Journal of Mechanical Research and Application JMRA
ISSN: 2251-7383, eISSN: 2251-7391
Vol. 9, No.2, 2017, 1-7

The Review Study of Forging and Effects on the Produced Part

Maryam saleh *

Received: 3 May 2017 Accepted: 24 December 2017

Abstract: There are several method for forming bulk material, such as forging, rolling and extrusion. Every of these methods have advantages and dis-advantages of their selves. Forging process is one of the most common of them that include a die, press and in some case heater with controlling system, and has a special place in automotive, military and aerospace industries due uniformity of the final product, speed of process, repeatability and low final cost. Forging die has an upper and lower part. There are numerous studies about simulation, die design, load estimation, understanding and optimizing this process. In this article, forging is discussed briefly. This study is conducted in the field of process tools, analytical methods, simulation and result comparison of analytic, analysis and excremental conditions and also the effect of the forging in micro-structure and mechanical properties(such as tensile and hardness) in some cases studied briefly as a review of other researches.

Keywords: forging, simulation, analytical methods

1. Introduction

In recent decade, there are many research about forming. The purpose of these researches is increasing quality, optimization, achieve higher strength to weight ratio and improve the efficiency of the pieces, several forming methods have been developed for these goals achievement. These methods are classified into casting, bulk formation, bonding, sheet metal forming and machining processes. Bulk formation processes include forging, rolling, stretching and extrusion [1]. The schematic view of these processes are shown in Figure 1. Each of these processes can be used as cold, warm and hot, and the temperature range of each one is shown in Table 1. The most important factors for choosing type of process and working temperature depend on the number of part (production volume), workpiece material, raw material and final product geometry.

*. (PHD student. Ario Juan Co., Tehran, Iran(Email address: MARYAMSALEH186@yahoo.com)

Table 1.
Temperature range classification of the processes [1]

Process	$(T/T_m)^1$
Clod work	**<0.3**
Warm work	**0.3-0.5**
Hot work	**0.6<**

Figure 2 presents the relationship between the part size and achievable tolerance in different manufacturing methods.

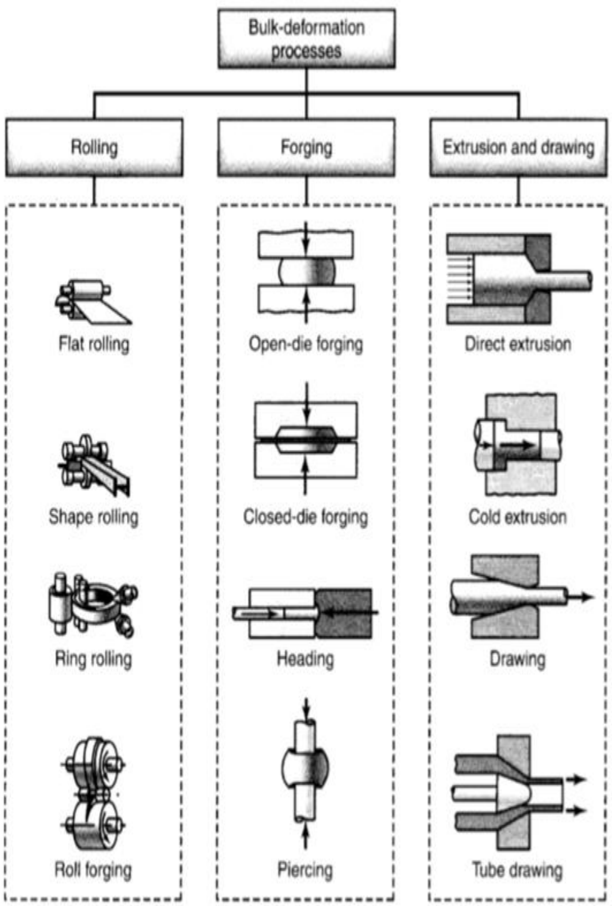


Figure 1- The schematics of bulk formation processes [1]

According to the figure 2 it can be observed that the accessible tolerance range of cold work is better than the warm work

and the best (least) tolerances will be achieved in micro-machining.

