Development of Turret Punch Cutting Tool Using Reverse Engineering Method

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***Abstract:** This paper presents the reverse engineering technique to develop turret punch cutting tool for Trumatic TC2020R FMC machine. Different shear angle being tested to investigate the cutting process and tool wear. Result shows that 12° cutting tool has the highest tools life with poor performance. Cutting tool with 4.5° to 6.5° shear angle obtains lower tool life and better performance compare with 12° shear angle. By increasing the shearing angle, it will reduce the stress on the tool.*

***Keywords:** Turret punch, Tool wear, Shearing angle, Tool stress.*

I. INTRODUCTION

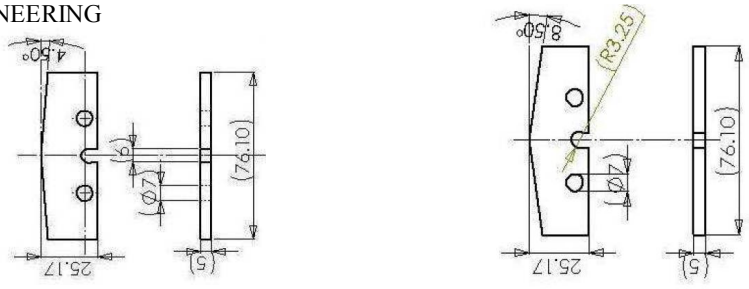
The cutting tool is very important part in the machining process. In the designing process of the cutting tools, a few important issues must be considered in term of costing, quality of the product and machining time. The factor that will affect the design is the work piece, tool material, punch geometry, sheet metal thickness and clearance [1]. Changing the cutting tool geometry, the tool life will be improved. This is because selection of right punch geometry is very important for tool life and the final product. The improvement of tool life is very important because tool will often facing adhesive and abrasive wear in contact zone [2]. In addition, tool will affect dimensional and form error. As in phase process of shearing, after given the force, work piece will be in plastic phase and then will reach fracture limit and micro cracks. The productivity and quality in sheet metal can be assessed by the burr height after blanking process [3]. The manufacturing processes involve in sheet metal processing are started with cutting, forming and finishing. Kapalkjian classified basic types of sheet metal processing into three groups; shearing, bending, and forming, [4] while Vukota Buljavonic classified into two groups; cutting and plastic deformation, [2]. But they agreed the processes related for cutting or shearing processes. Referred to Kapalkjian, he classified shearing processes are blanking, punching, die cutting, fine blanking and slitting,[1] while in plastic deformation or forming groups are bending, stretch forming, deep drawing and various other forming processes and shearing involves the cutting of flat material forms from sheet, plate or strip [3].

II. DESIGN OF THE CUTTING TOOL

Reverse engineering method is use to develop the cutting tools. Measurements on actual current available tools are vital and used to initiate and develop the ideas. These are to ensure alternative tools design can be realise. The Coordinate Measure Machine type of measurement instrument has been used in this study. Alternative design in work is very important because it need in analysis and fabrication steps. Design software has been used. CAD software has been employed to do the designing.

All of the parts were drawn with different shear angle. It will drawn with 4.5°,6.5°,8.5°,10.5°, *and* 12.5°. Figure 1(a) and 1(b) shows the design for the 4.5° and 8.5°.

III. REVERSE ENGINEERING



(a) (b)

Figure 1: (a) 4.5° design (b) 8.5°

Finite Element Analysis been done to predict the critical point of the insert during punching or blanking process. ALGOR V16 Fempro been used to do the analysis. This analysis is used to predict the critical part which is wear will occur. The most important analysis must be conduct due to tool wear cannot be measured during the process.

IV. FABRICATION OF CUTTING TOOL

Electrical Discharge Machining (EDM) wire [5] has been selected to fabricate the cutting tool. Surface grinder has been used to reduce the thickness of the tool. Testing is one of the methods to verify the design, even analysis software can be used to predict wear but in the real practice,

experiment of tool life must be carryout. The test will used Trumatic TC2020R FMC. NC programming and the drawing is needed. NC program use to set up with Top 300 software. The work piece to shape is rectangle 76.1 x 154 mm. Every tool will generate 30 pieces of rectangle. Every tool will have 180 strokes. Type of material used was Aluminium 1100 with 3mm thickness, where the speed is 10%. Test flow shown on Figure 2.

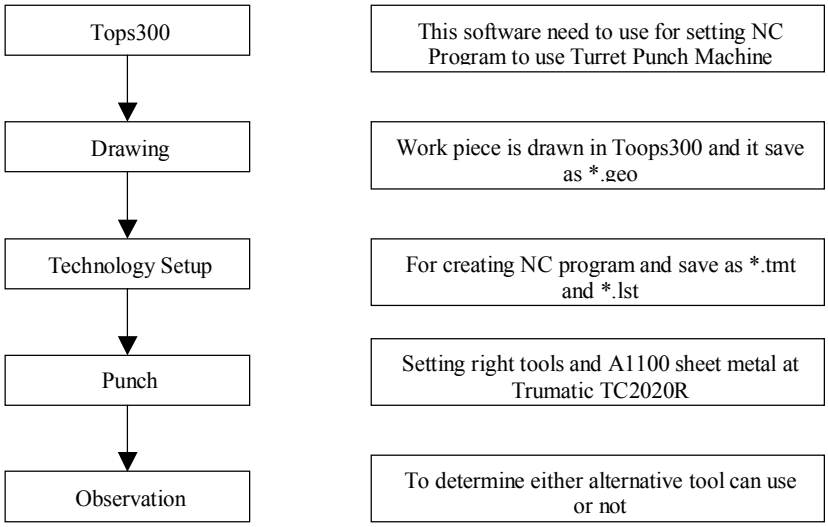


Figure 2: Testing flow

V. RESULTS AND DISCUSSION

Table 1 show the result of the stress at the beginning of the punch. The highest stress value happens at the angle of 6.5°. The minimum stress absorb by this tool is at 4.5°. The stress result after punching shown in the Table 2. The value of stresses will be decreased by increasing the shear angle. The highest absorption will increase the wear as Luo[6] reported the increasing shear of angle it will easier to shear but the burr height at punch will increase. Figure 3 and 4 shows the simulation results.

