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Select the Optimum Die Design for Flange Coupling Forming By Hot Forging

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***Abstract* - In this study, dies are designed and manufactured to produce a flange coupling with hot-closed forging process to select the optimal die by comparing the locations of flash. The study was carried out computationally using DEFORM 3D program in two stages. The first one was used to obtain a work piece with suitable dimensions used in the final stage of the forming process to prevent the defects of the forming process. Through the simulation process for all the proposed dies, the results of forming load, effective stress, strain effective and movement of metal particles were compared for optimum die. Experimentally, the forging process was carried out on a mechanical forging machine for the optimal die according to the data obtained from the simulation program.**

Keywords: die design, simulation, flange coupling, forging, flash.

I. INTRODUCTION

Metal forming is a very important manufacturing process, as distortion occurs using a tool usually called a die in metal forming, which affects stresses that exceed the yield strength of the metal, so the metal is formed to take a shape determined by the geometry of the die. The effect of the temperature used in forming metals leads to a discrimination between cold forging, warm forging and hot forging. There are other factors that affect the behavior of the metal in forming, such as friction, strain rate, and others [1]. The forging process is one of the important forming processes in which the metal is formed by compressive forces shed by pressing machines. The forging process is also considered one of the old methods used in the forming processes. This process was used in the past in manufacturing of coins, jewelry and some metal tools used at that time by hammering with tools made of stones [2]. A group of researchers studied the effect of the area of metal exit (flash) of the forging die by simulation methods on the forming load [3], The researchers proved that the load required for forming increases with the increase in the width of flash and decreases with the increase in the thickness of the flash. They also mentioned in their research the ease of changing the die design, as the cost and numerically effort are feasible compared to experiments in practice to reach the optimal design. As for the development of the design of the forge die using the DEFORM 3D program to produce two pieces of the connecting rod produced in the pressing stroke, it was conducted developed by C E Megharaj and etc.[4]. The researchers concluded that the design reached can reduce the pressing stroke time, as well as that the appropriate die design for forging can increase productivity. While used the finite element method [5] for the closed forging die to study the stresses, strain and temperatures of the product, as well as studying the stresses in the die by making several designs for the same die with changing the geometry of the excess metal exit area (flash) to reach a good design and accuracy in product dimensions. As for the study of the effect of the excess metal exit area on the die in the forging process using the finite element method carried out by [6], it was proved in their study that changing the thickness and width of the excess metal exit area (flash) has an effect on the forging die by causing plastic deformation in the die, which it leads to deformation in the product, depending on the type of metal used. While using the program Q Form 2D to simulate the design of a cold forging die to avoid folds inside the product, knowing the effect of stress and strain on the metal [7].In this study, a metal die was designed and manufactured for the production of the flange coupling by hot forging process in a closed die by using a mechanical method based on the die design schemes. The aim of the research is to design and manufacture the best metal die for the production of a flange coupling by the hot forging process using numerical simulation to reach the 0ptimum design for the forming die by studying the forming loads, stresses, metal flow, obtaining a good flow rate of the metal inside the die cavities and predicting errors and defects before they occur and bypassing them, and then manufacture the best die and validate it experimentally.

II. FINITE ELEMENT METHOD

In this study, DEFORM 3D was used to simulate the process of forming flange coupling. The forging process was numerically computationally done by using the finite element method. Initially, using AutoCAD program, the required parts were designed in 3D for each of the workpiece (billet), die (bottom die) and ppunch (top die) and stored in (STL) format. After that, each part was called to the simulation program,

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assembled together and made in preliminary contact with the upper die, work piece and lower die. Then the simulation was performed. Fig.1 shows a two-dimensional diagram of the proposed coupling.

