مجلة جامعة بني وليد للعلوم الإنسانية والتطبيقية
تصدر عن جامعة بني وليد – ليبيا
Website: https://jhas-bwu.com/index.php/bwjhas/index
العدد التاسع والعشرون، 2023

Wear Resistance evaluation of punching process in Bani Walid Industrial Factory

Mahmod Gomah[1*] ,Mohamed Alaalam[2], Abdussalam Ali Ahmed[3]
[1,2,3] Mechanical and Industrial Engineering Department, Bani Waleed University, Bani Walid, Libya
*Corresponding author: samadmssamad@gmail.com

تاريخ الاستلام: 2023-06-17   تاريخ القبول: 2023-06-27   تاريخ النشر : 2023-09-07

Abstract: The process of punching has become prominent in the manufacturing industry because of its ability to make highly specialized parts that minimize waste and cost. With punching process, the goal is to use what is stamped/punched out rather than what is left after going through the die. In this paper, the evaluation of wear resistance and productivity of cutting die that uses to make holes in gun safety part is discussed and studied. The results of this work showed that, there is attempts by some engineers in the factory to teach a high productivity of the die, but they failed, Where the dies used had many problems, including the decrease in the toughness of the punch, and an error in the design of the punch, To solve the problems that occur in the die, which were the reason for reducing productivity, we suggest choosing other wear-resistant materials to design new dies and making a suitable design for the die by applying the shear angle and suitable clearance between the bunch and the die.

Keywords: Blanking process, Wear, Cutting die, clearance.

Introduction

Bani Walid Industrial Factory is one of the important factories in Libya. It is located in Bani Walid City about 10 Km from the city center. It has been opened in (1982) to produce light machine guns such as revolvers, pistols, rifles, general-purpose rifles and some special equipment for army. The planning section in the Factory has reported some defect problems in one of the production lines especially for the Klachenkov rifles. This production line is to fabricate one of the parts, which is the safety part in the rifles. This part consists of a ring fixed on a small bar, which is fixed on the rifle body. To fix the safety part on the rifle, a hole on the ring and bar should be drilled. To make this hole, the safety part pass through the cutting process by the cutting die to obtain an initial hole and then the hole is machined to obtain the right and accurate measurements. The production strategy for the safety part is to produce 3000 pieces daily (i.e., 1500 pieces per shift). These pieces pass under the pressing bar which contains the cutting die to the pulling machine. The cutting die is sharpened between the shifts (i.e., after producing 1500 pieces). This has been achieved by the old cutting dies, which are made in Russia. Once the old cutting dies run out of the stores, the Factory has fabricated these dies locally due to difficulties to obtain them from abroad. Unfortunately, those locally fabricated dies did not perform well when they have been used in the production line.

There are some problems related to this die such as:

1-The productivity of those dies have been decreased to 430 pieces before sharpening.

2-The percentage of defected parts is increased. The ring separates from the bar during the cutting process or following processes. The quality control team does not accept this percentage.

3- The Broaching tool failure before the expected lifetime during the brushing process. The productivity of this tool has dropped rapidly from 1200 pieces to 250 pieces.

Since these problems appeared, the planning section in the Bani Walid Industrial Factory has tried to overcome them but without any success. Therefore, the main goal of this study is to investigate and solve the problems concerning the cutting dies. Reverse engineering played a major role in collecting the data for the cutting dies. But since the original dies are not available, the locally fabricated dies are used. The strategies that have been tried by the planning section were studied to benefit from them and realize the failure reasons to avoid them in the new study. In order to improve the cutting die, it is required that all dimensions should be measured and prepare all drawings using computer.

Mechanical properties such as surface roughness, hardness have been measured. Metallographic examination was carried out to study the microstructure of the old die. Once all data have been obtained, many experiments have been carried out with some modifications to solve the problems.

Reverse Engineering

Reverse engineering is the disassembly, measurement and documentation of all the parts of an existing product unlike conventional forward engineering which begins with a problem or idea and works toward a solution or product, reverse engineering begins with a product and results in understanding, documentation or idea. (1)

Reverse engineering is a four-stage process in the development of technical data to support the efficient use of capital resources and to increase productivity. The stages, all of which are conducted after a rigorous prescreening of potential consist of data evaluation, data generation, design verification, and design implementation.

