocation | | | 300 €/h x 4 h =1 200 € |

**Figure 17.** Principle of Process-Based Model

The figure 17 uses the manufacturing process of planet wheels as an example to illustrate the principle of process-based model. Gear grinding is the constraining activity of planet wheel process and thereby the load of planet wheel process –stage equals to the load of gear grinding -stage. The labor costs are generated at each stage of a planet wheel process, but the load of constraining activity solely defines the amount of production overhead that is assigned to the product. The labor and production overhead costs of hardening are generated at hardening stage according to the kilogram or hour-based cost rate as discussed in chapter 6.3.

The cost assignment in Lean System is executed by adding an extra stage called for example *planet wheel process* into the end of each item's routings. An extra stage must have the same load that the constraining activity has and it reports costs to a specific process resource (RESID) according to the standard cycle time used at constraining activity and process unit cost. The labor costs are created according to the standard labor times as described in the sixth chapter.

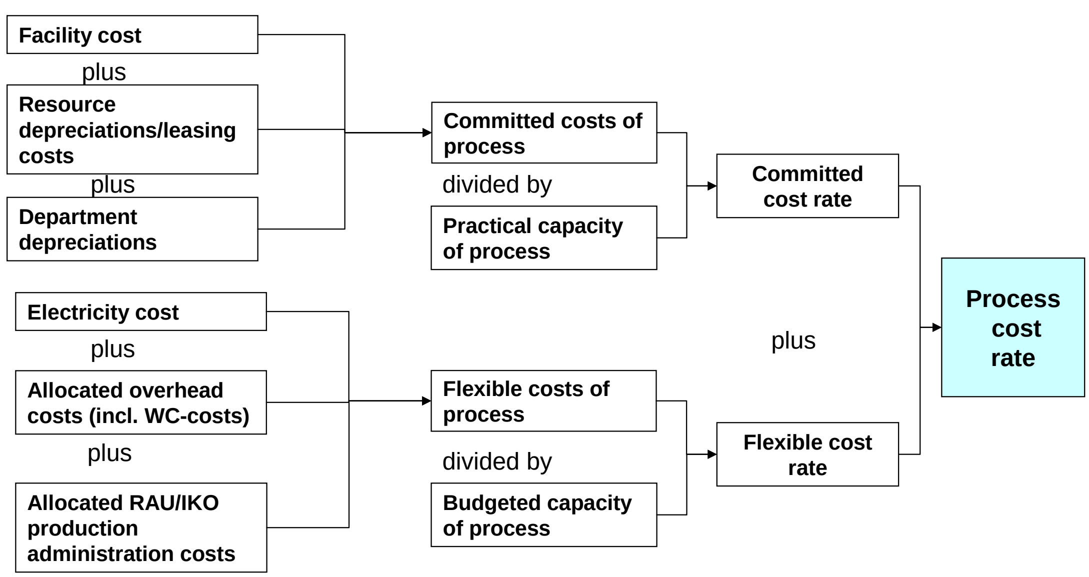



**Figure 18.** Procedure for Process Cost Rate Calculation

In process-based model, only one process cost rate is calculated for each manufacturing process. The capacity of a process equals to the capacity of constraining activity. The unit cost of using the constraining activity (process cost rate) is calculated by adding up committed cost rate and flexible cost rate (figure 18). The committed cost rate is calculated by dividing the sum of whole process's facility costs, depreciations and leasing expenses of machines and general depreciations of workshops by the practical capacity of constraining activity. The development engineers have the best view on the constraints of production, so they should be asked to define the constraining activity and its capacity for each process. The flexible cost rate is calculated by dividing the sum of electricity costs, overhead costs and production administration costs of a process by the budgeted capacity of constraining activity. The procedures for calculation of facility costs, electricity costs and production administration costs are presented in the following paragraphs. In a four-shift system, 6100 hours per machine annually can be used as practical capacity of constraining activity considering the machines that are possibly fitted during the year.

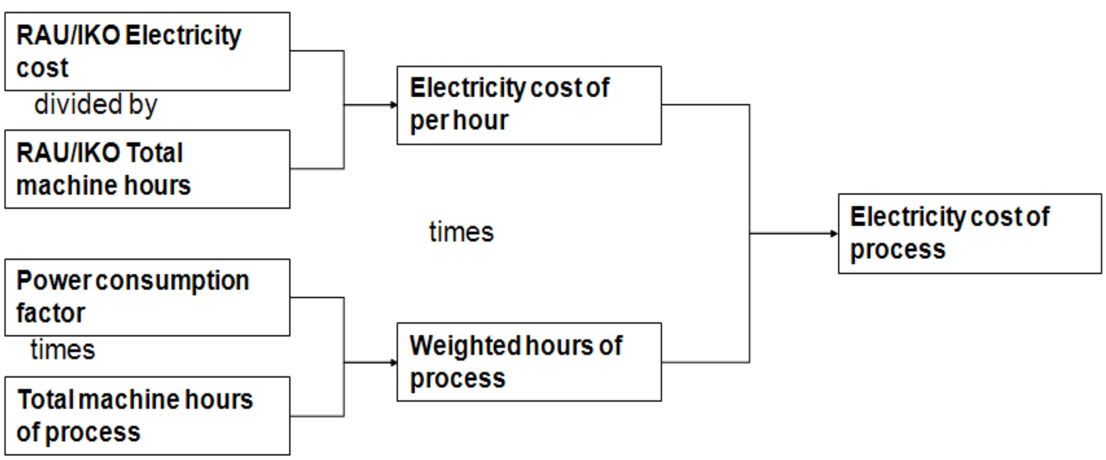



**Figure 19.** Procedure for Calculation of Electricity Cost

Electricity costs are traced back to processes by dividing the total electricity cost of Rautpohja or Ikola by total resource hours of a facility and by multiplying the electricity cost per hour -rate by the total sum of practical capacities of all activities involved in process. The processing hours of hardening departments has to be estimated unlike in the current model in order to allocate the electricity costs by the principle of causality. The higher electricity consumption of hardening department can be covered by multiplying the amount of hours processed by a power consumption factor of for example four or five according to the wattage of hardening furnaces.

