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The Effect of Creasing Method and Tooling on the Geometry of Formed Creases in the Creasing Process of Coated and Uncoated Paperboard

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Abstract. Creasing is a method, which is used to produce grooves in fibre-based materials, such as multi-layer paperboard or composite materials such as polymer-coated multi-layer paperboard. These grooves act as folding lines, which guide and control the subsequent folding of the material. The formation of creases is crucial for the functionality of produced blanks in subsequent processes, such as press-forming where the creases have an effect on the formability of materials. The plastic deformation and geometry of creases for polymer-coated and uncoated multi-layer paperboard were investigated using two different creasing processes, flatbed die cutting and a digital creasing and cutting table with a creasing wheel. The presence and dimensions of the creasing grooves were varied to investigate the effect on the formed shapes. A wide area 3D measurement system was used to analyse and measure (Figure 1) the dimensions of the formed creases. The analysis occurred in machine-direction (MD) of the fibre-orientation in the formed materials. The results show that that the used process and tool selection has a clear effect on the formed shapes.

1. INTRODUCTION

Creasing is a method, which is used to produce grooves in fibre-based materials, such as multi-layer paperboard or composite materials such as polymer-coated multi-layer paperboard. Creasing is utilized in many paperboard-packaging applications to control the folding of the material in subsequent processes, such as folding or press-forming [1, 2] Fiber-based materials have a tendency to wrinkle and in addition to the controlling of the folding, the creasing is done to prevent uncontrolled wrinkling. Previous work to investigate the creasing process related to 3D-forming of paperboard has studied different factors, such as durability of bio-coatings in creasing [3], tool dimensions [3, 4] and effect of creasing pattern design [5]. In creasing and folding recent studies have been published both regarding the numerical and experimental studies of creasing [6-7].

Previous works have showed that the creasing process has a great effect on the following processes and that there are differences in the behavior of creases between flatbed die cutting and digital cutting and creasing processes, which utilize different mechanisms to achieve the creasing pattern on the flat material sheets. The aim of this paper was to manufacture and analyse creases manufactured with these two processes using varied creasing groove widths to clarify these differences.

2. MATERIALS AND METHODS

In this chapter, the used materials and the methods are introduced. A commercial paperboard with and without polymer coating was used in the experiments.

2.1 Materials

The used substrates were Stora Enso (Finland) Trayforma Performance 350 + 40 (uncoated) and Trayforma Performance (coated) 350 + 40 WPET. The material is a paperboard with a base material grammage of 350 g/m². The coating layer was a polyethylene terephthalate (PET) extrusion coating with a grammage of 40 g/m². The baseboard consisted of two solid bleached sulfate (SBS) layers with a chemi-thermomechanical pulp (CTMP) layer between them. The main component of the substrate was hardwood fiber with alkyl ketene dimer (AKD) hydrophobic sizing additive. The fiber dimensions of the paperboard were measured using an L&W Fiber Tester (ABB, Stockholm, Sweden). The fiber length, fiber width, and kink index were measured at 1.1 mm, 22.5 μm, and 1.13, respectively. The thicknesses of the materials were 475 μm for the coated material and 460 μm for the uncoated material.

A constant humidity chamber was used to store the materials at 80 % relative humidity (RH) to ensure adequate humidity and to obtain the desired moisture content for the fiber-material. The moisture content was measured with a moisture analyzer (Adams Equipment PMB 53, New York, USA). The measured moisture content of the materials was approximately 7.1 %.

2.2 Methods

The forming of the creases was done by two processes: flatbed die cutting and a digital cutting and creasing table. The flatbed die cutting process cuts and creases the material in one single work phase, where the material is cut using sharp cutting knives and creased using creasing rules which have rounded edges. In flatbed die cutting these rounded creasing rules indent the board surface and push it into a creasing groove on the other side of the paperboard [8]. The used creasing pattern (Figure 3) was a typical blank pattern for press-forming of paperboard. Figure 1 shows the principle and the main dimensions of the creasing tools in the creasing process in a flatbed die cutting machine.