This process is typically applied for the improvement of production lines manufacturing capabilities; ideally, groupings of parts by system or subsystem produce the best pool of candidates for reverse engineering.

Accurate data development for long-term maintenance and support of technical capabilities is the cornerstone of reverse engineering. This process provides a level of technical support. Since reverse engineering requires the investment of capital, reverse engineering projects are carefully prescreened to ensure a high probability of success.

Those projects, which do not meet prescreened criteria, are typically not considered, berceuses success in reverse engineering is generally measured by return no investment. Figure (1) illustrates the difference between the traditional design process and the reverse engineering process. (2)

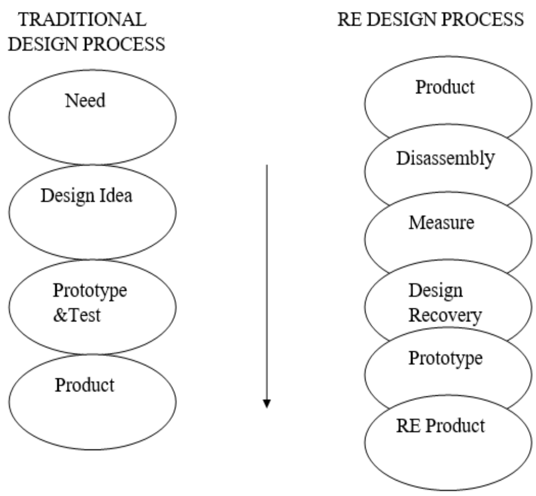


Figure 1: Traditional versus Reverse engineering design process [1]

Blanking and punching Operation

Whether the die shown in figure (2) is a blanking die or a punching die depends solely upon its intended use. it is called a blanking die if it is meant to produce blanks *B* of a desired contour and size by cutting them out of the required type of material *A*. the blanks are the desired product (piece parts) made by the die. In most cases, the material remaining after the blanks have been cut out is considered scrap.

If the purpose of the die is to make openings of a desired contour and size in the required material *A*, it is called a piercing die. In this case *A* represents the piece part and *B* is called the slug. The slug is usually considered scrap.

The basic elements of both dies are identical. The name of the die is derived from its intended use. The physical effects of the tool upon the stock material are the same whether it is punching in a piece part or whether it is punching out blanks which are the desired product of the die. (11)

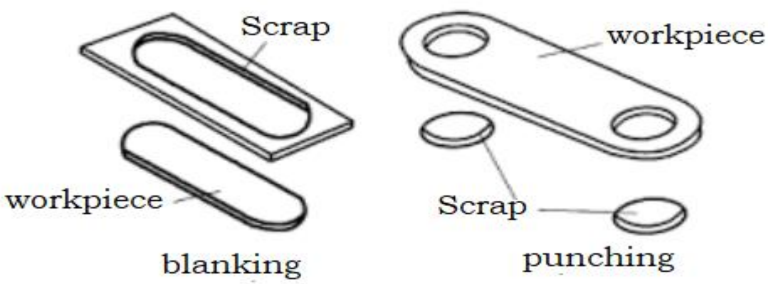


Fig. 2: Differences between blanking and punching [11]

Proper cutting clearance is necessary to the life of the die and the quality of the piece part. Excessive cutting clearance results in objectionable piece-part characteristics; insufficient cutting clearance causes undue stress and wear on the cutting members of the tool because of the greater punching effort required. (12)

The clearance between the punch and the die plays an important role in the blanking process.

The selection of clearance will influence the life of the die or punch, the blanking force, the quality of the workpiece.