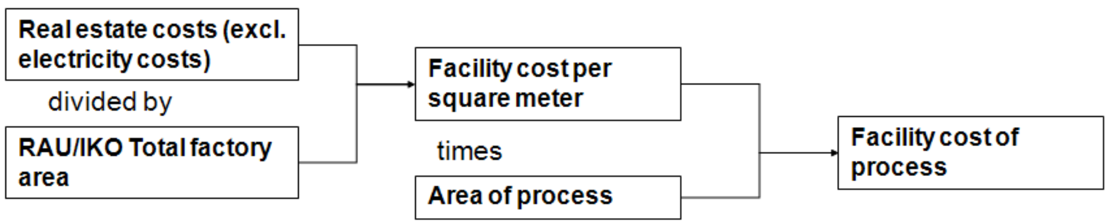



**Figure 20.** Procedure for Facility Cost Calculation.

The facility cost per square meter is defined by dividing the real estate costs of Rautpohja or Ikola by the total area of a facility. The facility cost of a process is calculated by simply multiplying the area that the process occupies by the facility cost rate.

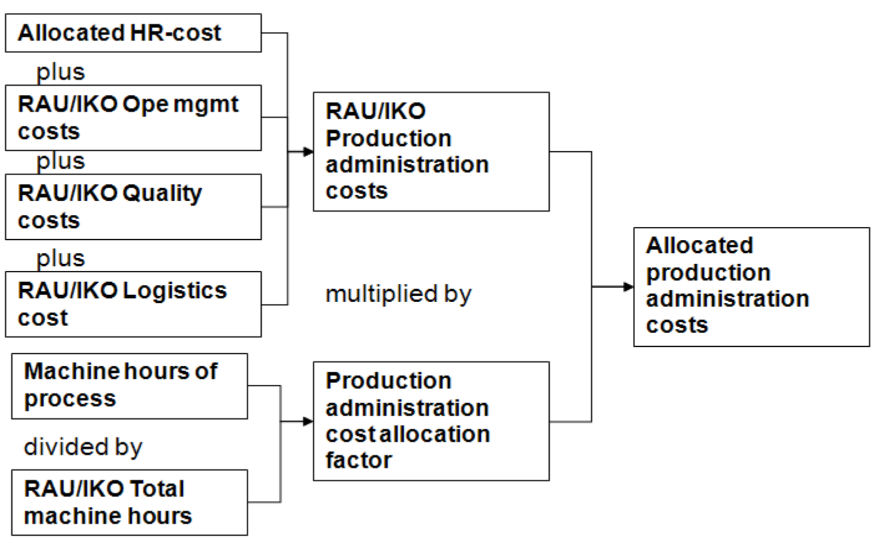



**Figure 21.** Allocation of Production Administration Costs

There is only one HR-cost center that supports both Rautpohja and Ikola, so the costs of this cost center must be allocated between these two facilities according to the total amount of machine hours worked. Operation management, quality assurance and logistics costs of Rautpohja and Ikola are also added up with allocated HR-cost, and the sum is then allocated to the processes according to total amount of machine hours of each process (figure 22).

If only one manufacturing process is performed at one cost center, the overhead costs and all depreciations of the cost center in question can be allocated to the process performed as whole. In optimal situation the cost centers would be equal with processes and little or no allocation would be needed in defining the process costs. At the moment there are two cost centers that are involved in several processes. The other of the cost centers, Rau Pinions and Service, could be divided into two or three separate cost centers according to the processes (high speed shafts, sun pinions and intermediate shafts). If the cost center is not split, the costs of these three processes have to be determined through costs of each resource in the same way as in the current system.

Rau Pinions and Service –cost center also includes the salaries of certain production administration personnel. The costs of these production administration personnel could form a separate cost center in the same way as assembly management does. There are also six older machines at RAU Pinions and Service –workshop that are mainly used for purposes of service business. The costs of these machining centers also have to be defined on a machine-level and have to be excluded from costs of processes.

The other of the two departments involved in several processes, Tourula machining, is a separate pre-machining unit that is located few kilometers from Rautpohja. Because of its separate location, it would be problematic to assign the machines of Tourula to the cost centers (departments) of Rautpohja. In order to allocate the costs of Tourula machining to the processes, the costs should first be allocated to the activities performed at Tourula (turning of intermediate shaft gearwheel, cogging of intermediate shaft, cogging of hollow shaft gearwheel, turning of sun pinion, cogging of sun pinion and turning of planet wheel), and the costs of activities are then added up with the costs of corresponding processes.

### 7.2 Feasibility of Process-Based Model

Process-based model is mainly based on principles of theory of constraints. Thereby the model has some features that clearly distinguish it from more traditional activity-based model. The following features are seen as strengths of a process-based model:

- simple reporting of idle capacity of processes
- effortless maintenance with few calendars and unit cost rates
- product costing through the use of scarcest resource supplied
- information on efficiency of processes.

In the process-based model the idle capacity is reported only from bottleneck activity. However, the process cost rate includes the costs of whole process (excluding direct labor costs) and therefore the idle capacity of whole process equals to the idle capacity of a constraining activity. In this model, the amount of idle capacity at nonconstraining activities is not relevant. If nonconstraining activities are able to fulfill the need of a bottleneck activity, the extra output that the nonconstraints could produce is non-marketable and therefore it would only increase the amount of work in process.

In this model, the accuracy of standard cycle times is not crucial at nonconstraining activities as only direct labor costs are reported through nonconstraining activities. As idle capacity is only reported from constraining activity, the amount of calendars needed in acquiring the practical capacity is reduced to the number of processes.

The process-based model assigns the costs of processes to the products according to the scarcest resource supplied with current equipment. If certain product uses a significant amount of the capacity of a constraining activity, the product also occupies the same share of income formation ability of whole process. Therefore it is justified to assign the same share of the costs of whole process to the product in question. The awareness of process costs also makes it possible to better control the efficiencies of processes. Time-based measures are not practical in performance measurement. If the constraint changes place, the output of a process may change significantly and therefore changes the input-output –ratio of a process. A better measure could be for example euros per component of a certain high volume product.

The following features are seen as weaknesses of a process-based model:

- flexibility
    - changes in place of bottleneck
    - widening of bottleneck activity through sub-contracting
    - product-specific routings
- awareness of resource consumption of nonconstraining activities
- long-term cost information in pricing
- comprehensive understanding of product costs by the organization.

Most of the weaknesses of a process-based model are connected with flexibility of the model and changes in the manufacturing environment. This model demands that the bottlenecks should be relatively stable, which means that the bottleneck activity does not change weekly according to the product mix. The widening of a bottleneck activity through sub-contracting should also be minimal and the amount of outsourced capacity should be known in the beginning of the year in order to define the bottleneck activity and process costs. In practice, for example gear grinding is often a bottleneck of a process, but it is rarely outsourced because it is usually one of the last stages of a manufacturing process. In general, the bottlenecks are usually at the end of the manufacturing process and therefore seldom outsourced. Even thought the bottleneck is widened, the routing for those individual cases could be the same as long as the costs of outsourcing are included in process cost rate. The other prerequisites for functional process-based model are constant processes and outsourcing policies, maintenance of routings and Lean calendars of constraining activities along with continuous follow-up of constraints in production.

