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Comparative Study between Hydroforming and Hot Stamping

Rohan R. Paradkar[1], Onkar S. Aloni[2], Sandhya M.Umre[3]
[1, 2.]*Student,* [3]*Assistant Professor, Dept. of Mechanical Engineering, St.Vincent Pallotti College of Engineering and Technology, Nagpur, India*

Abstract: ***Nowadays the requirement of a pollution free (eco-friendly) manufacturing technology is need of the hour, because of the increase in global warming. This research paper describes the advantages of hydroforming over hot stamping process with the help of comparative study on some important aspects. Hydroforming prototypes can be manufactured quickly and inexpensively, enabling a smoother testing process and faster implementation of design improvements. This process saves resources and energy because it leaves no carbon dioxide emissions. Production is carried out with the help of hydraulic pressure and minimal heating.***

I. INTRODUCTION

Hydroforming is defined as a metal forming process using fluid dynamics. The result of which is a lightweight, structurally strong, and hard part of the original metal. Hydroforming became widespread in the early 1900s when the automotive industry began to take root in the United States. This process provided automakers with a more desirable alternative to die set casting. More post-treatment was involved in manufacturing these parts, and due to metal elongation and excessive handling, structurally sound parts could not be manufactured. The Hydroforming Tool was born because of the in-depth research and development of the Cincinnati Milling Machine Company, founded by Geiger and Holtz in 1889. In the 1930s, the Cincinnati Milling Company was a major supplier of metal forming machines in the United States and Europe. As the demand for molded metal parts increased, the Cincinnati Milling Machine Company began developing deep drawing technology using illuminated reflectors and gear case covers. The company was reorganized into Cincinnati Miracron in 1956, accelerating research and development of the hydroforming process. This has given shape to a more sophisticated form of hydroforming. As a result, the old method of deep drawing has become obsolete, and more modern hydroforming techniques have begun to take the lead. By the 1970s, hydroforming was officially out of the early stages. These hydroforming machines reduce the need for excessive finishing of metal parts, thereby reducing part turnaround times, improving efficiency, and reducing the number of personnel required to produce high quality products.

II. LITERATURE REVIEW

1) Pereira, André Luiz & Freitas, Rodrigo & Marcial, Mauro & Yamada, William & Orfale, Eduardo. (2013). Sheet Metal Performance: Hot Stamping and Hydroforming Process Contributions for INOVAR Auto Program. SAE Technical Papers. 13. 10.4271/2013-36-0227. - This article has summarized an overview of the hot stamping and hydroforming processes with the aim of demonstrating potential uses in current Brazilian vehicles. It was explained in the theoretical background of both processes, and finally their usage. This paper reveals an existing gap in technical knowledge used by OEM subsidiaries on national territories.
2) Bell, C., Corney, J., Zuelli, N., & Savings, D. (2020). A state-of-the-art review of hydroforming technology. International Journal of Material Forming, 13(5), 789- 828. - The paper concludes with a discussion of the future of hydroforming, including current state-of-the-art technologies, research directions, and process benefits that help predict new hydroforming technologies.
3) Zhang, S. H., Wang, Z. R., Xu, Y., Wang, Z. T., & Zhou, L. X. (2004). Recent developments in sheet hydroforming technology. Journal of Materials Processing Technology, 151(1-3), 237-241. - This paper summarizes the recent developments in seat hydroforming technology, analyzes some important technical issues that need to be resolved for the development of seat hydroforming technology, and describes various seat hydroforming techniques.
4) Karbasian, H., & Tekkaya, A. E. (2010). A review on hot stamping. Journal of Materials Processing Technology, 210(15), 2103-2118. - This article summarizes the cutting edge of the thermal, mechanical, ultrastructural, and technical fields of hot stamping. Describes the investigation of the entire process sequence, from heating the blank to hot embossing and subsequent further processes.