In figure (3) blanking force-punch stroke curves for different clearance are presented. For material considered as rigid-plastic, the blanking force arising from the elastic deformation of the material is omitted. From fig (3) it can be seen that an increase in the clearance causes a decrease blanking force. (13)

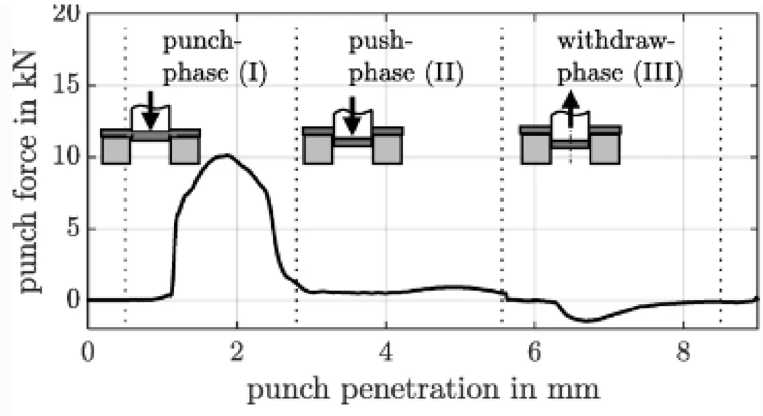


Fig. 3: The simulated punch stroke-blanking load curve. (10)

Determining cutting clearance

The physical properties and the thickness of the stock material are the factors that determine the amount of cutting clearance. The thickness is easily measured but the physical properties in relation to cutting clearance are not. Therefore, the optimum clearance must often be determined by actual experiment. (12)

The die-clearance chart figure (4) may be used to find the recommended die clearance to be allowed, and to be provided for, in designing a die for service as determined by the materials groups which follow, and for the reestablished percentage of material thickness of the original part which the die is designed to produce. (12)

Group1. 1100and 5052 aluminum alloys, all tempers. An average clearance of 4.5 % of material thickness is recommended for normal punching and blanking.

Group2. 2024 and 6061 aluminum alloys; brass, all tempers; cold rolled steel, dead soft; stainless steel soft. An average clearance of 6 % of material thickness is recommended for normal punching and blanking.

Group3. Cold-rolled steel, half hard; stainless steel, half hard and full hard. An average clearance of 7.5% is recommended for normal punching and blanking.

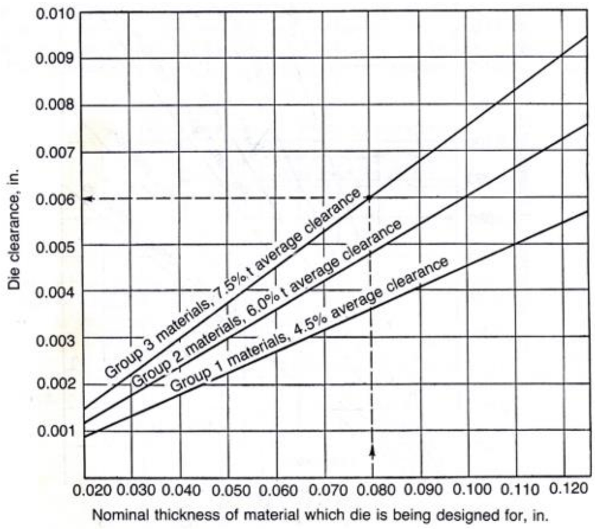


Fig. 4: Die-clearance chart by groups of materials, using the recommended of metal thickness. [12]

Experimental work

The Industrial Factory in Bani Walid is facing problems in one of its production lines that is specialized in producing one part of the Klashenkove rifle which is called the safety part as shown in figure (5). The problems include the following:

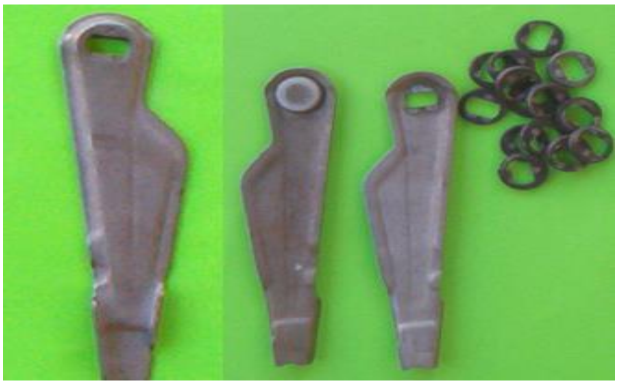


Fig. 5: The safety part

1- The Broaching Tool failure which is used in the broaching process.