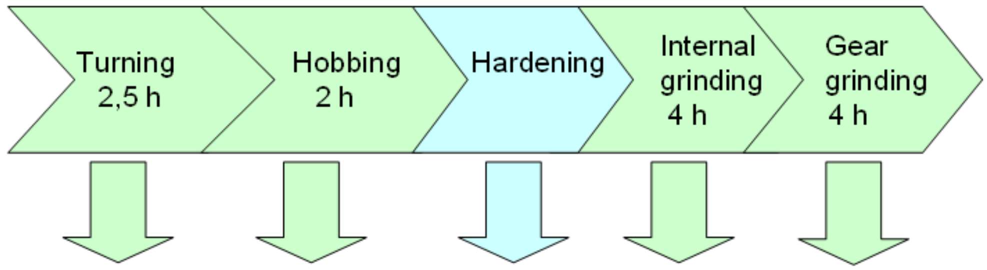
The budgeted costs of sub-contracting during the budget period should also be added to the costs of processes. This means that costs of outsourcing a specific stage should not be assigned to invidual componens but the costs of subcontracted work should be assigned to processes as a whole. If for example the first stages of a manufacturing process are sometimes performed outside the house and sometimes in house, the costs of outsourcing raise the cost rate of a process in the same way as the additional depreciations and processing costs would do. In this concept every component thereby receives a small share of the outsourcing and manufacturing costs regardless of the routing of an individual component. Otherwise the components that do not go through every stages of a manufacturing process in house would still receive the costs of whole process. As the outsourcing contracts are often made for a relatively long period, a specific stage of a manufacturing process is usually processed either in house or by a partner as a whole.

The process-based model also requires that most of the products that a certain process manufactures go through the same stages. At the moment almost all of the components within one process fulfill this requisite. Only some of the smaller intermediate shafts and three hollow shafts have remarkable variations in routings. The variations in routings often lie at the beginning of processes because of outsourcing of some stages. These variations do not disturbe the average product cost, but the costs of a single component can be blurred. The extra stages that components of some gears require are more problematical. Variations with low significance in product costs can be tolerated, but if the routing of a certain product differs significantly from routings of other products of a process, an individual process might be needed.

There is also a danger that using a process-based product costing model might blur the view of resource consumption of nonconstraining activities. The model does not illustrate the product-sustaining costs, for example a need for extra capacity at certain stage of a process. If this kind of a product uses only a small portion of the capacity of a bottleneck activity, the product might be considered a low-cost product despite the costs of new equipment it has incurred. The process-based model examines the product costs in short-term with current equipment and it cannot illustrate the resource consumption of components at nonconstraining activities. This may cause problems if it is used in longer-term strategic decision-making like in appraisal of investments or in pricing decisions. The special characteristics described above might also create confusion in the organization if the real meaning of process-based product costs is not fully understood.

### 7.3 Introduction of Activity-Based Model

The activity-based approach basically follows the rules of time-driven activity-based costing introduced in chapter 4.2, and each activity has its own hour-based unit cost rate. The principle of this model is largely the same as in the current cost accounting model with exceptions in hour reporting, grouping of activities and in contents of unit cost rates.




| | | | | | |
|---|---|---|---|---|---|
| **Direct labor (BC) cost** | 35 €/h x 2,5 h =87,5 € | 35 €/h x 2 h =70 € | Duration- or kilogram-based allocation | 35 €/h x 4 h =140 € | 35 €/h x 4 h =140 € |
| **Production overhead cost** | 100 €/h x 2,5 h =250 € | 101 €/h x 2 h =202 € | Duration- or kilogram-based allocation | 102 €/h x 4 h =408 € | 103 €/h x 4 h =412 € |

**Figure 22.** Principle of Activity-Based Model

The activity-based model assigns direct labor and production overhead costs in every stage of a manufacturing process (figure 22). The activity-based model defines unit cost rates for each activity (e.g. turning, hobbing). Activities include all substitutive machines, that is, for example all machines that are used for turning at certain workshop. The unit cost rates are thereby not defined for each individual machine as in current model. Finnish Accounting Board (2006) demands, that the unit cost rates should be updated at least once a year. The unit cost rates can be updated together with standard cycle times. The activity structure has to be revised if a machine is moved or its purpose of use is changed. If new machines are added to the activities during the year, the increased capacity also has to be noted in calculation of activity unit cost rates. The procedure for calculating the activity cost rates in activity-based model is presented in figure 23. The procedure is in many respects similar to the procedure of process cost rate calculation presented in previous chapter.