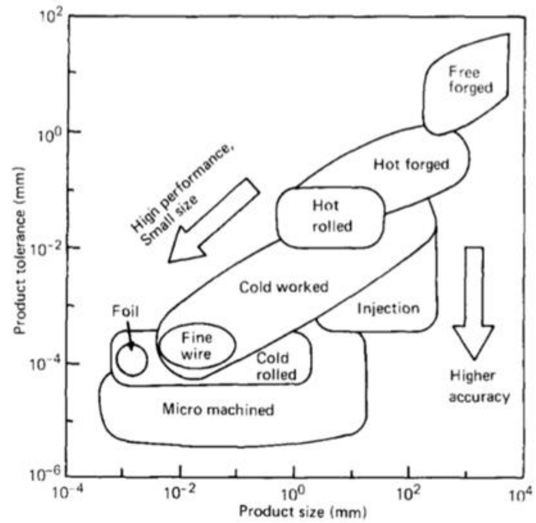


Figure 2 comparison between achievable tolerances of different manufacturing process [2]

1. Analyzing forging process

Two dies used in forging process that named upper and lower dies. Forming process include placing workpiece between dies and applying force to it by impact press to shape final part. The forming process may be single or multi-stage. A mentioned before, this process can be done as cold, warm or hot work[3, 4].

The manufactured part surface roughness in cold forging is better than hot forging and it will has not thermal defects. Surface roughness and geometrical tolerances in warm forging are better than hot forging and by using warm and hot methods compared to cold forging lower load needs for forming [3, 4].

In designing the forging process and choosing the press type some factors should be considering for example the workpiece material, temperature increase equipment, lubrication and heat treatment cycle [3, 4].

1. The ratio of process temperature to workpiece melt point temperature

2. Forging tools

Forging tools include: press, die lubrication systems. The heating device and temperature control systems are also added in case of warm and hot forging. The press used in this process is the impact press and its tonnage depends on the deformation ratio, type of process in terms of warm or cold and the die geometry [5]. The die is usually prepared by tool steel with hardening ability and WCL and JXZG02 alloy are most common [6, 7]. The workpiece dimensional and geometrical tolerance depend on the die build accuracy and as the die is made more precise, the final piece will be more precise. However it should be noted that not only the accuracy of the die structure but also the type of assembly and the guide's clearance and other parts will have a significant effects on the ultimate part accuracy [2]. Figure 3 shows a schematic view of the Close- forging die for an example.

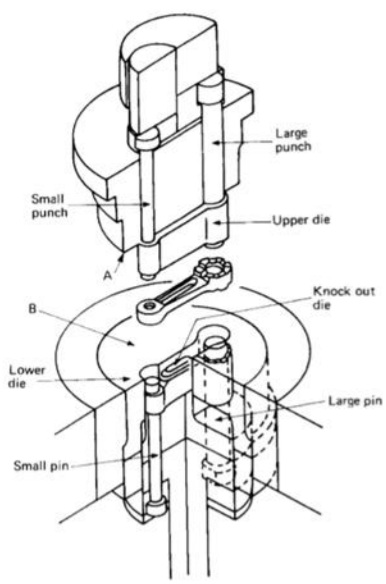


Figure 3 schematic of close die

Various methods can be considered for the production of a part; the method which is prior economically and flexibly is considered as the best production method [8]. Before performing the process at first it is necessary to assess the required tools As mentioned earlier, an impact press provide formation force in this process. Analytical methods and simulation software may use to analysis formation force and dies performance.

3. Analytical methods

Metal forming problems usually analyzed by three different method:

- The upper bound
- Slip line field
- Slab method

The upper bound approach based on estimating the external work with the internal consumed energy for deformation [9]. The slip line field method based on deformation area, in this approach planes with maximum shear stress formed slip lines. This is good method to analysis sticking friction and/with plane strain problems [7]. The slab method is suitable for compressive plane strain problems and estimating the role of friction [10]. Jian and Dong used the upper bound analysis for forging method and found that this method is in a good agreement with the finite element and experimental results [9].

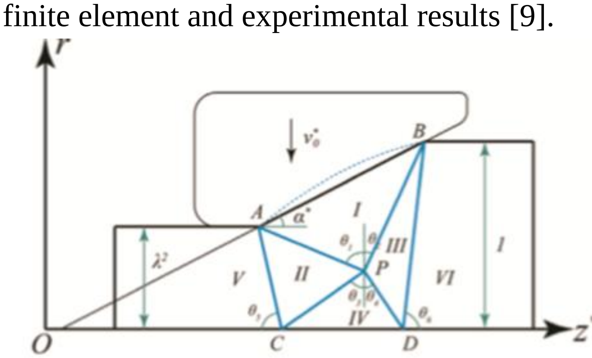


Figure 4 slip line field of forging[9]

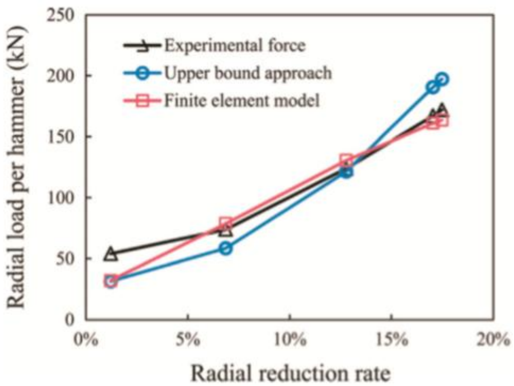


Figure 5 Comparing different methods of analysis and testing[9]

Figure 5 contain the comparison of experimental and analytical result for this study.

