

Analysis of progressive dies metal stamping components for yoke a plate to maximize age of wear

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Abstract. The use of materials as the main component and the amount of clearance used affects the performance of punch cutting and die cutting components and also the product of it. The small clearance applied will produce a good product with a very small burr but the application of small clearance very quickly cause wear on the components used. The analysis has been performed to improve the performance of progressive dies metal stamping Yoke A plate components and its product quality by identifying the mechanical properties of the material of the components, where the material used is SKD 11 and increasing the hardness of punch and die cutting components through heat treatment process (full hardening), quenching until reheat with tempering process, and calculating of clearance quantity used in the die set. The results of the experiments obtained hardness of 62 HRC can optimize the performance of progressive die component where punch component in one application reach 94.100 stroke and die cutting can reach 110.000 stroke. The calculation results obtained a value of 10% clearance can extend the life of the wear and also reduce the burr to 0.01 mm.

1. Introduction

Progressive dies yoke plate is a press tool with multistation system where the sequence of press process is made on pressing press (dies) used in sheet metal pressing process [1]. The working forces can affect the performance of the punch and die components found in the die set. Hambli has shown a dependence between the geometry of the blanking component and the magnitude of the force acting on the component [2]. In the field of the production process, often the pressure is increased in order to meet the needs of forces acting on the tools. In practice, pressure is often set higher than necessary. The excessive pressure does not reduce the friction, but only increases the air consumption [3]. The performance of punch and die components in the progressive dies used to cut metal sheets is determined not only by the magnitude of the forces acting on the components, but also by the material hardness level and the clearance value between punch and die. Improper clearance values may result in ruptured of the die component or burr may be formed on the product if the clearance is too large [4]. The research conducted by Lin shows the relationship between cutting products from die components with certain clearance value and the wear life on punch which used in the blanking process [5]. This model can be used to estimate the use of punch and die for industrial applications. Other researchers have also shown that the relationship between the clearance variables



and the contours of the part produces more uniform stress in the punch, thus increasing the life of the punch [6].

The main objectives of this experimental study are to identify the hardness properties of materials used as punch and die on the process of making the yoke A plate, as well as to improve the wear life of the punch and die components with the qualification of the production reach about 100.000 strokes with good product quality.

2. Specimens and experimental

The progressive dies component used in the production process of yoke A plate, made of SKD-11 steel material which has a hardness level of 63 HRC. The compression force used by the machine is 35 Ton. The design of the punch and die components on the progressive plate can be seen in Figure 1. The magenta color describes the profile of the punch that cuts the product form of the Yoke A Plate. The green color indicated by arrow in die plate design is the profile of print hole with offset dimension from the punch profile. Design is used not only as the initial calculation to determine the tonnage of the machine, but also for the clearance calculation, as well as the basic program for the Wire Cutting Electric Discharge Machine (EDM) to produce punch and die components.

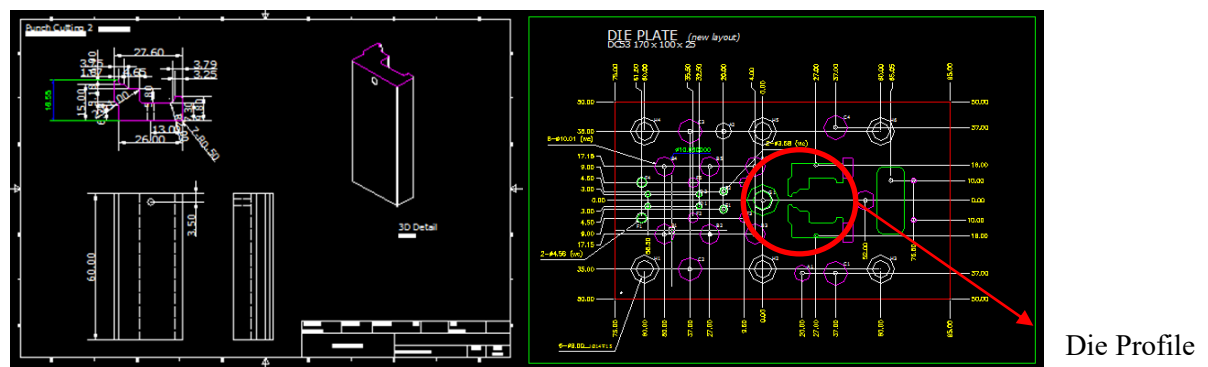


Figure 1. Design of punch and die components on progressive dies of yoke a plate

The SKD 11 steel material used as a component of punch and die because this type of steel has a high hardness and wear resistance due to the high chromium content of 13%. The chemical composition of SKD-11 steel is carbon 1.40-1.60%, Silicon 0.40%, Manganese 0.60%, Phosphorus 0.03%, Sulfur 0.03%, Chromium 13%, Molybdenum 0.80-1.2%, and Vanadium 0.20-0.30%.