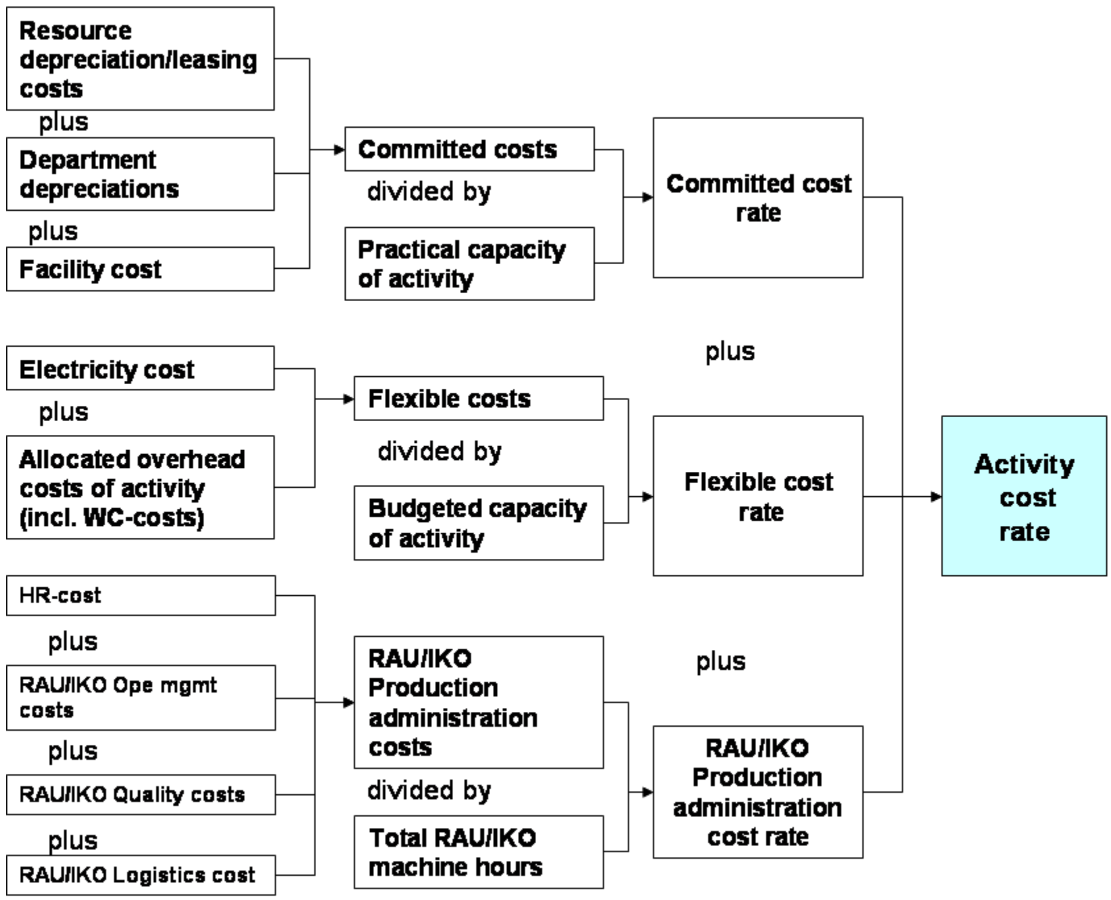



**Figure 23.** New Procedure for Activity Cost Rate Calculation

The activity cost rate consists of three components: committed cost rate, flexible cost rate and production administration cost rate. The committed cost rate is calculated by dividing the sum of depreaciations and leasing expenses of machines, general depreciations of workshop and facility costs by the practical capacity of an activity. The flexible cost rate is calculated by dividing the sum of electricity and overhead costs (incl. WC-costs) of a workshop by the budgeted capacity of an activity. The production administration cost rate for one's part is calculated by dividing the sum of production administration costs by the total machine hours of Rautpohja or Ikola facility. Two production administration cost rates need to be calculated, one for Rautpohja and one for Ikola.

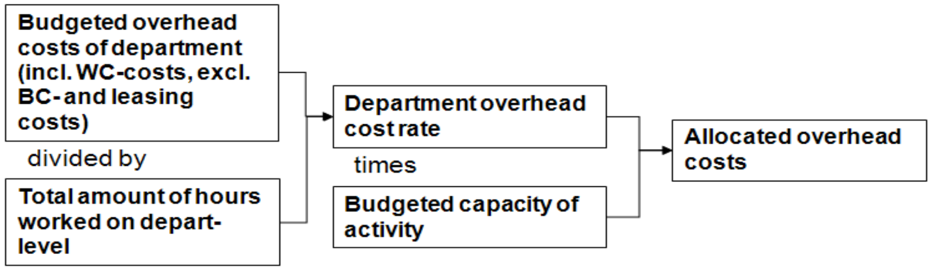



**Figure 24.** Procedure for Allocation of Overhead Costs

Figure 24 presents the procedure for allocation of overhead costs. A similar procedure is used also in allocation of general depreciations of workshops. The procedure is also similar to the current practice presented in chapter 3.1. The blue-collar and leasing costs are excluded from department overhead costs to avoid double allocation of these costs. The electricity cost rate is defined with a similar procedure as in the process-based model (see figure 19 on page 82). If standard cycle time –based model is not used at hardening departments, the electricity costs can be allocated between hardening departments and other production according to the measured power consumption of hardening departments.

The facility cost rate is defined with a procedure presented in figure 20 on page 82. The only difference is that the facility cost is calculated on an activity-level instead of process level. If all activities or machines of workshop occupy approximately same sized areas, the area can be defined by dividing the total area of the workshop by the number of activities performed at the workshop.

The determination of practical capacity is important in activity-based model. The target capacity for constraining or expensive machines is 6100 hours a year per machine in a four-shift system. This capacity should be used as practical capacity in calculation of committed cost rate and in reporting of idle capacity. The practical capacity can however be set to any level desired and it is also possible to use lower practical capacity for nonconstraining activities. The practical capacity of nonconstraining activities is usually determined at the level of activity that is needed when the manufacturing process is running at full rate. The product mix however affects the demand for nonconstraining activities and thereby the practical capacity of nonconstraining activities changes continuously according to the changes in product mix and it is very difficult to get reliable information on idle capacity. The simplest and most feasible concept is to use 6100 hours a year per machine as practical capacity for each activity.

### 7.4 Assessment of Activity-Based Model

The operational principle of activity-based model is quite similar to the current system. The basic concept of activity-based model is therefore well tested and functional. The biggest differences in activity-based model are the reporting of idle capacity, grouping of resources as activities and adjusted procedure for unit cost calculation.

Despite the promoted simplicity and flexibility of TDABC theory, some limitations exist. TDABC model is most efficient in companies or divisions where the amount of substitutive resources that are able perform all the activities equally well (e.g. equally skilled clerks) is dominant. Therefore the activity-based model is basically more like ABC model with some features from TDABC.

The following features are seen as strengths of an activity-based model:

- reporting of idle capacity
- flexibility
- simple and functional operational principle.

The reporting of idle capacity has some significant benefits discussed in chapter 4.4. The activity-based model is much more flexible for changes and adaptations in production compared to the process-based model presented earlier. For example variations in routings can be handled quite well in activity-based model as large variety of routings already exists. The fundamental operational principle is quite similar to the current system and therefore the activity-based model is well understood and safe to implement.

The following features are seen as weaknesses of an activity-based model:

- reporting of idle capacity of production administration not possible
- possible inaccuracy in reporting of idle capacity caused by grouping of resources.

The cost factors that should be included in committed cost rate according to Kaplan & Anderson (2007a, 42) were listed in chapter 4.3 on page 41. In recommended procedure for calculation of committed cost rate, the blue-collar costs are not included in activity cost rate because blue-collar workers have their own unit cost rate. The costs of white collar workers are also not included, because these people are mostly administrative personnel whose capacity and idle capacity are difficult to define and therefore not very relevant. In reality only electricity costs can be classified as truly flexible and cost factors like tools, wages of workshop foremen and production administration costs are more like step costs that increase gradually as the level of activity increases. It would be extremely difficult to report the idle capacity of these step costs and therefore the idle capacity is only reported from depreciations, leasing costs and facility costs.