4. Simulation

Another method used to estimate the forging force and analyze the process is the finite element method and simulation by its software such as Forge 2011 [9] or Poly works[7]. These software in addition to the analysis of the force and stress could be used to calculate the tool corrosion type and location.

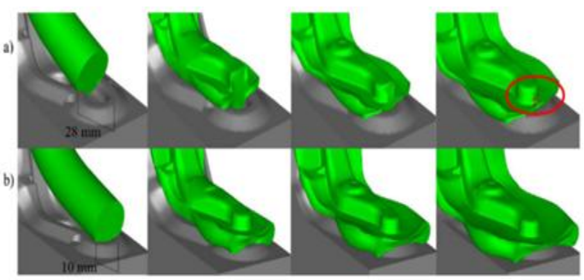


Figure 6- Filling the mold and forming the piece by /forge 2011[9

Lilly and Melligeri founded a dynamic model to estimate the forging force and reanalyzed the automation capability of the process by neural networks for open-die forge [11].

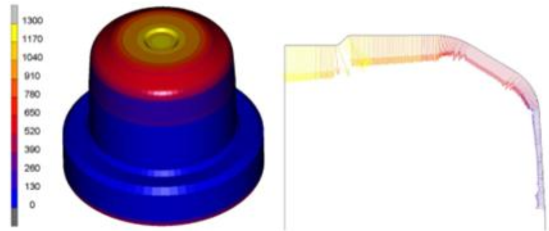


Figure 7- The diagram of stress applied on the tools during the process by poly works [7]

5. The effect on the micro-structure and mechanical properties

Forging like other mechanical work processes effects on the micro-structural of parts and this effect in hot or warm forming is much less than the cold work [10, 12].

Xiangsheng et al., evaluated the multidirectional forging of Mg-Gd-Y-Nd-Zr alloy and found microstructural changes on this alloy [10].

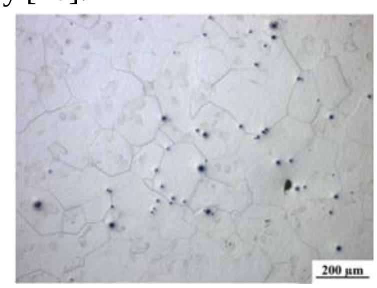


Figure 8- as-receive micro-structure [10]

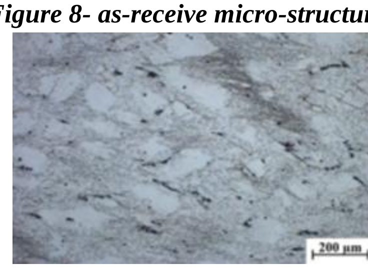
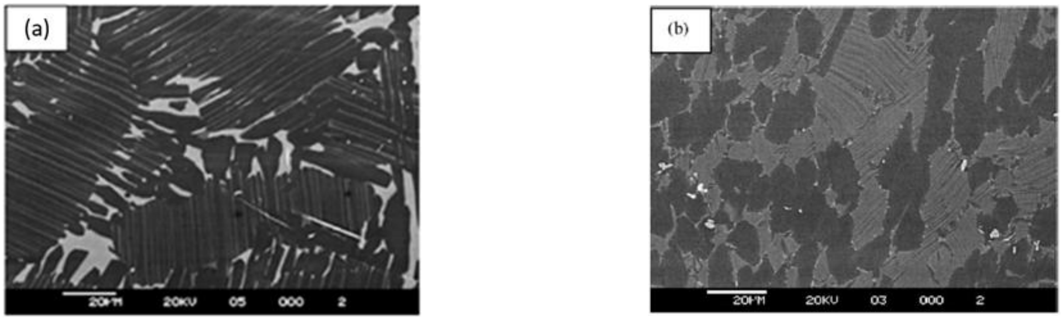


Figure 9- Micro-structure after forging [10]

Lin et al. studies the effect of forging and temperature on the micro-structure and mechanical properties of Ti-45Al- (8-9) Nb - (W, B, Y) alloy and found that the mechanical properties change depends on the temperature and with temperature increasing leads to increasing strength and reduction the value of UTS and YS. This reduction in the non-forged specimen is more than the forged one; thus it can be concluded that by performing the forging process the mechanical properties improved. Forging makes the structure more fine-grained [13].



