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Experimental investigation of incremental sheet metal forming on polyvinylchloride (PVC) by using CNC vertical milling machine

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ABSTRACT

The incremental sheet metal forming (ISF) is a new forming technology, and it produces low cost reasonable manufactured products. The single point incremental forming (SPIF) is one of the simplest ISF techniques, and it is the innovative and feasible solution for the manufacturing small rapid prototyping products and also forming heavy components. This process requires the simple fixture for holding of sheet, hemispherical ball nose tool and CNC vertical milling machine. The polymers are currently utilized in manufacturing applications but now days they are going for innovative flexible polymer processing techniques like SPIF and double point incremental sheet metal forming (DPIF). The aim of the paper is to investigate the formability of polyvinyl chloride (PVC) by varying the different input major parameters like spindle speed (rpm), feed rate (mm/min), tool diameter (mm) and incremental step (mm). The results show that the commercial PVC sheet at room temperature for manufacture of complex polymers sheet components by varying forming depths.

Key words: Single point incremental forming, Incremental depth and formability.

1. INTRODUCTION

The conventional sheet metal forming process is a part dependent tooling, which costs in terms of time and money. In recent days, so many forming techniques are developed with the aim of customized products and low manufacturing cost. Incremental sheet metal forming (ISF) is the new technique for manufacturing of low-cost products giving important in nowadays and single point incremental sheet metal forming (SPIF) process is one of technique in ISF techniques. By using these ISF and SPIF techniques, metal products are formed in past years (2005). For extending the research and application to other materials, Franzen etal (2008) was by using the SPIF technique for finding the better formability on different polymers. P.A.F. Martins etal (2009) focused on starin rate, effective formability and spring back effect for different polymers. M.B. Silva etal (2010) is focused on computational examining of formability limits of the process and major operating parameters. S.Alkas yonan etal (2012) concentrated on finite strain extension of non linearvisco plastic model materials for cold forming for finding the finite strain and forming they using the 3D software ABAQUS. Mohammad Ali Davarpanah etal (2015) is focused on the effect of incremental depth, tool rotation and micro structural properties for different polymer materials by using SPIF.

This paper concentrates on the effect of the incremental step of Δz, Spindle speed (rpm), Feed rate (mm/min) and Dia of the tool (mm) for better formability by varying the different in put major parameters. The experimental work is performed and described in section3, and the effects and results are described in section 3, 4.

2. MATERIALS AND EXPERIMENTAL WORK

Material and tool selection: A PVC sheet of thickness 1mm is selected. PVC is a normal impact, high corrosion resistant poly vinyl chloride. It is highly cost efficient, easy for fabrication and its economic balance make it the material of choice. To get the desired shape component, the tool is necessary it plays a key role in making any component shapes of sheet metal forming. The tools used for this process is a hemispherical ball nose tool and the tool diameters is 5mm ,10mm, 12mm is selected and the tools are shown in figure 1.

Figure.1.Different size of tools

Spif Clamping System and Machine Selection: The fixture is used as a supporting tool for the holding of the sheet metal and this fixture is having different sub-assembly parts. Those assembly part names are given below and assembly of the fixture are shown in fig2.

The five parts of the SPIF fixtures are:

1. Base plate
2. Top plate
3. Backing plate

4. Clamping plate
5. Four columns

Fig.2.Assembly view of the fixture

The machine used for the experiment is 3 axes CNC vertical machining center having Sinumerk 828d controller with 8000 rpm of maximum spindle speed , 10000 mm/min feed rate .X, Y and Z-axis are 450mm, 350mm, and 350mm.Table size is 600*350mm, Positional Accuracy- 0.01mm, Repeatability-0.05mm. The CNC milling machine is shown in figure 3.

Fig.3.CNC vertical milling machine

Parameter selection: The input major parameters like spindle speed(S), feed rate (f), tool diameter (d) and incremental depth (Δz) and the different input parameters are shown in table1.

Table.1.Process parameters

Material	Incremental depth(Δz)(mm)	Spindle spees(rpm)	Feed rate(mm/min)	Tool diameter(mm)	Wall angle(ά)(degrees)
Polyvinyl chloride(PVC)	0.5,1	1000,1500	1500	5,10,12	65

Forming Shape and Program generation: By using the CATIA software created the nose cone shape for maximum height. After that the STL file is imported to MASTER CAM X6 software then in master cam by changing the tool diameter and feed rate and spindle speed and incremental depth generating the tool path for nose cone shape and generated CNC programs for parameters as mentioned above and the nose cone shape is shown in fig4.