There may be a problem in reporting of idle capacity in certain cases if resources are grouped as activities instead of having individual unit cost rates. If an activity includes a machine that is more expensive and almost fully utilized along with supporting machine that has no depreciation and that is used once in a while. In these cases the practical capacity would be set as 12 200 hours a year (2x 6 100 h). Consider a situation in which the more expensive machine is used for 6 100 hours, and supporting machine is not used at all. If we consider only depreciations and the practical capacity of an activity is 12 200 hours a year as proposed, the system would report that half of the costs of an activity were not assigned to products. This issue is examined more carefully in chapter 8.3.

As a summary it can be stated that process-based model has more limitations and activity-based model can handle most of the problems of process-based model. The process-based model has its strengths and it can provide some pieces of information that the other model cannot. Fundamentally the process-based model gives an answer to the question “If we manufacture this product mix with out current equipment, how big share of the process costs does the specific product incur?", while activity-based model more like answers the question “How big resource consumption does the product incur in the long term?”. Based on the assessment of both models, the activity-based model seems to be more feasible for Moventas Wind.

# 8 DEVELOPMENT PLAN

## 8.1 Recommended Long-Term Solution

Several alternative models and concepts were developed in this study. This chapter puts together the most feasible parts of these models and concepts and summarizes the recommended long-term solution for Moventas Wind.

**Table 2.** Recommended Long-Term Solution

| Subject of Development | Recommended solution(s) | Notes |
|---|---|---|
| **Irrelevant hour reporting system** | Standard cycle time system, current kilogram-based system at hardening departments | Arrow Machine Track in productivity control at machining, Flexim system at assembly departments. See table 1 on page 75 |
| **Product costing** | Activity-based model | |
| Adjustments in unit cost rate calculation | New procedure for unit cost calculation | See figure 23 on page 89 |
| Handling of idle capacity | Practical capacity as denominator value for committed costs, reporting of idle capacity | See appendix 4 |
| Aggregation of resources | Substitutive resources grouped as activities | See appendix 3 |

The problem of irrelevant hour reporting can be solved by implementing OEE-based standard cycle time system in product costing. This, however, requires that Arrow Machine Track has to be implemented also at Rautpohja and other locations in order to stay in touch with the level of productivity. At assembly departments, the productivity control must be conducted by registration of reference hours with Flexim barcode reader. Standard cycle times can be applied at machining workshops, assembly departments and service assembly department. At machining workshops the standard cycle times are defined as suggested in chapter 6.2. At assembly departments the workshop managers should compare the stage times observed within Opex project with reference data acquired from Flexim system in order to find the times that best reflect the current level of productivity. At service assembly departments, the Flexim reference data and direct observing are the sources of standard cycle times. The difficulties in applying standard cycle time system at hardening departments were discussed in chapter 6.3. The benefits achieved through improved accuracy and uniformity of standard cycle times may not be worth extra effort, complexity and possible confusion of new approach. The model that is currently being implemented at both hardening departments seems adequate. The hour reporting can be stopped and the costs that are generated according to kilograms hardened incur so small error in costs of hardening that it does not affect the decision-making.

Considering the strenghts and weaknesses of process-based and activity-based models, the latter seems more feasible. The process-based model has some definite advantages over activity-based model, but it is also more rigid and vulnerable. Especially the changes in the bottlenecks and weak control over the processes might cause the process-based model to fail. The recommended long-term solution suggests that the procedure for activity unit cost rate calcuation should be as presented in figure 23 on page 89. The simplest way to define the practical capacities for calculation of idle capacity would be to calculate two unit cost rates and use 6 100 hours a year per machine as a denominator value in calculation of committed cost rate for each activity. It is important that idle capacity is reported if practical capacity is used as a denominator value. The grouping of resources can be implemented with relatively little effort. The procedure for implementation is presented in chapter 8.4 in short-term development plan.

## 8.2 Analysis on Unit Cost Rates

The aim of this study is to document the present state and introduce a development plan. Thereby the functionality of recommended long-term solution could not be observed in practice with strong market test presented by Kasanen et al. (1991). The confidence of decision-makers in recommended solution, that is, the weak market test, either could not provide reliable evidence on the accuracy of new cost information. The unit cost rates were calculated on both resource- and activity-level with new procedure presented in figure 23 on page 89, and the cost rates were compared with reference values of current model in order to validate the recommended procedure. The results are presented and analyzed in detail in the following paragraphs. The results of comparison suggest that with cost structure of Moventas Wind, the improvement in accuracy of production overhead and direct labor distribution has to be substantial in order to justify the extra effort needed in more accurate cost assignment.

The new procedure for material overhead calculation yields a material surcharge percentage that is about a half of the reference value. This means that in recommended solution more costs are assigned through production administration cost rate, facility cost rate and electricity cost rate according to the consumption of these resources. Rautpohja production administration surcharge is 26 percent lower than the reference value if it is calculated with recommended procedure. This mainly results from separation of real estate costs from production administration surcharge into electricity and facility cost rates. Material and production administration surcharges represent rather arbitrary allocations of overhead costs and therefore the accuracy is improved if less costs flow through these surcharges.

In recommended solution, the electricity cost that is charged per hour worked is equal to the current system. The benefit of the recommended solution is the possibility to treat electricity cost case-specifically because of the separate electricity cost rate for example in allocation of electricity costs of assembly and hardening departments. The problems identified in chapter 3.4 can be avoided if hours of assembly departments are excluded from calculation of electricity cost rate and no electricity costs are allocated to these departments. Correspondingly, the hardening departments can be charged with fair electricity cost. In analysis of unit costs, the resources of machining of housings –workshop received their electricity cost with a factor of 0,4 according to the lower power consumption of these machines. In reality, almost all machines have different power consumption, but for example a difference of 10 kW in power consumption incurs an error of only 10 percent in electricity cost rate. Electricity cost rate is not very significant cost factor and therefore it is more important to consider which activities should not be charged with electricity cost at all.

In current model, 84 percent of budgeted facility costs are allocated to the products, and facility costs are allocated between workshops according to the budgeted amount of hours worked. In recommended solution, the total area of Rautpohja or Ikola factory that is used in calculation of facility cost rate defines the amount of facility costs that are allocated to the products. The facility cost rates were calculated according to the recommended solution. A similar share of facility costs, 84 percent, was allocated to production in analysis of recommended solution in order to get comparable results. The effects of new procedure tested were as supposed. The facility cost per hour was decreased by roughly 50 percent at assembly departments. At product development center where relatively few machine hours are worked during the year, the facility cost per hour was almost four times higher than in current system. Generally the facility costs per hour were lower than in current system because practical capacity was used as a denominator value in calculation of facility cost rates and logistics function of Rautpohja was also charged for occupancy of facilities.

