International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 11 Nov 2021, pp: 724-727 www.ijaem.net ISSN: 2395-5252

Recent Advances in various types of forging- A research review

S. Wangchuk[1,a*], H. Mehta[2,b], V. Singh[3,c], A. Kumar[4,d], AK. Madan[5,e]

[123]Production and Industrial Engineering, Department of Mechanical Engineering, Delhi Technological University, Bawana Road, ShahbadDaulatpur, Rohini, Delhi 110042, India,

Submitted: 10-11-2021 Revised: 21-11-2021 Accepted: 24-11-2021

ABSTRACT
Forging is one of the famous and primitive sorts of manufacturing processes. The history of forging dates to even earlier than 4000BC which involved a couple of hand tools and anvils called smith forging which relied on hits and trials requiring huge skills and high precisions. These days, the forging tools, operations, and methods are automated and power-driven. In this research, the recent developments and advancements in various forging processes are analyzed by reading various research papers and journals of the last two decades. The papers were evaluated for substantial upgrades in precision and technologies. The use of power hammers, artificial intelligence such as the use of robotics, computer numerical controls (CNCs) has made forging a drastic shift towards mechanization. This review will help to highlight the recent progress of the forging processes and act as an easy guide to encapsulate the recent optimization of various processes.

Keywords: Forging, power hammers, artificial intelligence, computer numerical controls, optimization.

I. INTRODUCTION

The manufacturing process which involves the shaping of metals by use of compressive power is termed forging. Warm, cold, and hot are the three types of forging that are named based on the temperature which is done [1]. It is an effective method of producing workpieces of various shapes of discrete parts. It includes bolts, rivets, crane hooks, connecting rods, gears, turbine shafts, hand tools, railroads [2]. Forging parts are used from early times but their demand drastically increased during the industrial revolution for developing new technologies and improvements of mechanical properties of the material [1]. Forged parts are considered better than casting due to grain flow [1,2].

II. IMPORTANCE OF FORGING

Forging techniques have various significances. The forging process is an economical manufacturing process and increases mechanical properties like strength, toughness, and hardness [5]. Moreover, can reduce defects of casting (porosities, cavities) thus obtaining almost perfect workpieces by ensuring uniform plastic strain throughout the job [14,15].

Forging allows varieties of metals and alloys to be forged such as Aluminium, Copper, Magnesium, Carbon and low steels, Nickel, and Titanium alloys [1]. It produces heavy-duty components and versatile dimensions of workpieces [3].

III. HISTORY OF FORGING PROCESS

The art of forging dates to as early as 4000BC.Blacksmiths are early pioneers of forging processes. It involved self-skills and manual work. Hammers are lifted by hands placing work pieces on anvil and hydraulic energies were used by some blacksmiths at their workplace. Some of the forging that time constituted of set hammer, anvil, swage block, tongs, hammer, hot set, heading tools, fullers, flatters, punches, and drifts. The energy sources used in early forging processes included the charcoal to heat metal piece up to certain forging temperature [1]. Toward the end of the 19th century the simultaneous development of the open-hearth steel making processes were employed making forging industry now had a reliable, low-cost volume raw material [12]. Some of furnace types are continuous and batch type, box type, muffle types and electric resistance heated furnaces [1].

1. Open die-forging process

Open die forging is an essential forging technology mainly employed to produce large components with improved tensile properties and

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 11 Nov 2021, pp: 724-727 www.ijaem.net ISSN: 2395-5252

toughness behavior together with reliability of the forged parts [6].It involves pressing of workpiece using dies of various shapes: V-shape or concave. The job undergoes a plastic deformation at high temperature followed by presses of multiple strokes along feed direction. It leads to change internal and geometric properties of workpiece [14]. It is mainly used to produce large parts with good mechanical properties and reliability [5].

In the past, the common idea of the work was to develop a process model which can merge data from online measurements and plasto-mechanical model for determination of equivalent strain, strain rate and core temperature of the workpiece [14]. The Artificial Neural Network (ANN), an algorithm developed are used mainly to calculate optimum number of passes for reduction of forging cycle and economization of power. A new formulation of ANN is employed to quickly evaluate plastic strain at the core of job. The correct evaluation of plastic strain can improve the internal integrity of material and optimization of microstructures [7].

2. Impression die forging

It uses slapped die for controlling metal flow. The heated metal is located at the lower cavity and one or more blows are attached on upper part of die. The metal flows when hammered and die cavity is filled completely. Excess metal is squeezed out around the periphery of the cavity. The flash formed is cleared out (by trimming) with trimming die. It contains different die cavities. The final shape to job is obtained by subjecting to series of cavities in the die set. The die cavities are designed in such a way that the metal flows evenly so that desired shape is obtained according to die cavities [16].