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5) Kang, B. S., Son, B. M., & Kim, J. (2004). A comparative study of stamping and hydroforming processes for an automobile fuel tank using FEM. International Journal of Machine Tools and Manufacture, 44(1), 87-94. - This paper uses a commercially available explicit FEM code to compare the seat hydroforming molding process for manufacturing automotive fuel tanks with traditional stamping. A modeling methodology for the correlation between stamping and hydroforming has been proposed to obtain optimal process parameters for manufacturing solid hydroforming fuel tanks.

III. COMPARATIVE STUDY

A. *Hot Stamping*

1) *Process:* In hot stamping, the metal is heated in a furnace-like environment with an internal die. The oven is heated up to 2,000 degrees in a process that can take up to an hour. Then place the material between the male and female parts of the die and press the metal into a new shape. This process is ideal for small parts that cannot be cold moulded. Stamping have been used in the manufacture of consumer goods and products for a very long time. Some even believe that the history of metal stamping can be traced back to smithing, tin smithing, silversmithing and more. It's a venerable ancient process that deserves its place in history but is quickly overtaken by hydroforming. Each product in this process is stamped from blanks at a production rate of approximately 500 pieces per hour using mechanical or hydraulic stamping lines. Each component then goes through a die stamping, trimming, and moulding process, resulting in approximately 20% total waste. Then, finally, it is ready for assembly by MIG or spot welding. The entire process takes about 60 hours per assembly.

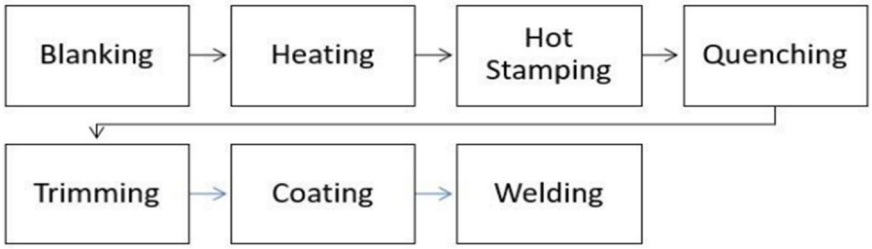


Figure 3.1: - Hot stamping process layout

2) *Environmental:* As furnaces are involved in this process, there is environmental hazard as toxic gases are released to the atmosphere through the furnace, there is 20% metal waste generated which ultimately affects the environment.
3) *Economical:* Metal stamping also generally requires the metal sheet to overlap the stamping tool by a specified amount for the tool to punch and form the material. Depending on the application, this process can generate more than 20% material waste.
4) *Time:* The average cycle time is 6-10 mins depending on the product.
5) *Tooling:* The tooling in steel stamping includes a male (core) 1/2 of and a female (cavity) 1/2 of. The time and fee to provide each half of the tooling can cause improved production charges and longer lead instances when you consider that extra time is wanted to layout and broaden the tooling.
6) *Design:* Design changes are difficult and costly to implement with metal stamping. You may need to create an entirely new tool to make changes. Redesigning and rebuilding the two parts of the mold can delay manufacturing times and increase manufacturing costs.
7) *Mechanical Properties:* It affects the martensitic transformation of the material due to austenite deformation. If the heating temperature and time is increased, the thickness of coating layer increases.

B. *Hydroforming*

1) *Process:* In comparison, sheet metal hydroforming (especially deep drawing and tubular processes) is a relatively new means of manufacturing load-bearing parts with complex shapes. However, it is becoming the preferred production base for many industries of various specific parts such as automobiles, plumbing and home appliances. Products that go through the hydroforming process start with the rolling section of the tube. It is usually pre-cut to the desired length and finished cut to each component. The computer numerical control (CNC) then begins to bend the tube into the desired shape and is hydroformed by a hydraulic press. Then remove the part from the press and trim it as needed (typically less than 10% waste, and in some cases zero).