The effects of using different denominator values in calculation of activity cost rates at ring wheel workshop are illustrated in appendix 3. If practical capacity is used as a denominator value in calculation of committed cost rate and budgeted capacity is used in calculation of production administration and flexible cost rates (see figure 23 on page 89), the activity cost rates are generally 1-30 percent lower than in the current system. The difference is naturally biggest with resources that have high depreciations or leasing expenses or lower budgeted level of utilization. If only practical capacity would be used as a denominator value in calculation of activity unit cost rates, the unit cost rates would drop significantly as illustrated in second column in appendix 3.

The costs of hardening are calculated per kilogram hardened in current system. The time needed to harden a certain component correlates quite well with the weight of a component. In reality, the hardening time correlates with hardening depth, but the hardening depth correlates quite well with weight of a component. The hardening times of certain components were thereby examined in this study. It was found that in hardening of planet wheels, the error is less than 20 percent if kilograms are used instead of standard cycle times in definition of hardening costs.

### 8.3 Cost Effects and Relevance of Cost Information in Recommended Solution

Production overhead forms a relatively small share in total costs of a wind turbine gear. Therefore even significant changes in amount of assigned production overhead cost usually change the total cost of a gear unit by only few percent. The effects of recommended solution in product costs are analyzed in this chapter.

The unit cost rates were calculated for each activity. It was found that the error caused by grouping of resources is in most cases totally neglible. More error will probably be caused in estimation of budgeted expenses. An extreme case in which an activity includes machines that have big differences in level of utilization and in depreciations or leasing expenses was also examined. It was found that the error in production overhead costs is only around 10 percent, but in cost of idle capacity the error may be dozens of percent. However, these extreme cases are very uncommon and in majority of activities there are not any problems. This issue does not affect the reporting of idle capacity in a larger scale and therefore it does not prevent the grouping of resources.

Table 3 summarizes the results of analysis that was carried out to estimate the effects of recommended solution on costs of goods sold. Four different cases were compared with current system and the results are presented as percentage more (+) or percentage less (-) than in the current model. Five components of two high volume products were used in analysis. The components examined are key components of a gear unit and they form a significant share of total costs.

**Table 3.** Effects of Recommended Solution in Production Overhead and Labor Costs

| | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|
| | TARGET Cycle times, 2009 unit costs with current cost rate calculation procedure without grouping | | Current Cycle times, 2009 unit costs with current cost rate calculation procedure without grouping | | Estimated cycle times from 2008 simulator, 2009 unit costs with new cost rate calculation procedure with grouping | | Current cycle times, 2009 unit costs with new cost rate calculation procedure with grouping | |
| **Component** | **Labor** | **Prod. OH** | **Labor** | **Prod.OH** | **Labor** | **Prod.OH** | **Labor** | **Prod.OH** |
| **Hollow shaft 1,5 MW** | -33,6 % | -28,4 % | -14,2 % | -14,1 % | 0,0 % | -0,7 % | -14,2 % | -14,8 % |
| **Ring wheel 1,5 MW** | -12,5 % | -10,9 % | -5,2 % | -4,2 % | 0,0 % | -0,3 % | -5,2 % | -4,5 % |
| **Ring wheel 2 MW** | -11,8 % | -10,3 % | 8,2 % | 5,2 % | 0,0 % | -0,4 % | 8,2 % | 4,7 % |
| **Planet wheel 1,5 MW** | -6,6 % | -4,0 % | 16,2 % | 14,1 % | 3,7 % | -7,0 % | 16,2 % | 7,1 % |
| **Housing 1,5 MW** | -20,0 % | -23,6 % | -16,7 % | -19,7 % | 0,0 % | 6,4 % | -16,7 % | -15,5 % |

Target cycle times are the cycle times that development engineers have set as targets for year 2009. Current cycle times are the average cycle times that development engineers have acquired from Lean system. Estimated cycle times are the cycle times that are currently used in product costing and profitability analysis in simulator presented in chapter 3.3.

The current cost rate calculation procedure is the current practice presented in figure 4 on page 17. New cost rate calculation procedure is the recommended procedure for unit cost rate calculation presented in figure 23 on page 89. All unit costs were calculated with budgeted costs for year 2009. Without grouping means that individual cost rates are calculated for each machine. With grouping means that resources are grouped as activities instead of calculating individual unit cost rates for each resource.

Case one examines the effects of using target OEE-percents in definition of standard cycle times. The results suggest that especially the direct labor costs would drop significantly. As target cycle times do not reflect the current state of productivity, they should not be used as standard cycle times. Case two examines the effects of using current average cycle times in product costing. The results show that the estimated cycle times of simulator are higher on some components, but the current cycle times are also higher on some components. Case three keeps the cycle times constant and evaluates the effects of using the recommended procedure and activity structure for activity unit cost calculation. The results show that the grouping of resources and the new procedure for unit cost calculation have very low impact on direct labor and production overhead costs.

Case four represents the recommended long-term solution. The results show that if recommended solution is implemented, the production overhead costs of most products would slightly decline. This results mainly from implementation of idle capacity reporting. The cycle time seems to be the most crucial component in product costing. The accuracy of unit cost rates would be slightly better if recommended solution is implemented, but the biggest benefits would be in reduced nonproductive work and in improved accuracy of standard cycle times. Because of material-intensive cost structure of a gear unit, a change of ten percent in production overhead cost would change the total costs of a gear unit by only 1-2 percent. Even the faults in current allocation of electricity and facility costs cannot incur significant errors in total costs of a gear unit. In previous chapter, the change in electricity cost per hour was found to be as much 50 percent at some departments. A change of 50 percent in electricity cost rate of certain department will however change the total cost of a gear unit only marginally. Therefore the rationality of more accurate allocation of facility and electricity costs should be considered. The cost accounting system of Moventas Wind is not sensitive for errors in allocation of overhead costs because of the cost structure, but also because almost all products go through mainly the same stages of work and therefore the errorneous distribution of overhead costs effectively levels out.

The principles of relevance of cost information were discussed in chapter 5.2. Also the recommended long-term solution produces cost information that has to be interpreted case-specifically. In recommended model, the idle capacity will be reported if standard cycle times are exceeded or there is not enough work to employ a full capacity. People using the cost information should be aware of this twofold meaning of idle capacity. The idle capacity is also assigned to single work ids, but the idle capacity cost does not describe the resource consumption of a work id in question. The amount of idle capacity should rather be controlled on a department- or activity-level. The follow-up on item-level is also possible, but this piece of information has rather low significance.

If OEE-percent of a certain activity has improved, the standard cycle time must also decrease. This means that the product receives less cost because of improved efficiency. On the other hand this means that more products have to be processed through the whole manufacturing process or the supply of resources has to be decreased in order to avoid the growth of idle capacity and gain cost savings.

