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INFLUENCE OF LUBRICANT VISCOSITY ON THE SURFACE ROUGHNESS OF PEHD AND PVC PLASTIC SHEETS IN SINGLE POINT INCREMENT FORMING PROCESS

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ABSTRACT

The aim of this work is to study the influence of different oil lubricant on the surface roughness of polymer material by single point incremental forming process (SPIF). In this research incremental forming work were performed on polyethylene (PEHD) and polyvinylchloride (PVC) sheets to create a cone shape. Roughness was studied by different variables (oil lubricant, tool diameter, spindle speed and feed rate). From this study, it was found that the surface roughness was improved as oil viscosity, tool diameter, spindle speed and feed rate increases. Also it was the surface roughness as a function of parameters (tool tip diameter, lubricant viscosity, spindle speed and feed rate) are fitted with Weibull model at fully correlation coefficient 100 % and zero standard deviation for polyethylene (PEHD) and polyvinylchloride (PVC) materials.

Keywords: ***Single point*** **incremental forming (SPIF), polymer sheets, tool diameter, speed, federate, oil viscosity**.

1. INTRODUCTION

Incremental Forming is a new process that is development. Its applicability is wide because it allows the obtaining functional sheet material parts without higher costs. Due to this feature, areas such as biomechanics rapid prototyping and customization features of products this process make a target of interest. In this process, a spherical head tool is used and tool path is controlled by CNC milling machine. The process carried out on a conventional CNC machine and the sheet material is usually fixed in the horizontal plane on the fixture.

The main advantage of incremental forming it's punches and dies can be avoided(dieless process), design changes can be easily and quickly performed [1].The main factors effect on the process, like sheet material thickness, tool diameter, spindle speed, feed rate and type of lubricant used.

Le, et al. (2008) [2] studied the effect of (tool radius, spindle speed and step size) on the formability of polypropylene (PP) sheet. They found that the formability increase as the increase together (step size & spindle speed), (tool radius & step size) and (spindle speed & tool radius).

Silva, et al. (2010) [3] studied the effect of (sheet thickness, feed rate and forming tool diameter) on the formability of polyvinylchloride (PVC) sheet. They found that the formability increase as the sheet thickness, tool diameter and feed rate increases.

Durante, et al. (2010) [4] presents a model to compare between the analytical and the experimental values of the surface roughness of a pyramid shape component. They found that the surface roughness decreases as the tool diameter increase.Hamilton, (2010) [5] studied the effect of oil-based lubricants with different kinematic viscosity to study their influence on the internal and external surface roughness of an oval shape. He concluded that the cutting fluid emulsion used as lubrication was not the best choice for creating a smooth interior surface.

In this work incremental forming experiments

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will be performed on polyethylene (PEHD)and polyvinylchloride (PVC) polymer sheets to form a cone shape. Surface roughness will be studied at different four parameters (tool diameter, spindle speed, feed rate and oil type).

2. EXPERIMENTAL WORK

The aim of the experimental work is to study the using ofoil on the surface roughness of polyethylene (PEHD) and polyvinylchloride (PVC) polymer sheets during the single point incremental forming process. To do so; a clamping arrangement was designed and manufactured. The experimental set-up comprising of polyethylene polyvinylchloride (PVC) polymer sheets (200*200*5 mm).The mechanical properties are listed in Table (1). Holes were drilled at the edges of the sheet to hold it in the fixture as shown in Figure 1.