2- The Productivity of the cutting die (figure 6) is not satisfying the planning department in the factory.

3- The percentages of the defects were high, which is produced by this die. Also, the problem of separation of the ring which is fixed to the safety port by spot welding was 8.6%.

Fig. 6: The cutting die

Problem Identification:

Four different dies were chosen as samples to study the problems mentioned above as Shown in table (1)

The first die (Da) is the original one, the other were modified.

Table 1: Show four different dies

Dies	Productivity (Pieces)	Accepted (Pieces)	Rejected (Pieces)	Defect percentage	Problem
Da	430	393	37	8.6%	Wear on the punch and die block.
Db	65	62	3	4.6%	Fracture of punch
Dc	80	84	6	7.5%	Fracture of punch
De	85	76	9	10.6%	Wear on the edges of the punch

In order to investigate these problems, the dies were dies disassembled to carry out tests and measurements.

Figure (7) shows the basic elements of a blanking or piercing die. These elements are the die block in which the proper female die opening has been made, the punch, and stripper. (The back gage which locates the back edge of the stock material is, in this instance, a part of the stripper.) They are mounted on a die set in order to achieve and retain proper matching of the punch and the die opening.

The die block and stripper are secured to the die shoe by means of screws and dowels. The punch is screwed and doweled to the punch holder.

When the die is set up or mounted in the punch press, the punch holder is secured to the ram of the press and, of course, moves with the ram. The die shoe is secured to the press bed and remains stationary.

The stock material *A* is fed or loaded in the proper position on the top surface of the die block. When the press is tripped, the ram drives the punch through the stock martial *A* into the die opening, thereby producing an opening in the stock material by cutting out the blank or slug *B*. this blank or slug remains in the die opening when the punch is withdrawn and is pushed through the die by the blanks or slugs produced subsequently.

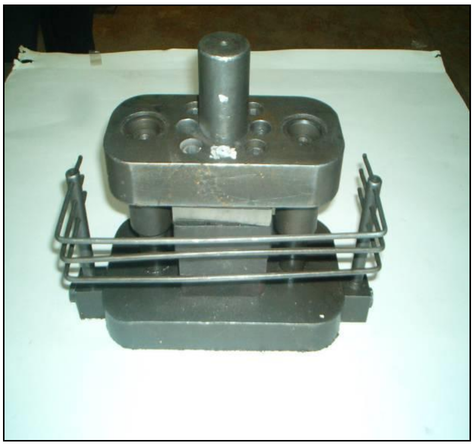


Fig. 7: The basic element of a blanking or piercing die.

Disassembly of Blanking Die

This component is composed of five main parts, which are:

1-Die Block

The die block (figure 8-part D) is the female part of a complete blanking die which is used to produce piece parts consistently to required specifications.

2- Punch

A punch is a male member of a complete die which mates or acts in conjunction with the female die to produce a desired effect upon the material being worked. a die can be a simple tool composed of punch, die block, and stripper, or it can be an extremely Factory mechanism which performs many and varied operations. (Figure 8-part B)

3- Punch Holder

This part is shown in figure (8-part A). It is used to fixing the punch of longitude for insuring no deflection from die block.

4- Stripper

The purpose of this part is to insure no moving of the punch of the cycle (figure 8-part C)