Prior to the heat treatment process, the raw material is done by machining process using milling machine and grinding machine to get the dimension of material that will be used for punch and die component which according to component design as shown in table 1, then later the profile form is made with the wire cutting electric discharge machine (EDM).

Tabel 1. Material block dimension for punch and die component

Component Name	Length (mm)	Wide (mm)	Thickness (mm)
Punch cutting	60	55	55
Die cutting	170	100	25

In the heat treatment process SKD-11 steel specimens were heated to above austenite temperature of 1000°C with 2 hours hold time and cooled with liquid nitrogen medium. The result of heat treatment of SKD-11 material can be seen in figure 2, it is seen that the hardness of SKD-11 rises from austenisation temperature 980 °C to austenisation temperature 1040 °C, from HRC ± 62 to HRC ± 65 respectively.

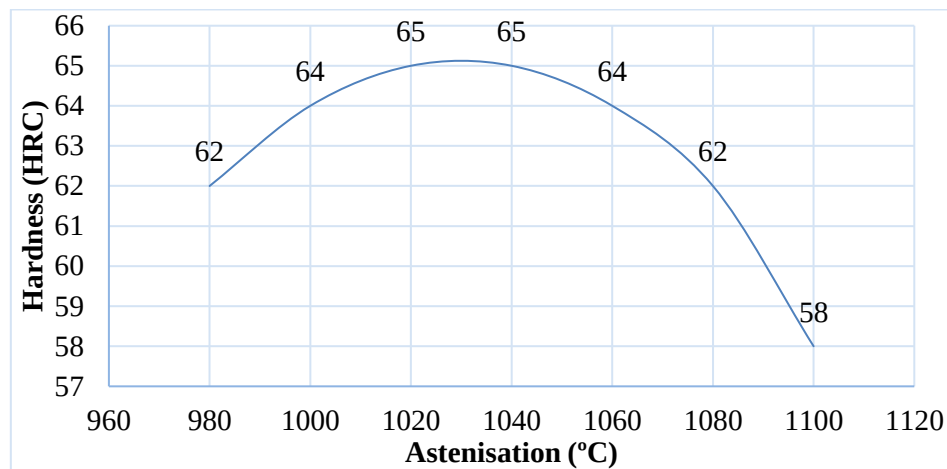


Figure 2. Diagram of the austenisation temperature and the hardness value

The decline in hardness occurs after heating at temperature about 1060 °C due to clotting or cementite growth followed by a decrease in hardness, because the increase in temperature will accelerate carbide clumping, while the hardness will continue to decline. Referring to the tendency of the curve of this diagram, the recommended austenisation temperature for SKD-11 steel is 990 - 1050 °C, with the hardness value after the obtained process is a minimum of HRC 63.

The length of the cooling process in the quenching process can affect the hardness, where the longer the detention process (cooling) it will get high hardness. In this quenching process, the five specimens of SKD-11 steel were tested for hardness with 5 variations of cooling containment. The first specimen with 5-minute immersion resulted in a hardness of 61.6 HRC, then a second with a 10-minute dipping obtained of hardness of 62.4 HRC, the third with a dipping time of 15 minutes of hardness was 63.1 HRC, the fourth by immersion 20 minutes to produce 63.6 HRC hardness, then cooled with 25 minutes dyeing to produce 63.6 HRC hardness is due to SKD-11 steel material is completely cold so no reaction is generated. This result can be seen in Figure 3.

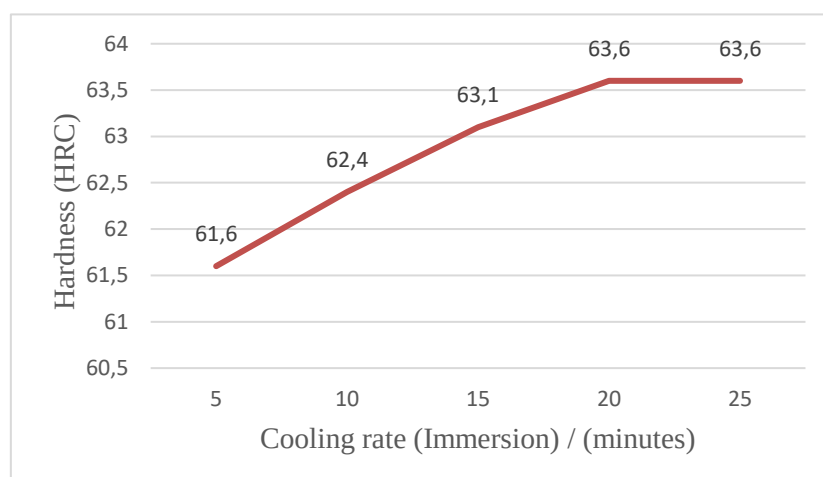


Figure 3. The relation between the duration of the quenching process and hardness