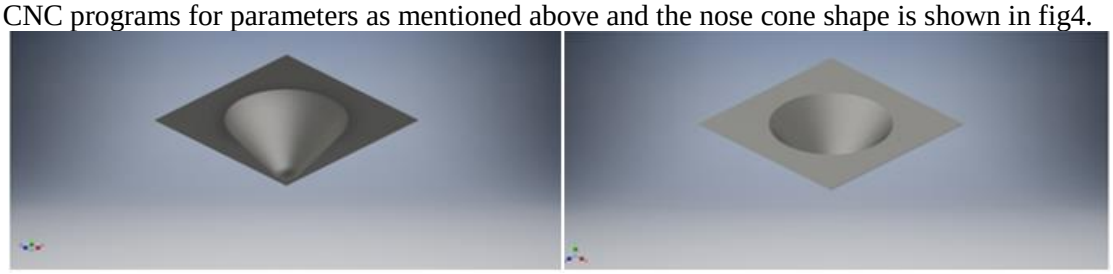

Fig.4.Nose cone shape

3. RESULTS AND DISCUSSION

The different components which were formed by varying the parameters were selected and the formability was measured. The effects of varying these parameters are shown in table no2.

Table.2.The effects of varying parameters and forming height

Spindle speed(rpm)	Feed rate(mm/min)	Toll diameter(mm)	Incremental depth(Δz)	Forming height(mm)
1000	1500	5	0.5,1	45,41
1500	1500	5	0.5,1	43,37

1000	1500	10	0.5,1	40,34
1500	1500	10	0.5,1	40,32
1000	1500	12	0.5,1	36,24
1500	1500	12	0.5,1	30,18
1000	2000	5	0.5,1	20,16
1500	2000	5	0.5,1	17,12
1000	2000	10	0.5,1	8,6

Fig.5.Formed shapes

Effect of incremental depth (Δz) (mm) on formed parts with the tool diameter 5mm: By using the 5mm diameter tool and spindle speed 1000rpm and feed rate is 1500mm/min we can see that there are not many effects in formed parts. There is no tearing by using the incremental depth is 0.5mm and the forming depth is reached up to45mm but when the incremental depth is change to 1mm wrinkling occurred at the height of 41mm. for same diameter tool and spindle speed is 1500rpm and the incremental depth is 0.5mm by using these parameters wrinkling will be happened at the height of 43mm and for incremental depth 1mm the wrinkling will be happened at the height of 37mm.

Effect of incremental depth (Δz) (mm) on formed parts with the tool diameter 10mm: For the 10mm diameter tool and spindle speed 1000rpm and feed rate is 1500mm/min tearing and wrinkling effects in formed parts. Incremental depth is 0.5mm wrinkling effect is observed at the height of 40mm but when the incremental depth is change to 1mm wrinkling is occurred at the height of 34mm. for same diameter tool and spindle speed is 1500rpm and the incremental depth is 0.5mm by using these parameters wrinkling will be happened at the height of 40mm and for incremental depth is 1mm the tearing will have happened at the height of 32mm.

Effect of incremental depth (Δz) (mm) on formed parts with the tool diameter 12mm: When the 12mm diameter tool and spindle speed 1000rpm and feed rate is 1500mm/min tearing and wrinkling effects occurred on the formed parts. Incremental depth is 0.5mm tearing effect observed at the height of 36mm but when the incremental depth is change to 1mm tearing has happened at the height of 24mm. for the same diameter tool and spindle speed is 1500rpm and the incremental depth is 0.5mm by using these parameters tearing will be happened at the height of 30mm and for incremental depth is 1mm the tearing will have happened at the height of 18mm.

For above three effects, the federate will be constant. But when the federate is changed to 2000mm/min maximum forming height is up to 20mm only at the height 20mm itself the tearing effect has occurred.

4. CONCLUSION

This paper is concentrated on the formability by varying the primary input parameters by using single point incremental sheet metal (SPIF) forming technique for forming of polyvinyl chloride (PVC) material. From observed results mainly the incremental depth is playing the central role in better formability. When using small diameter tool getting better formability at the same time feed rate also one of the effective parameters for good formability. When increasing the feed rate and incremental depth simultaneously, the sheet will be wrinkled, and tea read at the minimum height. If the spindle speed is increased means the sheet will got tea red and wrinkling will happen.

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