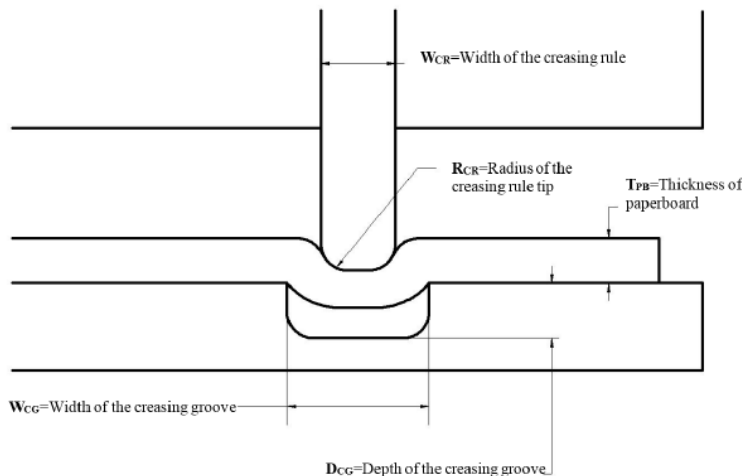


FIGURE 1. The principle of creasing and main dimensions of the creasing tools in a flatbed die cutting machine [2].

The used dimensions of the creasing tools were W_{CR} 710 μm , R_{CR} 341 μm and D_{CG} 500 μm . W_{CG} was varied between 1400 μm and 1700 μm . The creasing grooves were machined into steel plates (Figure 3b). The upper die cutting tool is shown in Figure 3a. The total used creasing force was 120 N / 10 mm of creasing rule.

In the digital cutting and creasing table, the creasing was done using a creasing wheel shown in Figure 2. A commercial digital cutting and creasing table (Kongsberg XE-10, Kongsberg, Norway) was used. The creasing wheel width was identical to the W_{CR} of the flatbed die cutting machine, 710 μm . The creasing was done with creasing grooves cut into paperboard as a matrix (Figure 3c), and without creasing grooves. The used creasing force was set to 200 N and the creasing roller diameter was 26 mm. The table was equipped with a PVC underlay with suction to hold the material in place during the creasing and cutting operations.

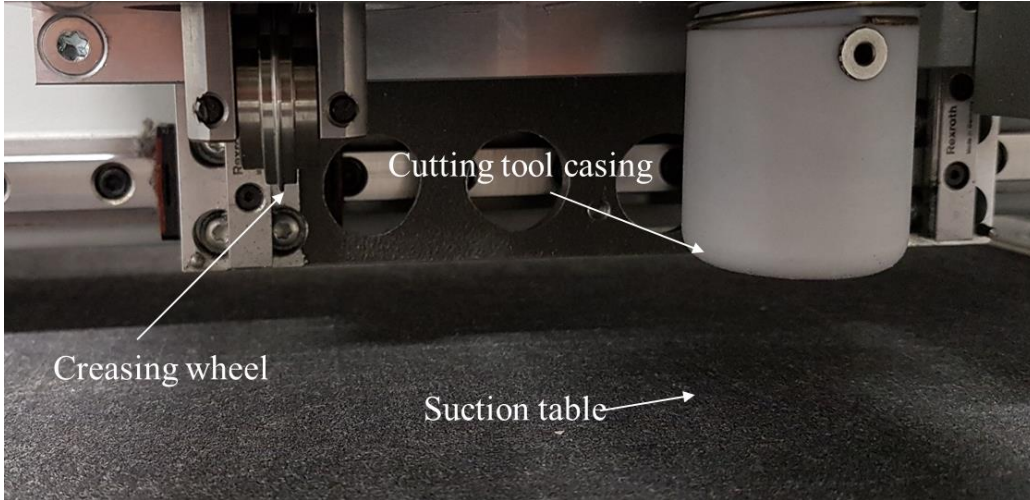


FIGURE 2. The creasing wheel, cutting tool casing and suction table in the digital cutting and creasing table, modified from [4].