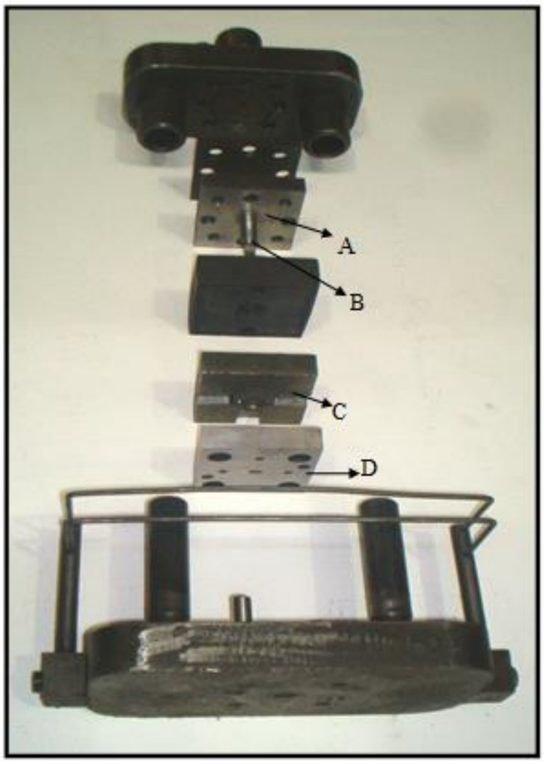


Fig. 8: Disassembly of blanking die, A- Punch holder, B- Punch, C- Stripper, D- Die block

Measurements and Drawing

The dimensional measurements were taken using calipers, micrometers, and coordinate measuring CMM as shown in figures (9).

Fig. 9: Measurement Tools.

Fig. 10: Die block.

Fig. 11: punch

Hardness Measurement

The Rockwell hardness (scale C) measurements were taken on polished samples. Tests were mode using a standard a Rockwell hardness test machine and a load of 150 kg.

The hardness values are the average of 10 minimum reading this method is the most widely used hardness test. Its general acceptance is due to its speed, freedom from personal error, ability to distinguish small hardness differences in hardened steel, and the small size of the indentation, so that finished heat-treated parts can be tested without damage.

This test utilizes the depth of indentation, under constant load, as a measure of hardness. A minor load of 10 kg is first applied to seat the specimen. This minimizes the amount of surface preparation needed and reduces the tendency for ridging or sinking in by the indenter. The major load is then applied, and the depth of indentation is automatically recorded on a dial gage in terms of arbitrary hardness numbers.

Impact Test

In general Impact tests are designed to measure the resistance to failure of a material to a suddenly applied force such as collision, falling object or instantaneous blow. The test measures the impact energy, or the energy absorbed prior to fracture.

Charpy test specimens of dimensions 55x10x10mm were cut from the dies. The sample have a V-sharp notch, 2mm deep, with 45 angle and 0.25 mm radius along the base

Surface Roughness Measurement

Surface topography is of great importance in specifying the function of a surface. A significant proportion of component failure starts at the surface due to either an isolated manufacturing discontinuity or gradual deterioration of the surface quality. Typical of the former is the laps and folds which cause fatigue failures and of the latter is the grinding damage due to the use of a worn wheel resulting in stress corrosion and fatigue failure. The most important parameter describing surface integrity is surface roughness. In the manufacturing industry, surface must be within certain limits of roughness. Therefore, measuring surface roughness is vital to quality control of machining work piece. Surface roughness measurement is performed on Sutronic 3+ devise as it can be seen in figure 12

Fig. 12: Sutronic 3+devise.

Chemical Analysis

Spark emission spectrometry is a rapid, precise and reliable method for elementary analysis of conducting solids, whose discovery dates back to the last century.

Today this technique is used on a systematic basis in the steel, metallurgy and foundry industries for developing, producing and providing quality control of metals and alloys.

In spark spectrometry, the emission source consists of a sparking stand and a spark generator.

The sample to be analyzed, hard faced with an abrasive, is a held on the support plate by an attachment device.

Spark emission spectrometry is an analytical technique which is routinely used in the metal industry. Chemical composition of the samples under investigation were measured using spectrophotometer.

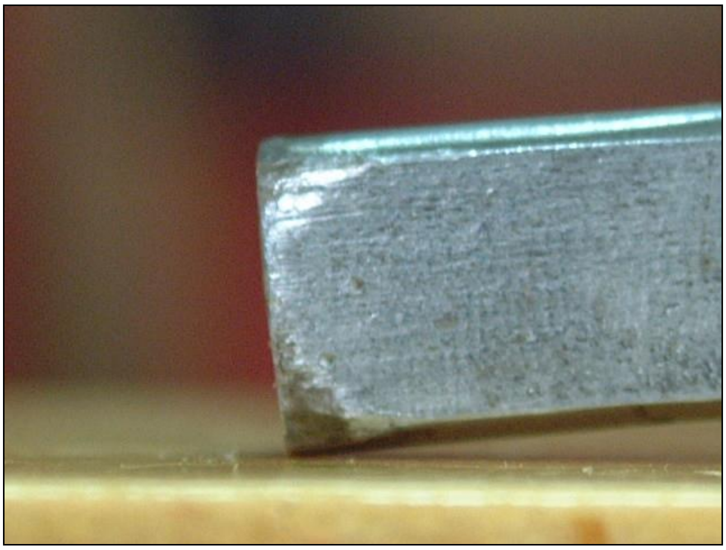
(Cutting Die Lowness of Productivity)

To study the low productivity of the selected dies manufactured at Bani Walid Factory, tests and measurements were carried out as can be seen in table 2.