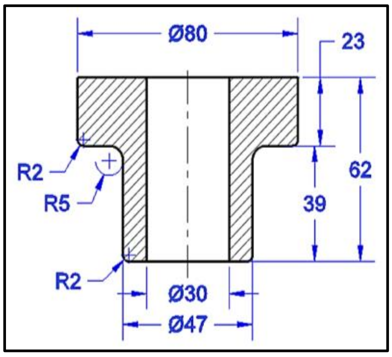

Figure 1: Two-dimensional diagram of the proposed coupling

The forging process was carried out in two stages, the first simulating the forming process with a primary die, which is the die that is used to change the shape of the work piece to the most appropriate shape for the final pressing process, The second stage, which is the final stage of the forming process, is carried out to obtain the final shape of the product. Two stages of the forming process are used to obtain the product with the least load of the forming process and to address some defects that appear if one die is used to carry out the entire forming steps.

Fig. 2 shows the simulation of the forming process for the first and second stages.

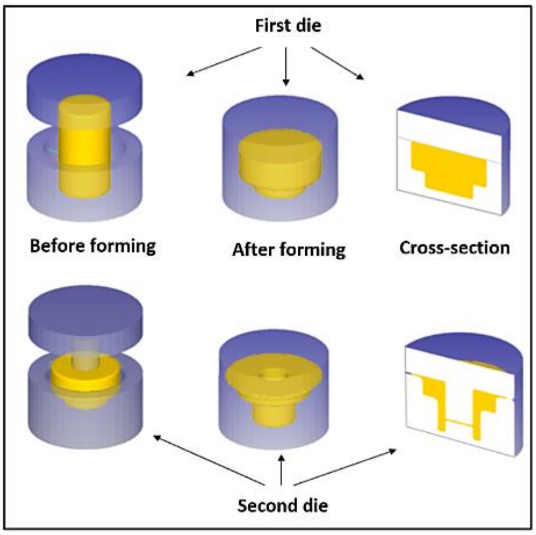

Figure 2: Simulation of the forming process for the first and second stages

Table 1 shows the parameters of the input data that are used in the simulation process for forming the hot forging work piece in the primary die to produce the primary product, with the appropriate dimensions to simulate the final forming process in the second die to produce the final product.

Table 1: Parameters of the process used in the simulation

Parameters	Name, Values
Billet material	M.S.
Billet length	93 mm
Billet diameter	45 mm
Billet temperature	1000°C
Top die temperature	150°C
Bottom die temperature	150°C

Fig. 3 shows the results of simulating flange coupling with the arrangement of the lower die, billet and upper die after final forming.

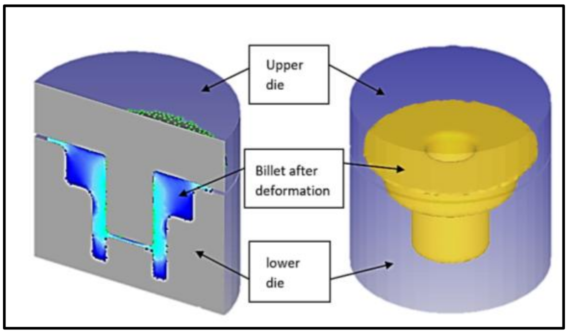

Figure 3: Results of simulation of flange coupling

In this study, many dies were designed and simulated. All of these designs were conducted in DEFORM 3D program and their results were compared to choose the best die design by changing the flash in the coupling flange when the punch meets the die in the center of the coupling as shown in Fig.4.The height of the upper part of the flanged coupling, which is 23 mm, was divided into five locations for the excess metal to exit (flash) from the top of the die (0, 5.75, 11.5, 17.25, 23mm) respectively, and five heights of the punch were designed (30,37.5,45,52.5,60mm) respectively to determine the flash between the two parts of the die.