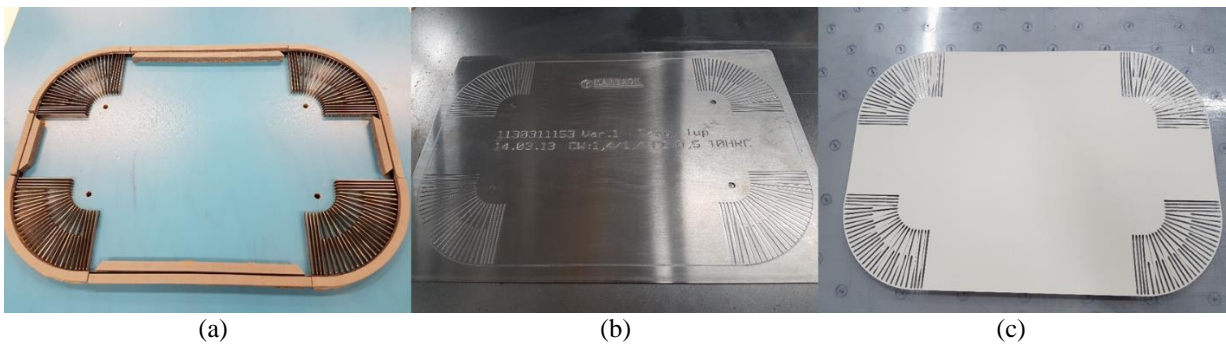


FIGURE 3. (a) The upper die cutting tool, (b) The steel creasing matrix, (c) Paperboard creasing matrix. The size of the samples was 319.3 x 216.3 mm.

The creased samples were analysed using a wide area 3D measurement system (Keyence VR 3200, Itasca, USA) in machine direction (MD), cross direction (CD) and at 45° angle, but for the sake of clarity and for the fact that the effect of fibre-orientation has been widely researched earlier, the analysis will focus in MD. The measurements were performed on the top and bottom side of the creases. An example of a sample measurement is shown in Figure 4. The measurements were performed on 12 creases per parameter.

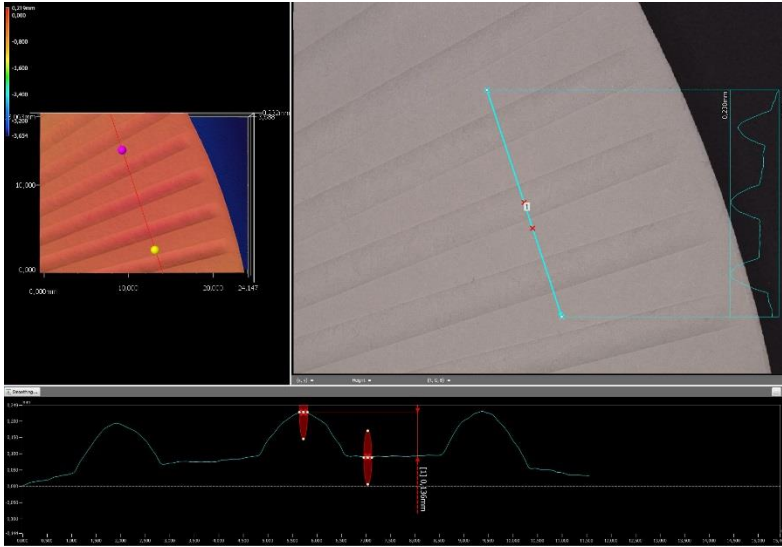


FIGURE 4. An example of the measurement of creases in the wide area 3D measurement system.

RESULTS AND DISCUSSION

Figure 5 shows the average crease heights on the backside of the uncoated material in MD. The backside shows how the shape is transferred through the material.