It should be considered case-specifically which costs are relevant for example in make-or-buy decisions or in assessment of profitability of new orders. If for example the decision to accept an order has no effect on depreciations, leasing costs or direct labor costs, these costs are sunk and therefore irrelevant in decision-making. If the company has idle capacity, the cost of manufacturing a subcontracted component in house is no more than the cost of material plus truly flexible costs such as electricity cost and auxiliary materials.

## 8.4 Short-Term Development of Cost Accounting

Some elements of the recommended long-term solution require moderate effort and need time in order to be implemented effectively. The modifications of Lean system, collation of standard cycle times and communication of new practices all take their time. Even though the focus of developing the cost accounting should be on subjects presented earlier, some short-term improvement acts can be carried out meanwhile. This chapter presents some guidelines how the present cost accounting system could be fine-tuned without changing the fundamental solutions of current model.

**Table 4.** Short-Term Development Proposals

| Subject of Development | Recommended solution(s) | Notes |
|---|---|---|
| **Irrelevant hour reporting system** | Revision of variances in current system | |
| **Product costing** | Activity-based model | |
| Adjustments in unit cost rate calculation | New procedure for unit cost calculation, adjustments in cost centers of production administration personnel | See figure 23 on page 89 |
| Handling of idle capacity | Budgeted capacity as denominator value, development of simulator | |
| Aggregation of resources | Substitutive resources grouped as activities | See appendix 3 |

The biggest problems of present cost accounting system lie in hour reporting and product costing practices (see chapter 3.4). Flexim access control system provides accurate information on the amont of presence hours because of its connection with the payment of wages. The amount of Flexim hours should be compared with hours reported in Lean system and the variance should be revised with responsible workshop managers. Some possible reasons for variance were found in conversations with workshop managers (see chapter 3.4). If present hour reporting system is used, the use of Flexim bar-code reader has to be examined carefully especially in situations an employee changes department or machine he operates with, becomes ill or otherwise is unable to control his reporting. It should also be examined whether the reporting method affects the amount of erroneous hours registered. It is possible that the blue-collar workers are unable to input their hours correctly into the Lean system in complicated situations like in cases they have concurrently operated several machines. The instruction of new workers and trainees is also important in maintaining the reliability of hour reporting system and it should be made sure that every worker has a technical possibility to register his hours into the Lean system if he is asked to do so. The hour registering discipline also has to be kept on an acceptable level despite the fact that it is difficult to get precise cost information according to the hour reporting of blue-collar workers as long as there are not any real incentives of compulsion.

The new procedure for activity unit cost rate calculation can be implemented without a need for any major changes. The proposed procedure (figure 23 on page 89) slightly improves the accuracy of hour rates and it can be implemented at least partially in the short term. The areas and electricity consumption factors are the only pieces of information needed in implementation of this new procedure. The practical capacity of recommended long-term solution can be replaced with budgeted level of activity if hour reporting system is not changed. If substitutive resources are grouped, new resource ids has to be established into the Lean system. This however does not mean that any major changes have to be made to the current way of action, so the grouping of resources can be implemented relatively easily. The new formula for calculation of material surcharge is also easy to implement. The inclusion of freight costs of purchased components does not have a significant impact on material surcharge but it also requires very little effort.

There are few white-collar workers at production of geared components in certain cost centers that serve the whole production of geared components. At the moment these personnel in vain lift only the unit cost rates of cost center they are assigned to. These administration personnel could form their own cost center in a same way as assembly management does.

The simulator can also be improved with little effort. Even though the reporting of idle capacity would not be performed in Lean system, the simulator can be used in estimation of costs of idle capacity for forthcoming year. There should also be an opportunity to observe product costs according to new procedure presented in figure 23 on page 89. If machines are grouped as activities, activity RESIDs can be input to the simulator and annual loads of activities can be examined and bottlenecks can be detected. The simulator can also provide various other pieces of information, for example gross profit per bottleneck hour used –ratios for each gear type, if bottlenecks are known.

# 9 CONCLUSIONS

The aim of this study was to document the present state of activity-based costing at Moventas Wind and to create a development plan. The development plan consists of short- and long term development proposals. The recommended long-term solution was presented in chapter 8.1 and short-term development proposals were presented in chapter 8.4. Seven features were set as requirements for long-term solution in chapter 1.2 on page 2. The results of this study are evaluated in the following according to these requirements.

The cost structure of a wind turbine gear and the needs for cost information set a framework for definition of optimal accuracy level. It has to be remembered that the most accurate cost system usually is not the best one. Chapters 8.2 and 8.3 evaluate the accuracy of recommended long-term solution, which is, the construction of this study. It can justifiably be said that the recommended long-term solution better follows the principle of causality for example in allocation of electricity and facility costs. However, the benefits of new procedure in activity cost rate calculation were not as big as it was supposed. The recommended long-term solution eliminates the need for hour reporting on most departments and thereby reduces the amount of nonproductive work needed. Activities are also grouped into activities and less unit cost rates need to be calculated when the system is updated. Therefore the recommended long-term solution incurs less nonproductive work than the current system. The recommended long-term solution also makes possible the estimation of costs in advance. This could also be done with current system, but if reporting of idle capacity is included in simulator, the controllers are able simulate the costs of goods sold but also costs of idle capacity with various levels of activity. The recommended long-term solution also motivates for improvements in productivity as the amount of idle capacity caused by exceeded standard cycle times is visible, and it urges on increasing the throughput rather just shortening the cycle times. The recommended long-term solution also satisfies the last three demands of uniformity, scalability and documentation presented in chapter 1.2.

The following issues are the key results of this study:

- documentation of problems in current cost accounting system
- concept of standard cycle time system with OEE-based data and reporting of idle capacity
- adjustment and validation of company's current unit cost calculation procedure.

The evaluation of current cost accounting system along with documentation of problem areas are the most important benefits of this study for Moventas Wind. Taking into consideration the complexity and limitations of real world, it seems obvious that the company cannot implement any of the models introduced as such. Larger modifications always take time and cost money and in current economical situation they might be difficult to conduct. Some of the concepts presented may be easier to implement later if for example company's ERP system offers some new features. The short-term development proposals can however be put into practice easily and the company now has an extensive appraisal of problems of its current cost accounting system together with several well-prepared models for long-term development of cost accounting. The recommended long-term solution along with other models presented provides understanding of the strengths and weaknesses of these new models and this master's thesis can act as a manual if some of the models presented will be implemented later. Some of the short-term proposals presented in this study are already implemented and most problem areas presented are under consideration.