[Figure 10- Microstructure of the piece: a)as- cast, b)as-forge [13

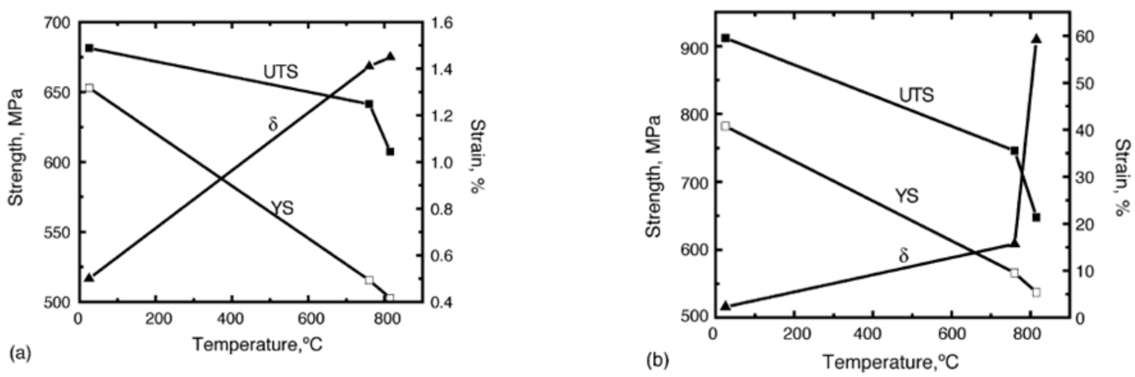


Figure 11- Comparing the tensile properties a)as- cast, b)as-forge [13]

Harandi et al. studied the effect of hot forging on micro-structure, mechanical properties and corrosion behavior of Mg - Ca alloy. This alloy is in bio-martial category and used in medical industry. They found that increasing α phase at higher temperatures leads to increasing hardness by increasing process speed and this has an increasing trend by raising the temperature and then it is reduced. Raising the temperature lead to more plastic deformation due to the increased active deformation plans in higher temperature. They found that reducing the grain size and increasing grain number leads to create more sites for attack by the corrosive element[12].

Figure 12 shows grain and their boundaries in different temperatures.

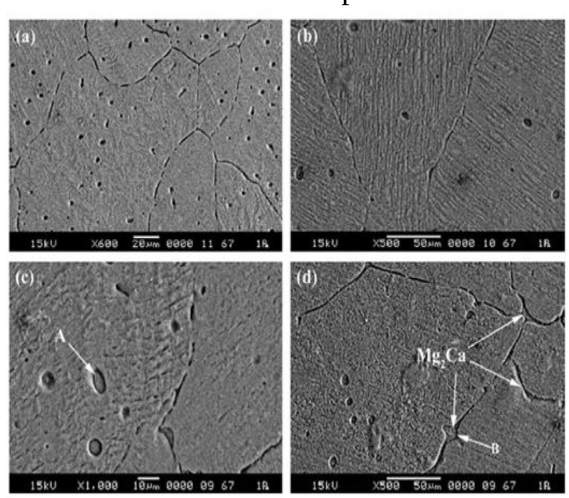


Figure 12- a) as-cast, b) 250 ˚ C, c) 350 ˚ C, d) 450 ˚ C [12]

Figures 14 and 15 present the changes in hardness in different temperature conditions and speeds.

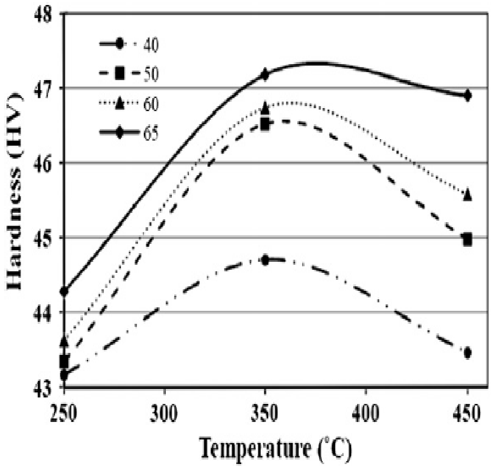


Figure 15- Hardness in different temperature[12]