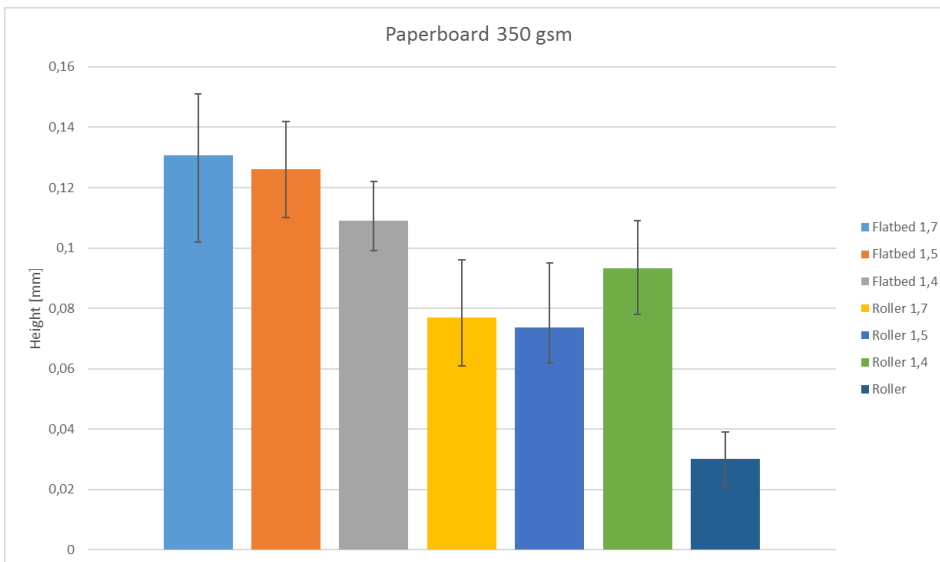


FIGURE 5. Height averages of the creases in the backside of the uncoated material with a thickness of 460 μm .

A few things can be seen from Figure 5. Firstly, the used die cutting method has a clear effect on the height of the creases. Flatbed die cutting resulted in higher values with every toolset. Secondly, it can be clearly seen that with the creasing roller without a matrix under the creased material the shape of the formed creases is significantly lower than when a matrix is used. The height of the creases seems to correlate with the width of the creasing groove, but these differences were inside the variation in the samples.

The average crease heights on the backside of the coated material in MD are shown in Figure 6, which shows similar behavior between the different methods; again, the flatbed die cutting resulted in higher values. It can be also seen that the coating did not have a significant effect on the creasing result.

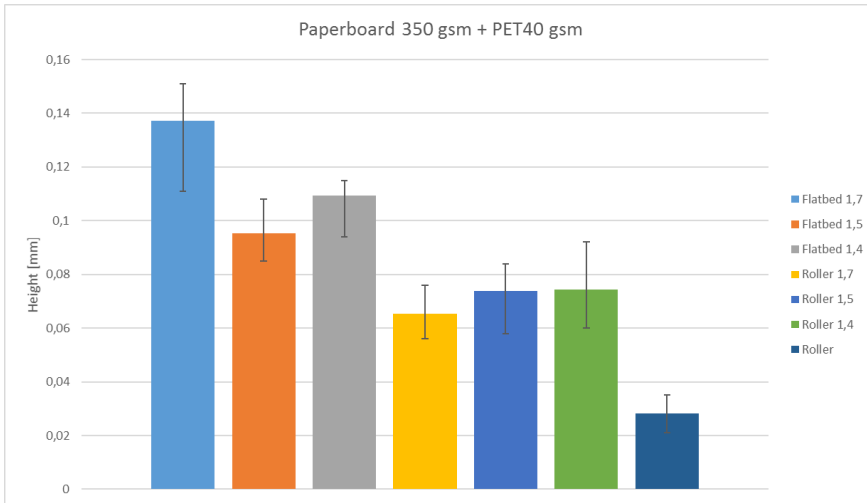


FIGURE 6. Height averages of the creases in the backside of the coated material with a thickness of 475 μm .

The results and the geometry of the formed creases were also analysed from adjacent creases (Figure 7).