The tempering process is carried out by holding temperature for 1 hour with temperature below the critical point of the specimen after going through the quenching process. With this process the ductility can be increased but the hardness and strength will decrease and then the hardness test is done on the specimen [7]. The result of hardness measurement can be seen in Table 2.

Tabel 2.Result of hardness test (Rockwell) atvarious tempering temperatures

No	Material	Temperature (°C)	Hardness (HRC)
1	SKD-11	none	42.3
2	SKD-11	200	62.0
3	SKD-11	300	62.3
4	SKD-11	500	63.6
5	SKD-11	550	61.7
6	SKD-11	600	48.7

The hardness of SKD-11 steel was measured by Rockwell hardness tester. It was recorded that the initial surface hardness (no heat treatment applied) was 42.3 HRC. The surface hardness tends to be increased when the quenching process was applied and tempering temperatures were raised until 500°C. At the tempering temperatures of 200°C, 300°C and 500°C, the hardness was increased by 62 HRC, 62.3 HRC and 63.6 HRC, respectively. If the tempering temperatures was increased above 500°C, the trend of hardness values were decreased, 61.7 HRC and 48.7 HRC was obtained at tempering temperature of 550°C and 600°C, respectively. These experiments show that the maximum hardness (63.6°C) was obtained at tempering temperature of 500°C.

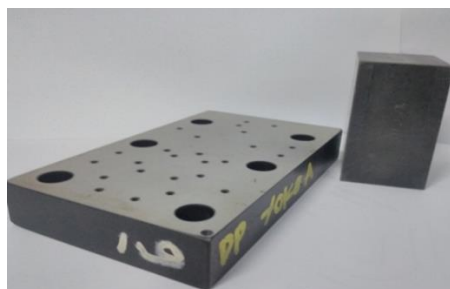
**Figure 4.** Material Punch cutting and Die Cutting(Heat Treatment)

Figure 4 shows the punch cutting and die cutting components of SKD-11 steel. The two components were fabricated by lathe machine and followed by heat treatment (full hardening). Two hardness values were used as one of parameters in the metal stamping experiments: 62 HRC and 63.6 HRC. These two numbers were selected as a value below and above the hardness of actual component before analysis process. Clearance analysis were determined by considering dimension of the Yoke A Plate product, 1.2 mm, with the material used is SPCC-SD with quality referring to JIS G3141 standard. Two workpieces of the product will be used for comparison purpose.

3. Result and discussion

Metal stamping experiments were done to obtain the production target of Yoke A Plate for about 5000 pcs/h. The 35 tons press machine, punch and die cutting was used during experiment where the hardness of full hardened punch and die cutting of 63 HRC was selected. The clearance of 8% was selected and the initial trial process can be used for about 60,000 strokes. Burr tolerance of 0.05 mm was selected as parameter for the result, it was expected that burr may occur but the value not exceed 0.05 mm.

Performance of one stroke process was determined where punch cutting component able to process (cutting/stamping) against die cutting component. The initial trial of stamping process has been done and able to do the process in the range of 60,000-65,000 strokes. This value was too low whilst

100,000 strokes was expected from the process. The experiment and analysis were then conducted to obtain higher stroke values. The performance of stamping process was optimized in order to obtain higher number of strokes and maintain punch and die cutting components in good condition.

First experiment was done by punch and die cutting where the value of hardness of 62 HRC, with four different clearance parameters: 7%, 8%, 9% and 10%. The results of process are then recorded and depicted as in the Figure 5.