The most important research contribution of this study is the evidence of possibilities to integrate overall equipment efficiecy and other lean manufacturing tools with standard cycle time –based activity-based costing system in order to increase the accuracy of time estimates and provide a common language between production and accounting personnel. The applicability of time-driven activity-based costing in manufacturing companies of mechanical engineering was also evaluated. It was found that it can be used, but the benefits are not as substantial as for example in labor intensive companies. The TDABC is less beneficial because of company's specialized resources that form their own activities and need individual unit cost rates. The level of aggregation of resources in defining the unit cost rates was also in a vital role in this master's thesis. It was found that at the moment, the processes cannot have single process-specific unit cost rates because the capacities of processes would be very difficult to define as the bottlenecks vary according to the changes in the product mix.

Some extra evidence was also found about the design of cost management systems in mechanical engineering companies like Moventas Wind. As the material costs dominate, the estimation of purchase prices in advance is essential in estimation of product costs. The cost accounting system should incur as little nonproductive work as possible and still report the costs roughly right. One ABC software was examined as part of this study. It was found that there are not any superior features in this ABC software that would benefit Moventas Wind so much that it would justify the implementation of an expensive separate system instead of using company's current enterprise resource planning system for cost accounting purposes. The problems in reporting the idle capacity in enterprise resource planning system without ABC module in environment of mechanical engineering were also examined and the reporting was found to be possible (see also Paranko 1996; Sievänen & Tornberg 2002).

Other companies encountering the same problems can utilize the findings of this study in design of their cost accounting system. Lean manufacturing ideology is receiving growing popularity also in Finland and the utilization of information of lean tools in cost accounting can prove to be functional also in other companies. The findings of this study however have to be evaluated cautiously and they have a limited applicability because implementation of recommended solution could not be carried out as a part of this study. Therefore this study lacks the practical evidence on functionality of recommended long-term solution.

The scope of a master's thesis is always limited and some interesting topics for further development of cost accounting of Moventas Wind arose during this study. The development of cost accounting and pricing in service business might be beneficial especially if the volumes keep growing. Time-driven activity based costing could be suitable for more accurate costing of service business, and there might also be possibilities for wider utilization of activity-based management at Moventas Wind. It would also be interesting to examine the practical applicability of lean accounting principles in mechanical engineering companies pursuing mature lean manufacturing.

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**APPENDIX 1.** Hour Reporting Variances at Hollow Shaft Workshop (1-9/2008)

| BC-Worker | Hrs in Flexim | Hrs in ERP | Difference | % Less in ERP | Productive hrs | Nonproductive hrs |
|---|---|---|---|---|---|---|
| 1 | 877 | 848 | 29 | 3,32 % | 848 | 0 |
| 2 | 1 058 | 1135 | -77 | -7,25 % | 1 088 | 47 |
| 3 | 1 195 | 629 | 566 | 47,38 % | 629 | 0 |
| 4 | 618 | 144 | 474 | 76,68 % | 144 | 0 |
| 5 | 1 160 | 1672 | -512 | -44,15 % | 1 639 | 33 |
| 6 | 723 | 1101 | -378 | -52,38 % | 1 101 | 0 |
| 7 | 1 005 | 1043 | -38 | -3,73 % | 1 027 | 16 |
| 8 | 740 | 725 | 15 | 1,98 % | 606 | 119 |
| 9 | 961 | 966 | -5 | -0,56 % | 891 | 75 |
| 10 | 973 | 910 | 63 | 6,43 % | 853 | 57 |
| 11 | 964 | 919 | 45 | 4,66 % | 917 | 2 |
| 12 | 1 060 | 580 | 480 | 45,26 % | 580 | 0 |
| 13 | 928 | 988 | -60 | -6,48 % | 965 | 23 |
| 14 | 705 | 733 | -28 | -3,96 % | 656 | 77 |
| 15 | 981 | 1022 | -41 | -4,14 % | 969 | 53 |
| 16 | 418 | 334 | 84 | 20,05 % | 321 | 13 |
| 17 | 1 168 | 1290 | -122 | -10,47 % | 1 263 | 27 |
| 18 | 949 | 937 | 12 | 1,27 % | 922 | 15 |
| 19 | 737 | 625 | 112 | 15,22 % | 589 | 36 |
| 20 | 1 288 | 1677 | -389 | -30,18 % | 1 615 | 62 |

**APPENDIX 2.** Cost Centers for Year 2009

**RAUTPOHJA**
RAU Real Estate
RAU OPE Management
RAU Assembly Mgmt
RAU Logistics
RAU Purchase
RAU Quality
RAU Pinions&service
RAU Pre-machining
RAU Hardening
RAU Ring wheels
RAU Hollow Shaft
RAU Machining of Housings
RAU Assembly, Tekno
RAU Assembly, Syrjälä
RAU Service assembly
RAU Assembly, Laaksola

**IKOLA 1**
IKO1 New personnel
IKO1 Soft Machining
IKO1 Hardening
IKO1 Hard Machining
IKO1 Assembly
IKO1 Test run
IKO1 Purchasing

**IKOLA 2**
IKO2 New personnel for OPE support
IKO2 New Factory Project mgmt
IKO2 Soft Machining
IKO2 Hardening
IKO2 Hard Machining

**SUPPORT**
WG Management
Finance
ICT
Human Resources
WG Engineering
WG RTD
WG Product Development Center
Logistics Center
Machining, Tourula

**IKOLA GENERAL**
IKO Real Estate
IKO OPE Mgmt
IKO Logistics
IKO Quality

**SALES**
WG Capital Sales
WG Service Sales
WG Service Spain
WG Service Wuppertal

**APPENDIX 3.** Effects of Different Denominator Values in Unit Cost Rates

| Practical capacity as denominator value in committed costs | Practical capacity as denominator value in total costs |
|---|---|
| Diff. compared to current system | Diff. compared to current system |
| 2,86 % | 13,81 % |
| 3,11 % | 13,33 % |
| 3,08 % | 13,39 % |
| 2,29 % | 14,94 % |
| | |
| 12,79 % | 20,11 % |
| 2,97 % | 13,59 % |
| 2,99 % | 13,56 % |
| 1,74 % | 16,01 % |
| 4,10 % | 11,37 % |
| 28,92 % | 33,06 % |
| | |
| 4,72 % | 14,90 % |
| 4,14 % | 11,30 % |
| 1,74 % | 16,01 % |
| 1,74 % | 16,01 % |
| 3,69 % | 12,19 % |
| 2,29 % | 14,94 % |
| 12,57 % | 20,75 % |
| 2,96 % | 13,62 % |

**APPENDIX 4:** ARROW Machine Track Machine Monitoring System