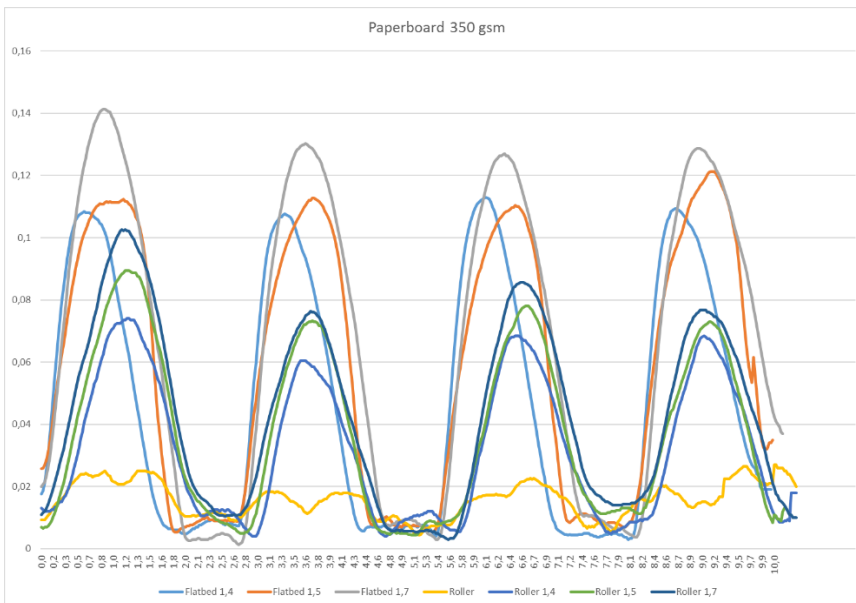


FIGURE 7. Average geometries of four adjacent creases in the backside of the uncoated material with a thickness of 460 μm . The values are in mm.

Figure 7 shows a clear correlation between the used method and the used creasing groove dimensions. It also shows that the creases manufactured with the creasing roller without a matrix have an undefined geometry compared to other samples. This result is most likely caused by the rigid PVC underlay, which prevents the material from assuming a clear form on the backside of the material. Therefore, a measurement on the topside of the creased material was performed to analyse the geometry. The results of this measurement are shown in Figure 8. From Figure 8 it can be seen that the shape is much more defined on the side of the actual crease. Again, it is clear that the wider creasing groove results in a deeper crease.

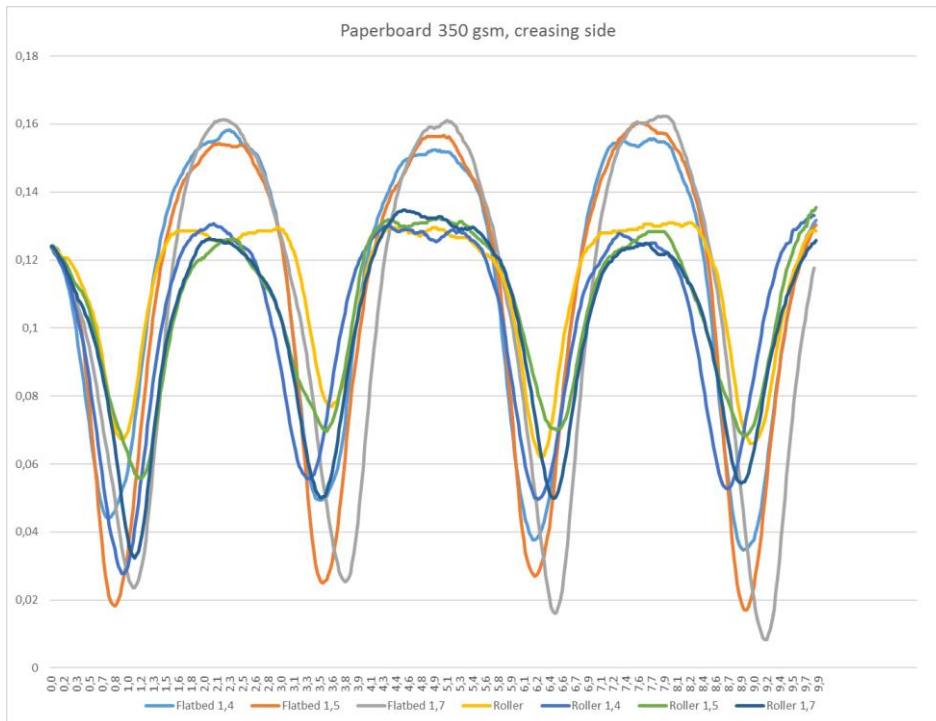


FIGURE 8. Average geometries of four adjacent creases in the creasing side of the uncoated material with a thickness of 460 μm . The values are in mm.

CONCLUSIONS

The scope of the work was to analyse creases manufactured with two separate methods with varied tool dimensions. The results show that the used creasing method and tooling has a clear effect on the geometry of the formed creases in polymer-coated and uncoated multi-layer paperboard. Flatbed die cutting resulted in larger height of the creases and a more defined geometry on the backside of the material, compared to a digital cutting and creasing table using a creasing roller. A wider creasing groove resulted in higher creases with both methods. The presence of polymer coating did not have a significant effect on the results. The use of a creasing matrix when using a creasing roller in a digital cutting and creasing table is recommended, if a well-defined geometry on both sides of the material is desired.

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