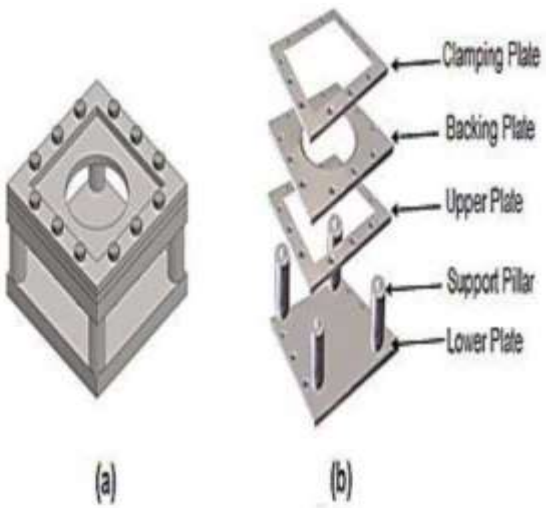

Fig. 1: Clamping Arrangement, a-Assembled b-Disassembled

Table (1) Mechanical Properties of Plastic Sheets

Polymer sheets	Ultimate stress (mm^2)	Elongation (%)
PEHD	18	60
PVC	60	40

A "TX 32" CNC milling machine was used to carried out the work. The fixture was fixed to the machine table as shown in Figure 2. The forming tool was a carbon steel (30-HRC) with spherical tip. Four different tools were used with tip diameter of (14, 16, 18, and 200 mm) as shown in Figure 3.four different oil lubricants were used in this work (7701, organic oil, 144 mg and HD 50) oil lubricant properties are listed in Tables 2.

Fig. 2 Fixture Mounting

Fig. 3 Forming Tools

Table 2 Properties of oil lubricant

Oil Types	Viscosity (Pa.sec) @ 40C°
7701	**15.37**
Organic oil	**70.18**
144 mg	**124.35**
HD 50	**140**

The cone base diameter was 80 mm and the depth was 30 mm with a draft angle of (79°) for polyethylene (PEHD) and (45°) for polyvinylchloride (PVC) polymer sheets. The forming tool gradually deformed the polyethylene sheet, which was fixed by the blank holder. The tool path was generated with the CNC milling machine. The tool path profile is spiral at three-dimensionalaxis; at each loop, the tool moves both in the Z-direction to form, the fixed depth to the blank, as well as in it has a radial displacement. At the end of movement, we obtain a conical shell as shown in Figure 4.

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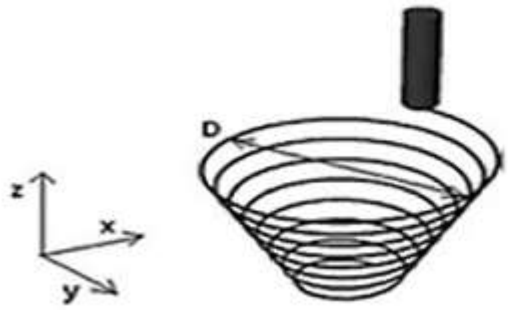

Fig. 4 Spiral Path

3. RESULTS

The results found that as the oil viscosity increase, the surface roughness decrease as shown in figure (5).This increasing in viscosity leads to an increase in the severity of adhesion cooling liquid molecules to each other and not to disintegrate the other hand, increase the strength of adhesion surface of the sample, which confronts the centrifugal force of the tool forming more than at least coolant viscosity leading to improve the surface roughness.

Figure (6) represent the effect of tool diameter on the surface roughness. It can be seen that increasing tool diameter leads to decreasing in the surface roughness. This is due to the increase in the tool curved surface area, which is in contact with the sheet surface. Large curved surface leads to smoothing the sheet surface more than the small curved surface. The tool with 20 mm diameter gives the best surface roughness, this confirms with the previous studies on the effect of the tool radius [3].

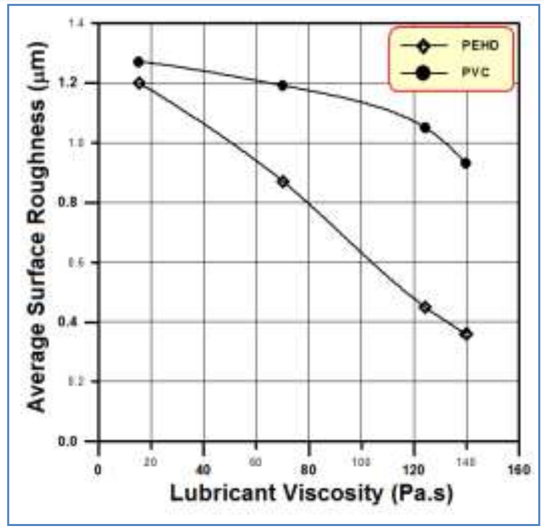

Fig. 5: Effect of Oil Viscosity on Surface Roughness. Feed Rate= 1200 mm/ min, Spindle Speed = 750 RPM, Tool Diameter = 20 mm