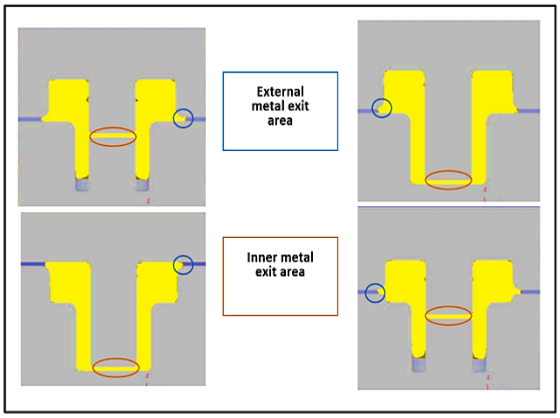

Figure 4: Locations of flash

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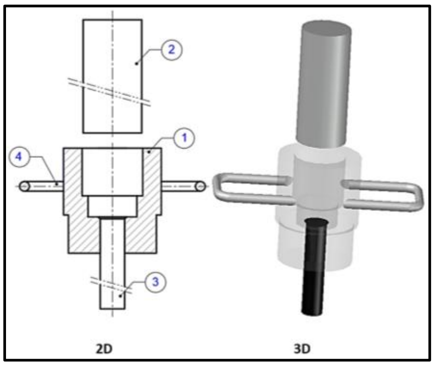
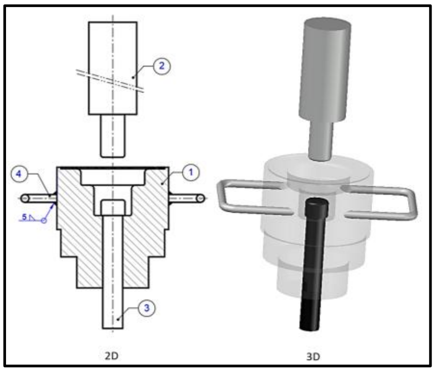
III. EXPERIMENTAL WORK

In the experimental work, two dies were designed and manufactured to produce the coupling in two stages. The first and second dies consist of the bottom part (bottom die), the upper part or the punch (top die), and the ejector as shown in Fig.5.In order to perform the hot forging process, an induction heating device was used, as the work piece was fixed inside the coil for a certain period of time until all parts of the work piece reached the required temperature (1000°C). Fig.6 shows the process of heating and pressing the workpiece used in the first stage, while Fig.7 shows the process of heating and pressing the resulting work piece of the first stage used as a workpiece in the final stage of the forming process.



(a)



(b)

Figure 5: The die used in the first stage (a) in the second stage (b)

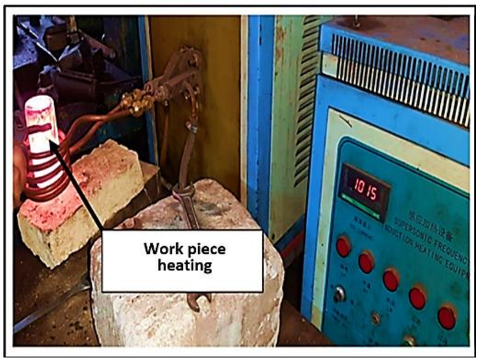


Figure 6: The process of heating and pressing the workpiece to perform the first forming process

Figure 7: Process of heating and pressing the workpiece resulting from the first pressing to perform the second forming process

Effect of the original volume of the flanged coupling on choosing the optimum die

The dimensions of the flange coupling selected in this study were measured in order to know its volume in order to use a work piece of the same original volume. After knowing the original volume of the flange coupling, a work piece was designed with the dimensions shown in Fig.8. all proposed dies were simulated. It was found that the products produced using the original volume contain defects as shown in Fig.9, in addition to the large load required to perform the hot forging process as shown in Fig.10.