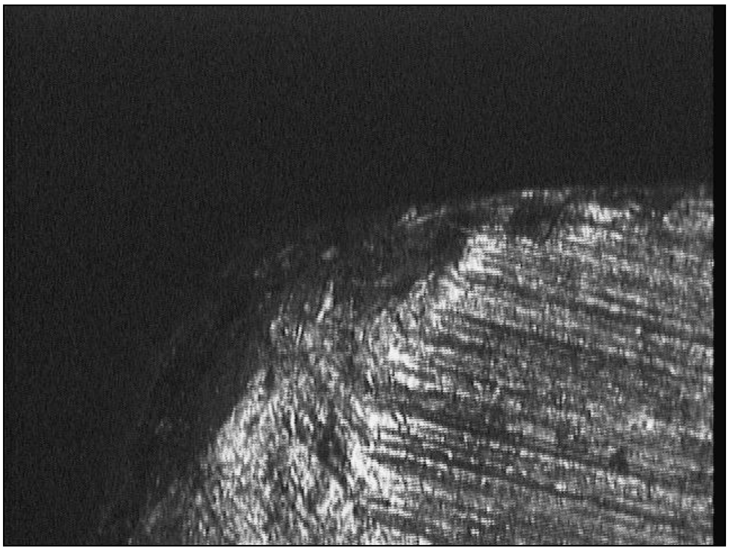
Table 2: shows an old dies specification

Dies	AISI Steel Type	Hardening temperature °C	Hardness HRC	Clearance mm	Productivity	Rejected	% of Rejected parts
Da	W1	800	59.8	0.008	430	37	8.6%
Db	W1	790	69.4	0.009	65	3	4.6%
Dc	W1	800	59.4	0.008	80	6	7.5%
De	W1	815	51.1	0.008	85	9	10.6%

Regarding the die Da wear occurred on the edges of the Punch and the Die block as shown in figures (13, 14(a, b)) due to pressure on the edges.

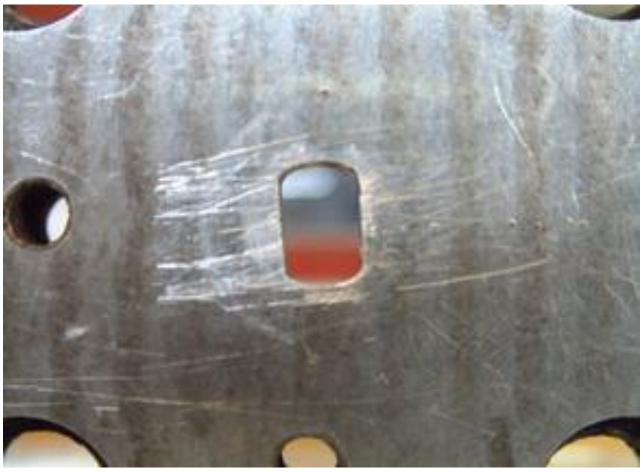


(**A**)



(**B**)

Fig. 13 A, B: Shows wear defect on the punch.