Table 1: Stress at beginning of punch

Angle (°)	Stress (MPa)
4.5	11.91×10^3
6.5	13.48×10^3
8.5	13.07×10^3
10.5	12.68×10^3
12	12.39×10^3

Table 2: Stress after the punch

Angle (°)	Stress (MPa)
4.5	32.83×10^3
6.5	30.26×10^3
8.5	29.37×10^3
10.5	29.26×10^3
12	28.76×10^3

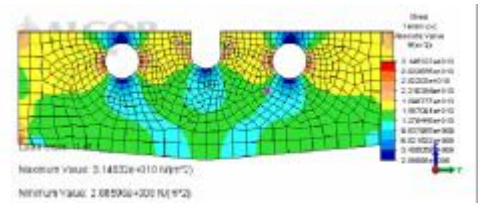


Figure 3: Result of Stress Tensor Z-Z for tool with 4.5° when Complete Punch

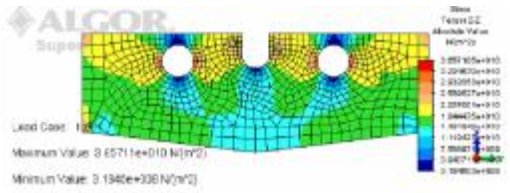


Figure 4: Result of Stress Tensor Z-Z for tool with 6.5° Complete Punch

Result shows that not all the shear angles of the tools can be used on Trumatic TC2020R FMC. At shear angle 8.5°, it will conduct in dangerous because the clamp position is not in the right position. In addition, the sheet metal attached with the tool, exposed to changing the dimension and it may damage the sheet metal, tools and machine. Figure 5 shows that defect at the product.

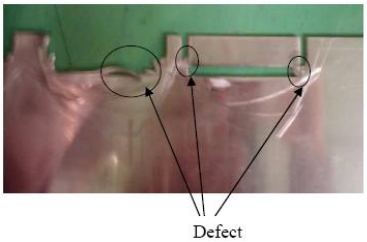


Figure 5: Defect of the product at punch

Three phases of strain stress curve is very important in sheet metal forming process. This process consists of plastic deformation stages, shear and fracture. The nature of deformation and crack has been shown in Figure 6, to explain the effect of stress impact in final product. As in testing pictures as shown in Figure 7, the punching scrap was bending where it explain about plastic deformation phase. In the testing result, by increasing angle of shear it will bent more than 90^o. It shown that after 8.5^o the process cannot work safely due to bending process must not more than 90^o.

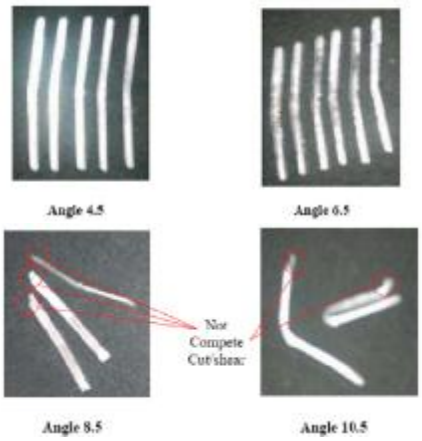


Figure 6: Stress impact

Figure 7: Effect at punching scrap

At shear stages, the slug was pushed into the die by punching process. The material will not resist force at the edges of punch, where the material will be shear. In this stage, the shearing was in smooth condition. The last stage was fracture stages, where shearing is completed when the material no longer resist force. The material remove was not going smooth. Base on this condition, by applying force will result the stress. As appearing stress condition, the sheet metal will be sheared. As in analysis result, by increasing shearing angle, the stress value can be reducing especially during shear process where full slug was pushed into the die.

The friction among tools and material will reduce. By increasing shearing of angle, the height between tips of tool to the side edges at incline is increase. But the elongation value of the product under same force will started a problem in final product. This condition has been explained in testing result. The problem occurred because at same strain, the material will fracture. By increasing shearing angle more than 8.5^o at this length is not suitable.

This problem can be solved if the force value can be change as explain in calculation in analysis part. By increasing the shearing angle, value of force must to reduce to ensure the strain will be longer. This analysis and observation found that by increasing shearing of angle will increase tool life but length of tools and force value need to be considered to ensure final product was in a good condition. Furthermore this punch must considering on types of material, thickness, the yield stress value and velocity of punch.

VI. CONCLUSION

In developing new turret punch cutting tools, different type of angles play the major role. From the simulation, its show that the stress has highest value at the edge of cutting tools and resulted wears. Increase the shearing angle, concurrently reduce the stress. Cutting tool with 4.5^o to 6.5^o shear angle produce fine tool life and cutting tool with 12^o shear angle perform badly.

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