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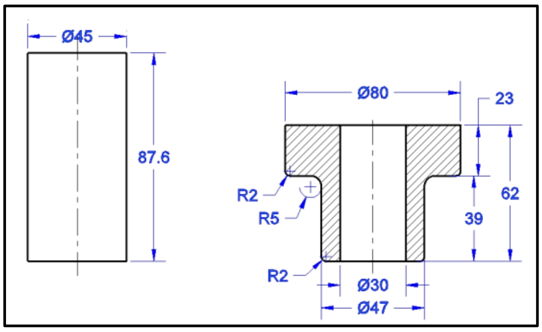

Figure 8: Using a workpiece of the same volume as the original coupling

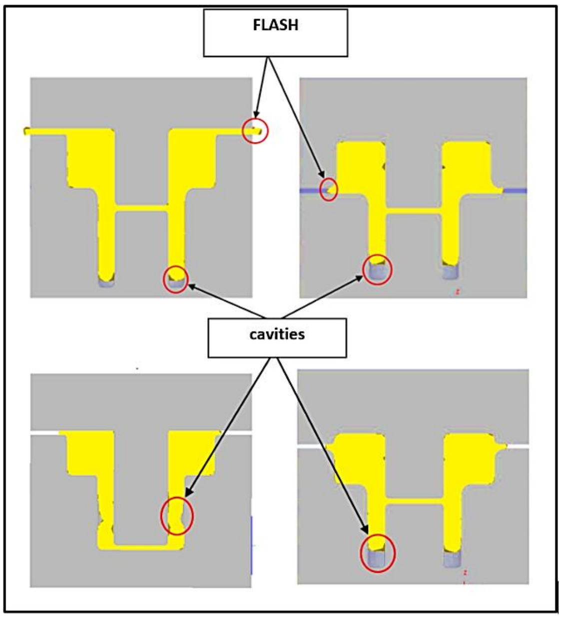

Figure 9: Product contains defects

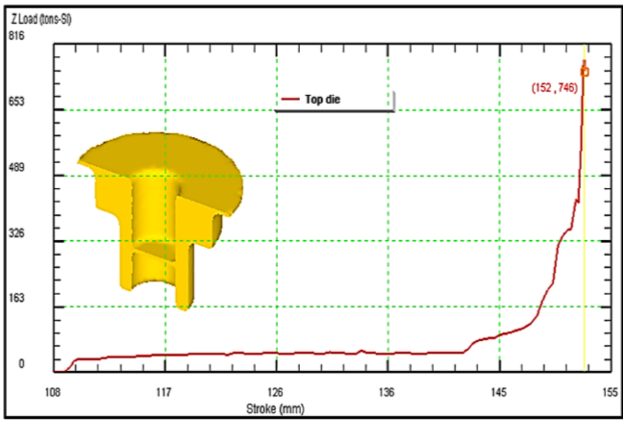

Figure 10: The required load for the formation

Effect of increasing the volume of the work piece on the choice of selecting the optimum die

An increase in the volume of the work piece used to produce the flange coupling was suggested to eliminate the defects that appear in the product such as incomplete filling of the die cavity and the high load required for the forming process. The process of increasing the volume was done by increasing the height of the work piece from (87.6) to the heights (90, 91, 92mm) respectively. The forming process has been simulated with the new heights and for all the proposed dies. While testing the simulated dies through the implementation of the pressing process, defects in the form of folds were observed in the product due to the increase in the height of the work piece, as shown in Fig.11.Furthermore, previous defects in some dies were observed.