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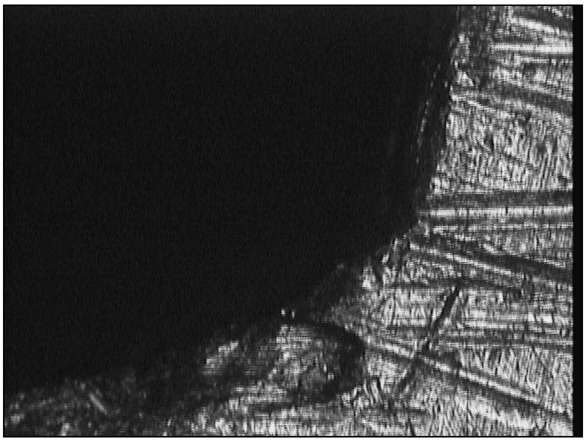


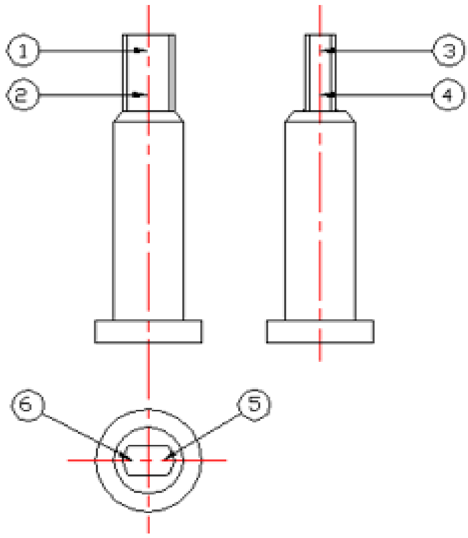
(**B**)

Fig/ 14 A, B: Shows wear effect on the die block

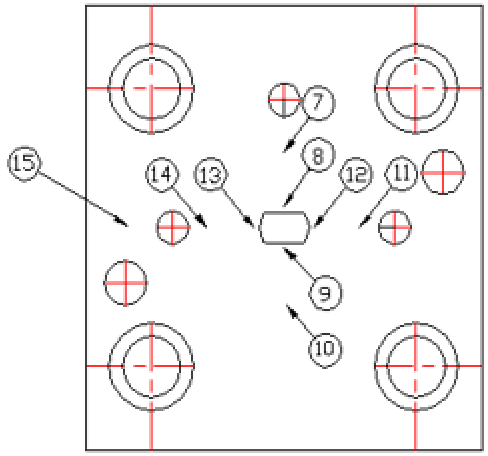
-Regarding the die Db, it was a try from the planning department in the factory to increase productivity by raising the hardness of the die to 68 HRC without considering that; if the hardness is high, the impact strength of the die will be less which causes fracture.
-To sharpen the die Dc more than two times, the planning department made the punch longer to raise the dies entire productivity, this caused the punch bend and fracture.
-Low hardness of De die caused wear on the edges of the punch and die block.
The main reason for low productivity is the wearing that occurs to the punch and die block. To increase productivity, we have to decrease wear problem. To obtain optimum specification many experiments were made.

Hardness Measurement

Hardness measurements were performed on old dies and new dies. The locations are shown in figure 15.
The hardness values of old dies (Da, Db, Dc, and De) are illustrated in table (3).



(**A**)



(B)

Fig. 15 A and B: Locations of hardness measurements

It can be seen that the hardness measurements of Da and Dc are equal. However, die Db has higher hardness and the lowest hardness was obtained for die De.

When the hardness is high, the die Db is fractured and the productivity was 50 pieces.

In contrast that the productivity of die De was 80 pieces this due to low hardness values.

Table 3: Rockwell hardness test results for Da, Db, Dc, De.

Location	Hardness Value (HRC)			
	Da	Db	Dc	De
1	60	71	60	52
2	61	69	60	51
3	59	67	59	51
4	58	70	59	51
5	60	68	61	50
6	59	70	60	52
7	62	69	59	50
8	60	69	60	51
9	58	68	58	51
10	59	70	59	52
11	60	71	60	51
12	61	71	60	52
13	60	70	58	50
14	59	69	59	51
15	61	69	61	51
Average	59.8	69.4	59.5	51.1

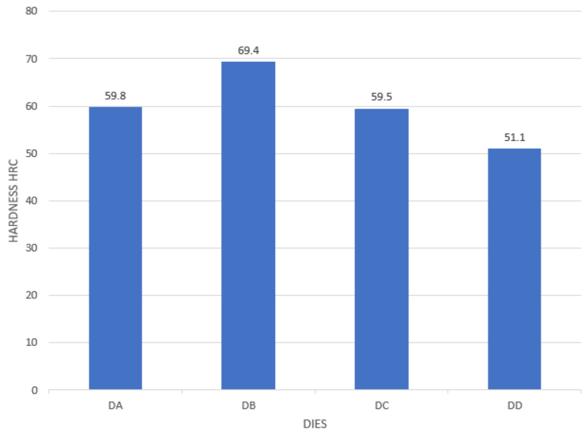


Fig. 16: Hardness measurements of dies

Impact Energy Results

The impact energy is one of the important properties, which needs to study to avoid the punch fracture during the operation. The impact result of old dies are given in table (4).