It is modified to auto forging. In this the metal piece is removed from the mold while it is hot. It is trimmed later like old techniques. The transferring from mold to die, forging and trimming are highly mechanized perhaps called Auto forging [19].

3. Isothermal forging processes

Die chilling involves the flow of metals from workpiece to die surfaces resulting in thermal gradients in the job. The plastic deformation is not uniform as the colder places of die areas has flow as compared to the hotter core areas. It is commonly heated to maximum temperature of (400 to 500)◦F [205-260◦F]. The chilling is reduced by using speed forging machines, hammers, screw, and mechanical presses. The use of glass lubricants also reduces thermal chilling processes. The die is heated to certain temperature equal to that of workpiece hence reducing chilling. It is called isothermal forging [17].

Defense Research and Development Organization (DRDO) has established isothermal forging processes such as high-pressure compressors (HPC) for deforming titanium alloy. The technology developed by Defense Metallurgy Research Laboratory (DMRL) a premier metallurgical Laboratory of DRDO at Hyderabad. It established self-reliance in the aerospace industry [8,10].

4. Press forging process

Press forging is the technique of shaping of metal by placing between two dies through mechanical or hydraulic pressure. It is done in forge press, a machine which applies gradual pressure in each die. The shape of workpiece is obtained by single stroke of pressure in each die among series of successive aligned dies [11].
It is mostly used for carrying out heavy forging of large sections of metal by using hydraulic presses. A continuous pressure by series of hydraulic presses makes deformation of job uniform. Hydraulic presses are available in capacity of 5-500MN but 10-100MN range are commonly used [9]. Press forging needs less flash and draft compared to open forging. Its applications are coining and hubbing [11].

In last two decades, it has emerged as alternative technique in manufacturing thin-walled electronic components of magnesium alloys. The process squeezes a thick sheet along pressure direction which is different from traditional ways of using thick sheets [18].

5. Upset forging

The upset forging involves increasing the cross section of metal piece in expense of its length. It was developed initially for producing continuous bolt heads. Parts are upset-forged from bars and rods of up to 200mm in both cold and hot conditions. Some of parts forged by this technique includes nails, valves, fasteners, and couplings [9].

Recently, upset forging is done for producing cylindrical billets having different frictional conditions at two die surfaces [1].

6. Roll forging process

Roll forming is mainly performed under hot conditions. It is of two types depending upon types of shape and tool set up and motions. They are discussed as below:

- **Longitudinal rolling:** the job undergoes translational motion between two spinning tools. The translational motion takes place parallel to the axis of the work;

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 11 Nov 2021, pp: 724-727 www.ijaem.net ISSN: 2395-5252

- **Cross rolling:** the work rotates between two tools which is set to same rotary motion as job. The point contact between tools and workpiece makes job to move along the plane perpendicular to axis of the work;

- **Helical rolling:** the work piece is subjected to both translational and rotary motions where rolls also rotating at same direction. The points if contact between work and tools results in central motion [4].

Roll forging is now used to make reductions in cross-sections and distribution of a metal of billet which reduces extensive work using forging hammers or presses [20].

7. Net shape or near net-shape forging

In this forging, the metal deformation takes place in the cavity where no flash is formed, and final dimensions are very accurate. Its produces parts that would require least or no machining process to complete. It can produce stronger components which can improve performance of engine [I]. The process uses dies with greater dimensional accuracy than any other dies which also requires high driving power. Typical parts forged by this method includes gears, turbine lades, fuel injection nozzles, and barring castings [19].

It is an alternative for open die forging [19].

In the last decade, CAD, CNC technologies and innovation in materials have contributed enormously on the development of NNS (Near net shape forging) technologies[13].

Meleform Flo- forge is an automated near net shape forging technology which requires no applied force but instead only one hydraulic cylinder. It also uses modular furnaces to maintain uniform die temperature [21].

IV. CONCLUSION

From this short review study, it can be summarized that various advances in different categories of forging technologies have been employed through various advances in science and technologies. In each technique starting from forging at early age, it has been observed that the methodologies have been enhanced requiring minimal manual human work force. Moreover, it should be noted that forging time and quality of forged parts are being drastically optimized forgreater productivity with minimal defects in finished forged components.