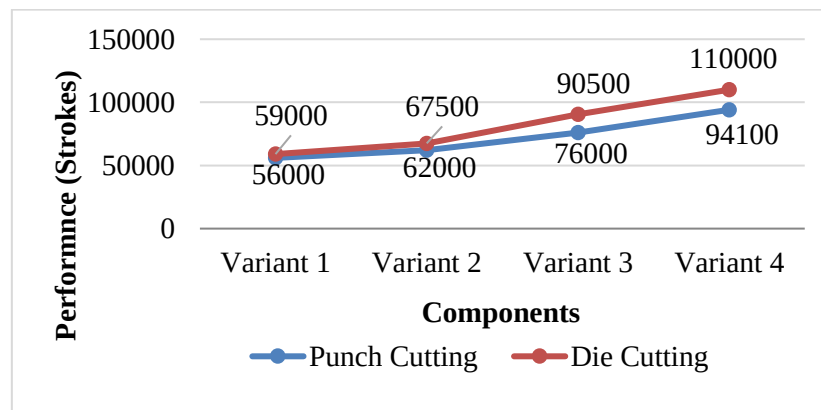


Figure 5. Relation between component punch cutting and die cutting with performance with 62 HRC

Figure 5 shows the relation between stroke and set of punch and die cutting process (variant). Variants 1, 2, 3 and 4 use different clearance of 7%, 8%, 9% and 10 %, respectively, but same hardness of punch and die cutting (62 HRC). The higher the clearance's value the higher the stroke obtained [6]. The process was recorded at relatively at the same time process where the punch and die cutting were still in good condition. The next experiment then conducted with similar parameter and process but the second hardness of punch and die cutting was 63.6 HRC. The result of the process can be shown in Figure 6.

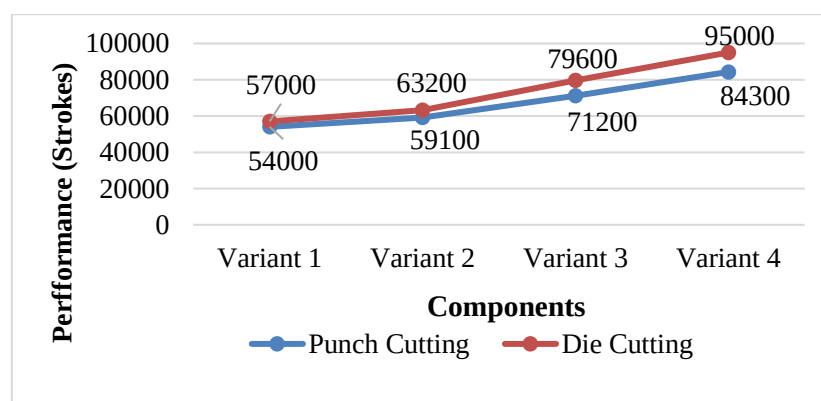


Figure 6. Relation between component punch cutting and die cutting with performance with 63.6 HRC

From the two figures, Fig.5 and Fig.6, where two different workpieces (punch and die cutting) have different hardness value, 62 HRC and 63.6 HRC, shows that the first experiment produce better performance. Set of trial number 4 (variant4) shows that punch cutting can generate 94100 strokes while die cutting generate 110000 strokes. Components with higher hardness result in greater wear and tear on the component. This agrees with the results of experiments by Picaset *al* that the level of hardness can affect the fatigue resistance of the material. Picas *et al* revealed that the hard material

tends to have a deficiency in its fatigue resistance [8]. Thus, it has caused the specimen material with hardness of 63.6 HRC with the same clearance value having reached only 95000 and 84300 strokes on the die and punch components respectively.

The burr value of 10% clearance was slightly higher but the values were still below the allowable tolerance ± 0.05 mm. The clearance of 10% of 62 HRC and 63.6 HRC materials produce burr about 0.01 mm. As Klocke has identified that the appropriate clearance distance does not exceed 20% and preferably in the range of 5 – 10% of the part thickness [9]. The performance of the experiment was determined of all set of parameters produce higher stroke, no failure of punch and die cutting and burrs were still in the tolerance values. The experiment concludes that the punch and die cutting that have full hardened to obtain the hardness of 62 HRC generate highest strokes 94,100 strokes for punch and 110,000 strokes for the die cutting.

4. Conclusion

The results obtained from this experimental research, including: The hardness properties of the material to be used as punch and die cutting components must have hardness of 62 HRC, then the material must obtain the process of full hardening treatment until the Austenit phase is reached, the quenching process using liquid nitrogen, and tempering with a temperature of 200 ° C. The results of the clearance calculation to be used as the component of the progressive dies ranging from variant 1 (7%), variant 2 (8%), variant 3 (9%), and variant 4 (10%), and the experimental results show that the value of 10% clearance can improve the performance of the previous condition with the burr generated after the measurement is 0.01 mm. Hardness value of component material with 62 HRC and with Clearance 10% showed optimum improvement result with achievement of punch cutting component in one application is 94.100 Strokes and Die cutting able to reach 110.000 Strokes, increased from previous condition only able to survive 60.000 strokes, where result of research - experiments that have been done can be used as a replacement condition of components that have been used.

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