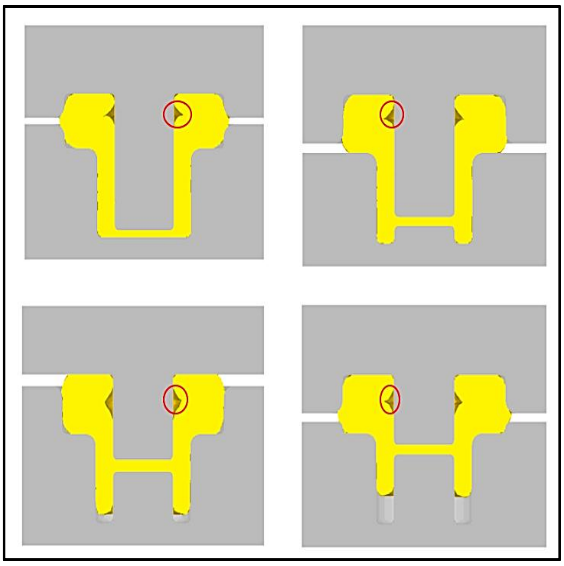

Figure 11: Appearance of defects in the form of folds in the product

Effect of adding an initial die on choosing the optimum die

After the proposal of conducting the forming process in two stages by adding a preliminary die to prevent defects in the previous tests for the production of the flanged coupling. The initial die is designed to produce a work piece that is used in the final forming process. The dimensions of the work piece used in the first forming process were adopted (diameter 45 mm and height 93 mm), and then the dimensions of the first die were chosen depending on the proportions of dimensions shown in Fig.12.It was approximately the optimum dimension was adopted as in No.5.Through a simulation of the hot forming process in the first stage, the workpiece for the second stage was obtained without defects, and as shown in Fig.13. A study was conducted for the required load in the first stage of forming and we found that the highest load required for forming is (387 tons) as shown inFig.14. After performing the first stage of the hot forming process, the product was obtained with the required dimensions, which is used as a work piece for the second stage. A simulation process was carried out for the final stage of the forming process and for all the proposed dies. It was noted that there are a group of successful products and other products that contain defects, therefore the best die was chosen from the last simulation

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process after comparing all the proposed dies with each other in terms of stresses, load and other study parameters.

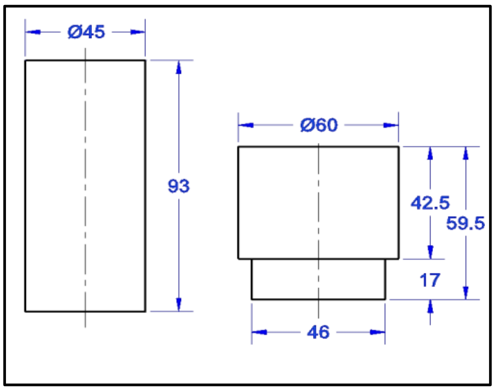

Figure 12: The work piece used in the first forming process with the work piece used in the final forming process

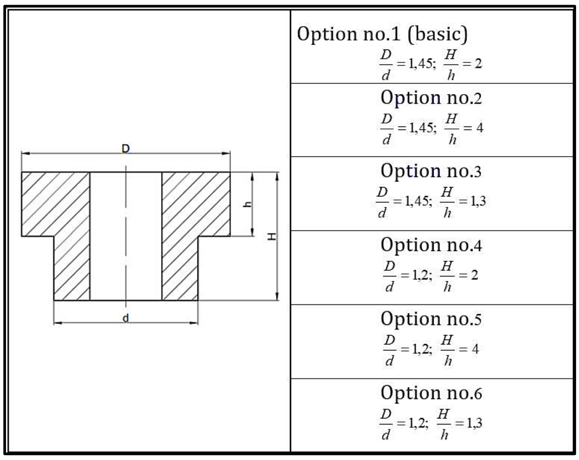

Figure 13: Choosing the dimensions of the initial die [8]