REFERENCES

[1]. Shalok Bharti, "Advancement in Forging Process: A Review", International Journal of Science and Research (IJSR), https://www.ijsr.net/get_abstract.php?paper_id=ART20178736, Volume 6 Issue 12, December 2017, 465 - 468
[2]. Mr.Praveena R, Mr.Abhishek C R, Mr. MujeburRehaman, Mr. Bharath Gowda G, 2019, Study on Development of an Automated Open Die Forging Machine, International Journal Of Engineering Research & Technology (Ijert) Ncmpc – 2019 (Volume 7, Issue 07)
[3]. Gontarz A. Forming process of valve drop forging with three cavities. Journal of Materials Processing Technology. 2006;177(1-3):228–32.
[4]. Pater Z, Tofil A. Overview of the research on roll forging processes. Advances in Science and Technology Research Journal. 2017Jun1;11(2):72–86.
[5]. Mancini S, Langellotto L, ZangariG,Maccaglia R, Schino A. Optimization of open die ironing process through artificial neural network for rapid process simulation. Metals.2020Oct21;10(10):1397–411.
[6]. Di Schino A. Open die forging process simulation: A simplified industrial approach based on Artificial Neural Network. AIMS Materials Science. 2021Sep9;8(5):685–97.
[7]. Kim, P.H.; Chun, M.S.; Yi, J.J.; Moon, Y.H. Pass schedule algorithms for hot open die forging. J. Mater. Process. Technol. 2002, 130, 516–523.
[8]. Raghu T, I Balasundar I, Rao M. Isothermal and near isothermal processing of titanium alloys. Defence Science Journal. 2011Jan6;61(1):72–80.
[9]. Prashant. FORGING. Lucknow, Uttar Pradesh: LucknowUniversity.
[10]. Ministry of Defense. (2021, May 28). DRDO develops critical near isothermal forging technology for aeroengines: Defence research and development organisation - DRDO, Ministry of Defence, Government of India. DRDO develops Critical Near Isothermal Forging Technology for aeroengines | Defence Research and Development Organisation - DRDO, Ministry of Defence, Government of India. Retrieved October 11, 2021, from https://www.drdo.gov.in/press-release/drdo-develops-critical-near-isothermal-forging-technology-aeroengines.

[11]. Analytik, F. I. O. N. I. C. O. N., Instruments, F. T. A., Technologies, F. Y. F. I., Solutions, F. H. C. S., Corporation, F. S., Ltd., F. B. I., & Radleys, F. (2019, August 1). Press forging – metallurgical processes. AZoM.com. Retrieved October 11, 2021, from https://www.azom.com/article.aspx?ArticleID=9696.

[12]. Analytik, F. I. O. N. I. C. O. N., Instruments, F. T. A., Technologies, F. Y. F. I., Solutions, F. H. C. S., Corporation, F. S., Ltd., F. B. I., & Radleys, F. (2017, August 1). Forging - history and key developments in the metals forging industry. AZoM.com. Retrieved October 11, 2021, from https://www.azom.com/article.aspx?ArticleID=2195.

[13]. Marini, D., Cunningham, D., &Corney, J. R. (2017). Near net shape manufacturing of metal: A review of approaches and their evolutions. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 232(4), 650–669. https://doi.org/10.1177/0954405417708220.

[14]. Sharma, D.K.; Filipponi, M.; Di Schino, A.; Rossi, F.; Castaldi, J. Corrosion behavior of high temperature fuel cells: Issues for materials selection. Metalurgija 2019, 58, 347–351.

[15]. Wolfgarten, M.; Rosenstock, D.; Schaeffer, L.; Hirt, G. Implementation of an open-die forging process for large hollow shafts for wind power plants with respect to an optimized microstructure. AIM 2015, 107, 43–49.

[16]. Virginia Polytechnic Institute and State University. (2011). Hot-rolling, cold-forming; extrusion, and forging .Structure And Form Analysis System (SAFAS). Retrieved October 2, 2021, from https://www.setareh.arch.vt.edu/safas/007_fdmtl_34_roling_extrusion_forging.html.

[17]. Forging Industry Educational and Research Foundation. (2020, January 12). 5.2.2.4 hot die and isothermal forging: Forging Industry Association. 5.2.2.4 Hot Die and Isothermal Forging | Forging Industry Association. Retrieved October 5, 2021, from https://www.forging.org/forging/design/5224-hot-die-and-isothermal-forging.html.

[18]. Chen, F.-K., Huang, T.-B., & Wang, S.-J. (2007). A study of flow-through phenomenon in the press forging of magnesium-alloy sheets. Journal of Materials Processing Technology, 187-188, 770–774. https://doi.org/10.1016/j.jmatprotec.2006.11.192

[19]. Shan, H. S. Prof. (2009, December 31). Mechanical Engineering - Manufacturing Processes I. NPTEL(The National Programme on Technology Enhanced Learning) . Retrieved October 7, 2021, from https://nptel.ac.in/courses/112/107/112107144/.

[20]. A Text Book of Production Technology, O.P. Khanna, M. Lal; Dhanpat Rai Publication, pp. 16.24 - 16.31, 16.49, 16.53.

[21]. Di Schino, A. (2021). Open die forging process simulation: A simplified industrial approach based on Artificial Neural Network. AIMS Materials Science, 8(5), 685–697. https://doi.org/10.3934/matersci.2021041