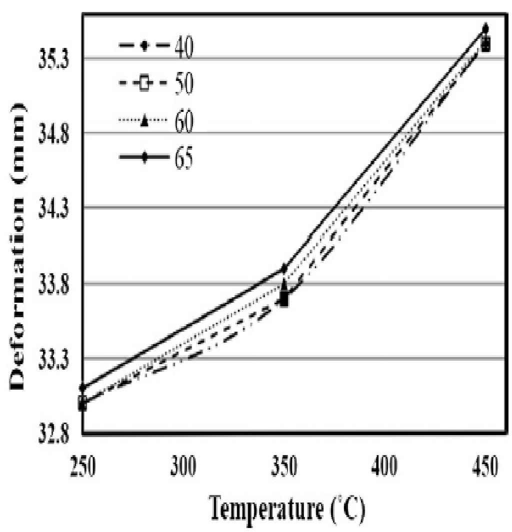


Figure 14- Deformation in different temperature[12]

Figure 16 presents the effect of process speed and its temperature on corrosion properties.

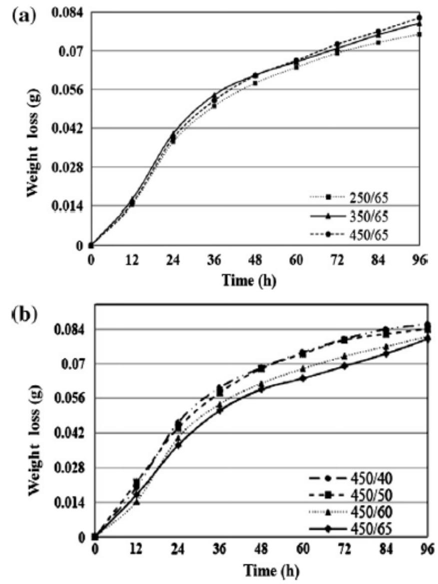


Figure 16) a)various temperature, B)various forging speed[12]

6. Conclusions:

According to the investigations it can be mentioned that the cold forging approach compared to the warm and hot forging produce part with better tolerance and roughness and while using the warm forging approach in addition to achieve acceptable roughness and tolerance forging force reduced.

The upper bound approach is used to analyze the forging problems and its results have well arranged with software simulation and experimental results.

Forging effects on the micro-structure and according Hal-Petch theory changes its mechanical properties occurred.

References

[1]. Kalpakjian, S., S.R. Schmid, and K.V. Sekar, *Manufacturing engineering and technology*. 2014: Pearson Upper Saddle River, NJ, USA.

[2]. Matsushita, T., *Improvement of equipment for close-tolerance forging and extrusion in Japan.* Journal of materials processing technology, 1990. **22**(3): p. 223-238.

[3]. Shivpuri, R., et al., *Recent advances in cold and warm forging process modeling techniques: selected examples.* Journal of materials processing technology, 1994. **46**(1-2): p. 253-274.

[4]. Ishinaga, N., *An advanced press design for cold forging.* Journal of materials processing technology, 1997. **71**(1): p. 100-104.

[5]. Wu, Y. and X. Dong, *Upper bound analysis of forging penetration in a radial forging process.* International Journal of Mechanical Sciences, 2015. **103**: p. 1-8.

[6]. Shen, L., et al., *Microstructure and mechanical properties of hot forging die manufactured by bimetal-layer surfacing technology.* Journal of Materials Processing Technology, 2017. **239**: p. 147-159.

[7]. Hawryluk, M., et al., *Analysis of the wear of forging tools surface layer after hybrid surface treatment.* International Journal of Machine Tools and Manufacture, 2017. **114**: p. 60-71.

[8]. Tayal, S., *Engineering design process.* International Journal of Computer Science and Communication Engineering, 2013: p. 1-5.

[9]. Hawryluk, M. and J. Jakubik, *Analysis of forging defects for selected industrial die forging processes.* Engineering Failure Analysis, 2016. **59**: p. 396-409.

[10]. Xia, X., et al., *Microstructure, texture and mechanical properties of coarse-grained Mg–Gd–Y–Nd–Zr alloy processed by multidirectional forging.* Journal of Alloys and Compounds, 2015. **623**: p. 62-68.

[11]. Lilly, K. and A. Melligeri, *Dynamic simulation and neural network compliance control of an intelligent forging center.* Journal of Intelligent & Robotic Systems, 1996. **17**(1): p. 81-99.

[12]. Harandi, S.E., M.H. Idris, and H. Jafari, *Effect of forging process on microstructure, mechanical and corrosion properties of biodegradable Mg–1Ca alloy.* Materials & Design, 2011. **32**(5): p. 2596-2603.

[13]. Xu, X., et al., *Effect of forging on microstructure and tensile properties of Ti-45Al-(8–9) Nb-(W, B, Y) alloy.* Journal of Alloys and Compounds, 2006. **414**(1): p. 175-180.