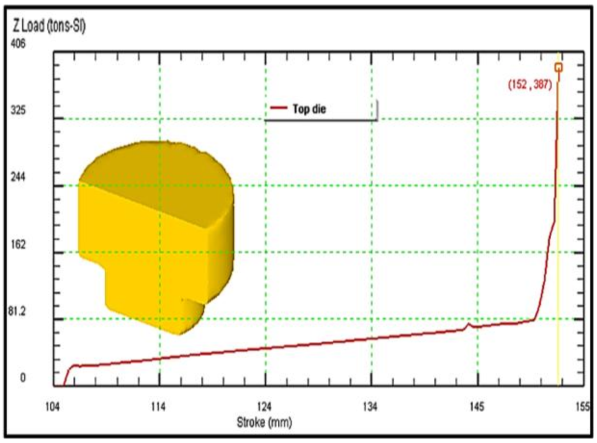

Figure 14: The load required for the first stage of shaping

Effect of location of excess metal on the load in the proposed molds

The load is one of the important parameters that must be calculated in order to know the capacity of the machine that must be available to produce the required piece. A study was conducted for the required load to produce the flange coupling for all the proposed dies, and after comparing the results for all the proposed dies shown in Fig.15, it was noted that the dies with the excess metal exit area at the five sites and at a punch height of 52.5 mm give the best loads regardless of the loads at height of punch 60mm, because of the height of punch is long and prone to fracture during the implementation of the forging process in practice. It was found that the required load for the best mold is (469 tons), as the comparison was made on the basis of choosing dies free of defects as well as the lowest value for the required load.

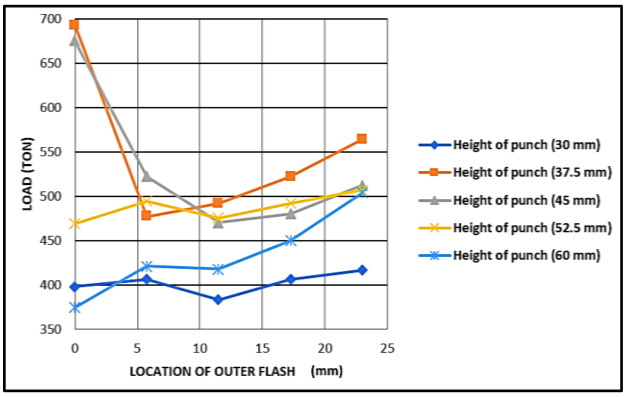

Figure 15: The largest formation load and locations of flash at different heights of the punch

Effect of excess metal locations on the effective stress in the proposed molds

The effect of effective stress distribution for all the proposed dies for the final forming process with hot forging was studied, and the best die was selected by excluding the dies that contain defects, as well as searching for the lowest effective stress value for the successful dies in the simulation process. Fig.16 shows all the maximum values for the effective stress of all the proposed dies. It was observed that the minimum effective stress value for the best die is (118MPa) at the excess metal exit area at the top of the flange of the flanged coupling and at the piston height 52.5 mm).

Effect of excess metal locations on the effective strain in the proposed molds

In the simulation when forming the flange coupling, the effect of the effective strain distribution for all the proposed dies was studied and analyzed. The results were compared for all dies and excluding dies that could not be implemented practically and dies that contain defects. It was noted that the best die had the excess metal exit area at the top of the coupling flange and at the piston contact area in the center of the coupling with a height of 52.5 mm. Fig.17 shows all values of effective strain, and it was noted that the best die had effective strain value (7.2MPa).

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Effect of location of excess metal on the flow motion of metal particles in the proposed molds

The movement and direction of the flow of the metal particles are major factors that must be observed during the forming process, after executing the simulation process for all the proposed dies to produce the flanged coupling. A comparison was made of the results of the movement of the metal particles as shown in Figure (18). To make the comparison, dies that contain design defects and dies that are difficult to manufacture in practice were excluded. It was found that the best die has the flash at the top of the coupling flange and at the meeting point of the punch in the middle of the coupling with a height of 52.5 mm. It was noted that the displacement value of the best die is (72.78 mm).