The samples were taken from the dies with dimensions. And as can be seen from figure 17, the relationship between hardness and toughness.

The impact energy increases as the hardness values decreases.

Table 4: Impact test results for Da, Db, Dc, and De.

Sample No.	Energy absorbed x 10(J)			
	Da	Db	Dc	De
1	0.25	0.1	0.20	0.42
2	0.25	0.1	0.20	0.41
3	0.20	0.1	0.25	0.40
Average	0.23	0.1	0.22	0.41

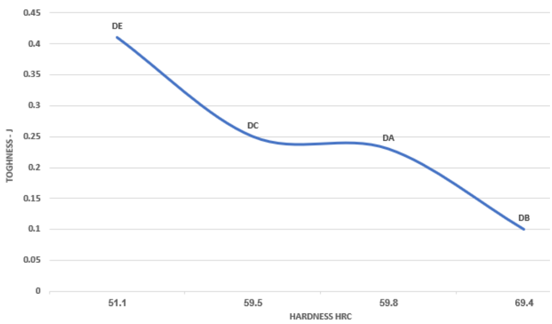


Fig. 17: Relationship between hardness and toughness.

Surface Texture Measurement Results

The surface roughness of the old dies and the dies used in the study are given in tables (5). The surface of the new dies was smothered than the surface of the old dies. These surface measurements were carried out to avoid fatigue problem.

Table 5: Surface Roughness Values for Da, Db, Dc, and De.

Location	The Value of Surface Roughness (**µm**)							
	Da		Db		Dc		De	
	Punch	Die block	Punch	Die block	Punch	Die block	Punch	Die block
1	0.40	0.48	0.40	0.47	0.39	0.44	0.40	0.46
2	0.42	0.49	0.40	0.47	0.40	0.45	0.42	0.46
3	0.41	0.48	0.41	0.48	0.40	0.45	0.40	0.45
Average	0.41	0.483	0.40	0.473	0.396	0.446	0.41	0.456

Chemical Analyses

In this study the chemical compositions of these alloys are shown in table 6.

Table 6: Chemical composition analysis of Da

Element	C	Mn	Si	Cr	Ni	V	Fe
Content%	1.031	0.207	0.452	0.112	0.107	0.054	97.98

Productivity

Table (7) shows the productivity results of different dies used in this work compared with dies produced by Bani Waleed Industrial Factory.

However, the optimum productivity of the old dies made by Da is 430 pieces.

Table 7: Productivity Results

Dies	Germany W.Nr.	AISI	Cutting clearance	effect Length of punch	Angle	Productivity	No. Defects	Defect percentage
Da	1.1550	W1	0.008mm	15mm	0°	430	37	8.6%
Db	1.1550	W1	0.009mm	15mm	0°	65	3	4.6%
Dc	1.1550	W1	0.009mm	28mm	0°	80	6	7.5%
De	1.1550	W1	0.008mm	15mm	0°	85	9	10.6%

Conclusion

Through this work and from the chemical analysis of the metal used in the manufacture of the die, it was found that the percentage of chromium is low, and this affects the wear resistance, so it is necessary to choose another metal that is better to obtain high productivity. It was also found that the clearance in the die used is insufficient and small in relation to the thickness of the insurance to be cut, and this increases the pressure on the edges of the pieces in the die and leads to rapid wear. We expect that increasing the length of the bunch to solve the problem is not an appropriate option because this increase weakens the bending resistance of the bench. We advise the factory administration to make dies from other materials, pay attention to the bunch design, and choose a suitable clearance in the die.

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