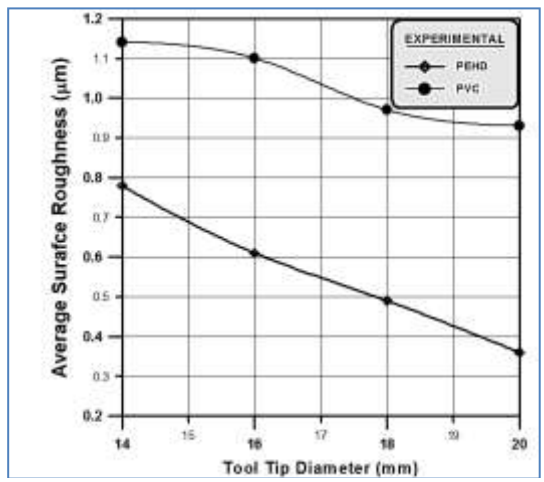

Fig. (6) Effect of Tool Diameter on Surface Roughness. Feed Rate= 1200 mm/ min, Spindle Speed = 750 RPM, HD 50 Oil

Figure (7) represent the effect of spindle speed on surface roughness for HD 50 oil. It can be seen that increasing tool speed results in decreasing the surface roughness. This improvement is due tool tip will pass on the formed zone more than slow speed so the surface roughness will decrease.

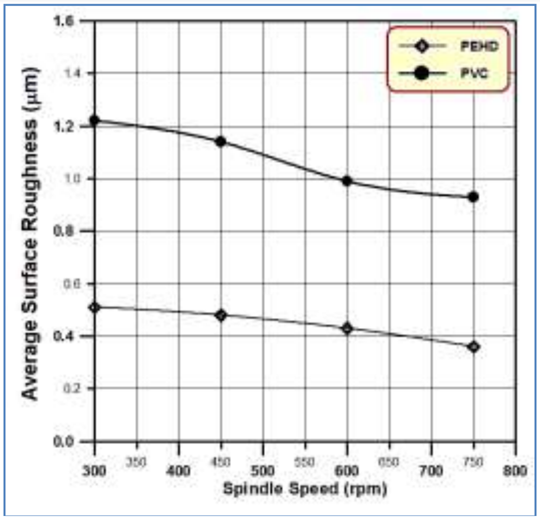

Fig. 7 Effect of Spindle Speed on Surface Roughness. Feed Rate= 1200 mm/ min, Tool Diameter = 20 mm, HD 50 Oil

Figure (8) represent the effect of feed rate on surface roughness. It can be seen that increasing the feed rate decreases the surface roughness of the cone and this is due to the shorter time to which the material is in contact with the tool tip.

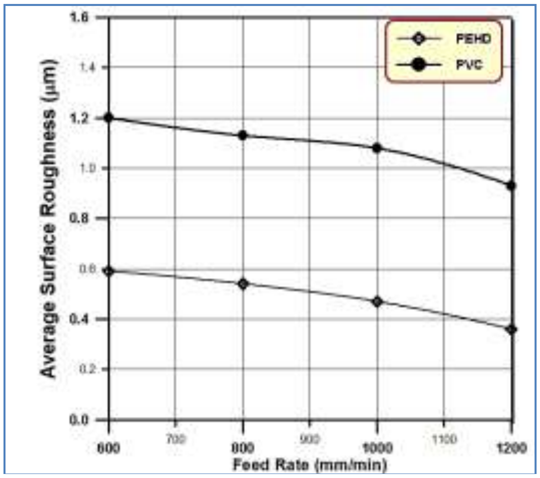

Fig. 8: Effect of Feed Rate on Surface Roughness. Spindle Speed= 750RPM, Tool Diameter = 20 mm, HD 50 Oil

4. CONCLUSION

It can be concluded from this study the Improvement in surface roughness with oil viscosity up to (70%) for (PEHD) and ((27%) for (PVC)polymer sheets, (54%) with tool tip diameter for (PEHD) and (18%) for (PVC), (29%) with spindle speed for (PEHD) and (23%) for (PVC) and (39%) with the feed rate for (PEHD) and (23%) for (PVC).

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