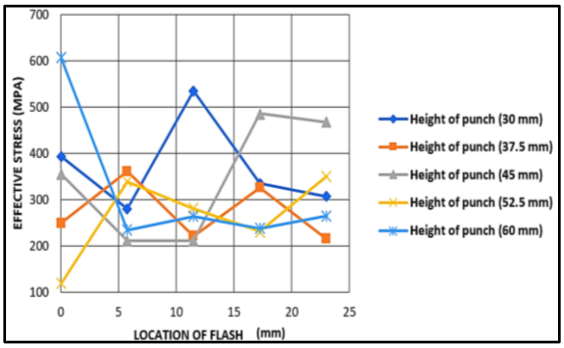

Figure 16: The minimum effective stress and locations of flash at different heights of the punch

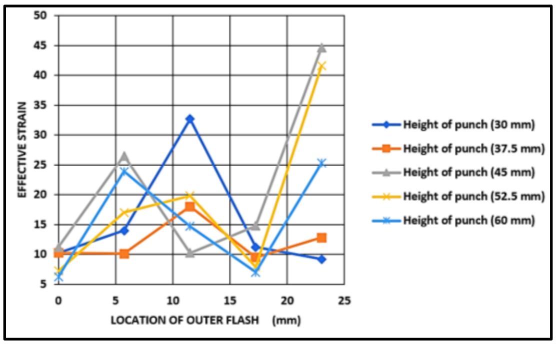

Figure 17: The minimum effective strain and locations of flash at different heights of the punch

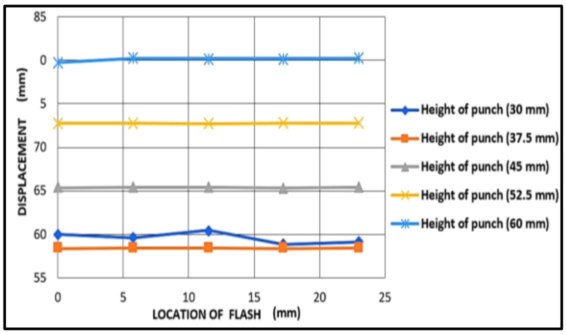

Figure 18: The minimum displacement of metal and locations of flash at different heights of the punch

IV. CONCLUSIONS

Through this study, it was found that the simulation method using the finite element method is the best way to reduce the time and cost required for design, as well as discovering defects in the forming process. A good die was obtained to produce the flanged coupling without production defects. The simulation process was carried out in two stages, as the first stage was used to obtain a work piece with suitable dimensions used in the final stage of the forming process to prevent the defects of the forming process. The results of forming load, effective stress, effective strain and movement of metal particles were compared to choose the optimal die, as it was noted that the best die design at the sites of flash in the coupling flange and at the height of the punch 52.5 mm. It was also noted that the best die has the flash at the top of the coupling flange and at the position of punch meeting in the middle of the coupling with a height of 52.5 mm. Experimentally, it was noticed that there were no problems in the product due to the agreement of the results in the simulation process with the experimental results of the hot forming process.

REFERENCES

[1] Mikell P. Groover, (2013), "Fundamentals of Modern Manufacturing Materials, Process and Systems", 5th Edition, John Wiley & Sons, Inc.

[2] Khaleed Hussain and etc., (2009),"A Study on Cold Forging Die Design Using Different Techniques", Modern Applied Science Journal, Vol. 3, No.3, p.143.

[3] M. Sedighi and etc., (2009), “Using FVM simulation and ANN to predict forging load for different gutter dimension in forging process”, Proceedings of the Third International Conference on Modeling, Simulation and Applied Optimization Sharjah, U.A.E.

[4] C E Megharaj and etc., (2016),” Design and Analysis of a Forging Die for Manufacturing of Multiple Connecting Rods”, IOP Conf. Series: Materials Science and Engineering.

[5] Dorin Luca, (2017), “A numerical solution for a closed die forging process”, Matec Web of Conferences.

[6] S. Javid Mirahmadi and etc., (2017), “Flash Gap Optimization in Precision Blade Forging”, International Journal of Mechanical Engineering and Robotics Research, vol.6, pp.200-206.

[7] Payman Abhari (2017), “Numerical simulation of cold forging process with enclosed dies to avoid folding defect in forming shape”, Mechanics and Advanced Technologies, vol. 2(80), pp. 71-77.

[8] Abdullah M.N., (2011), Increasing the efficiency of manufacturing flanged forgings on the basis of the

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