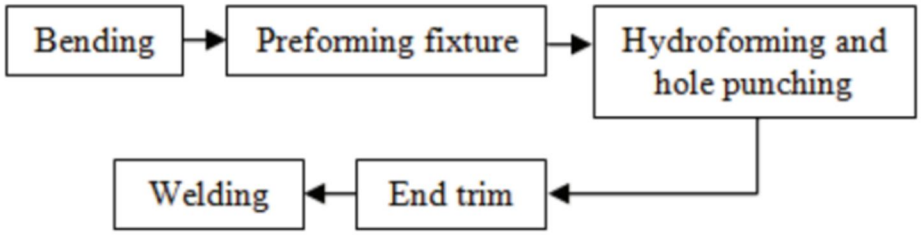


Figure 3.2: - Hydroforming process layout

2) *Environmental:* Hydroforming is an environmentally friendly process as the energy consumed for the process is very low compared to other processes, the forming force is water which can be re-used as there is no direct contact between the blank and the water, the environmentally harmful plastic parts or foundry parts are replaced by the metal ones, the raw material waste is reduced as the blank is already cut in the required shape, the waste produced can be reused, there is no emission in the process and the operations have very low noise levels.
3) *Economical:* When hydroforming the tube, the material can be pre-cut to the desired dimensions before feeding to the hydraulic press. As a result, parts are formed with little or no waste (usually 010%). In addition, the ability to precut and preform metals into the desired shape means that complex profiles can be manufactured with high reproducibility and accuracy within tight industrial tolerances. Reducing secondary work such as cutting and welding means reducing handling, machinery, and costs. Compared to sheet metal stamping, hydroforming is an efficient and economical manufacturing process for complex shaped aerospace composites as it does not require a die.
4) *Time:* Cycle times are typically 15 seconds to 1 minute or more, depending on the complexity of the component. The pressure depends on the application and material, but the large surface of the active ingot requires more force in the hydroforming process.
5) *Tooling:* Hydroforming uses a single mould surface tool that is either male or female. Using a single stiffness tool saves overall time and cost associated with mould design and manufacturing. The forces used to form steel are a common resource and come from water, which has a negligible cost impact.
6) *Design:* The components and die design is easy in hydroforming as compared to hot forming process as there are less parts involved in hydroforming.
7) *Mechanical Properties:* Surface quality gets better, and the formability is increased.

TABLE I

Sr no.	Parameters	Hot stamping	Hydroforming
1	Process	In this process, metal blank is heated before the stamping. The stamping is done by the help of a punch and the die.	The metal is formed with the help of the fluid force which is applied on the blank to get the desired shape. Only die is used in this process.
2	Environmental	Not environmental friendly, as heat emission is involved and also 20% material is waste after completion of process	Environmental friendly, as no heat is involved, parts are replaced from plastic to metal and the material wastage is minimum.
3	Economical	Setup cost and running cost is high for this process as many parts are involved.	Initial cost is high and running cost is low as the maintenance is low compared to hot stamping.
4	Time	Cycle time is more for this process as the material is heated first and the stamping	Cycle time is less as there is no pre-processing of the material.

		is done.	
5	Tooling	Tooling is more as punch and die both are involved.	Tooling is less as only die is involved.
6	Design	Design changes are difficult to implement as the tools may be entirely re-designed.	As less parts are involved designing is easy.
7	Working fluid	Hydraulic oil (for press)	Water or high pressure hydraulic fluid
8	Operating temperature	Temperature has to maintained throughout the process.	Can be operated at room temperature.
9	Effect on mechanical properties of material	As heating and quenching is involved, material properties can change or cracks/microfractures can develop.	Negligible changes in the material properties.
10	Weight	Final weight of product is more as welding is involved.	Final weight of product is less compared to hot stamping as welding is eliminated.

Comparison of Hot stamping and Hydroforming

IV. CONCLUSION

After comparing both the processes on the basis of:

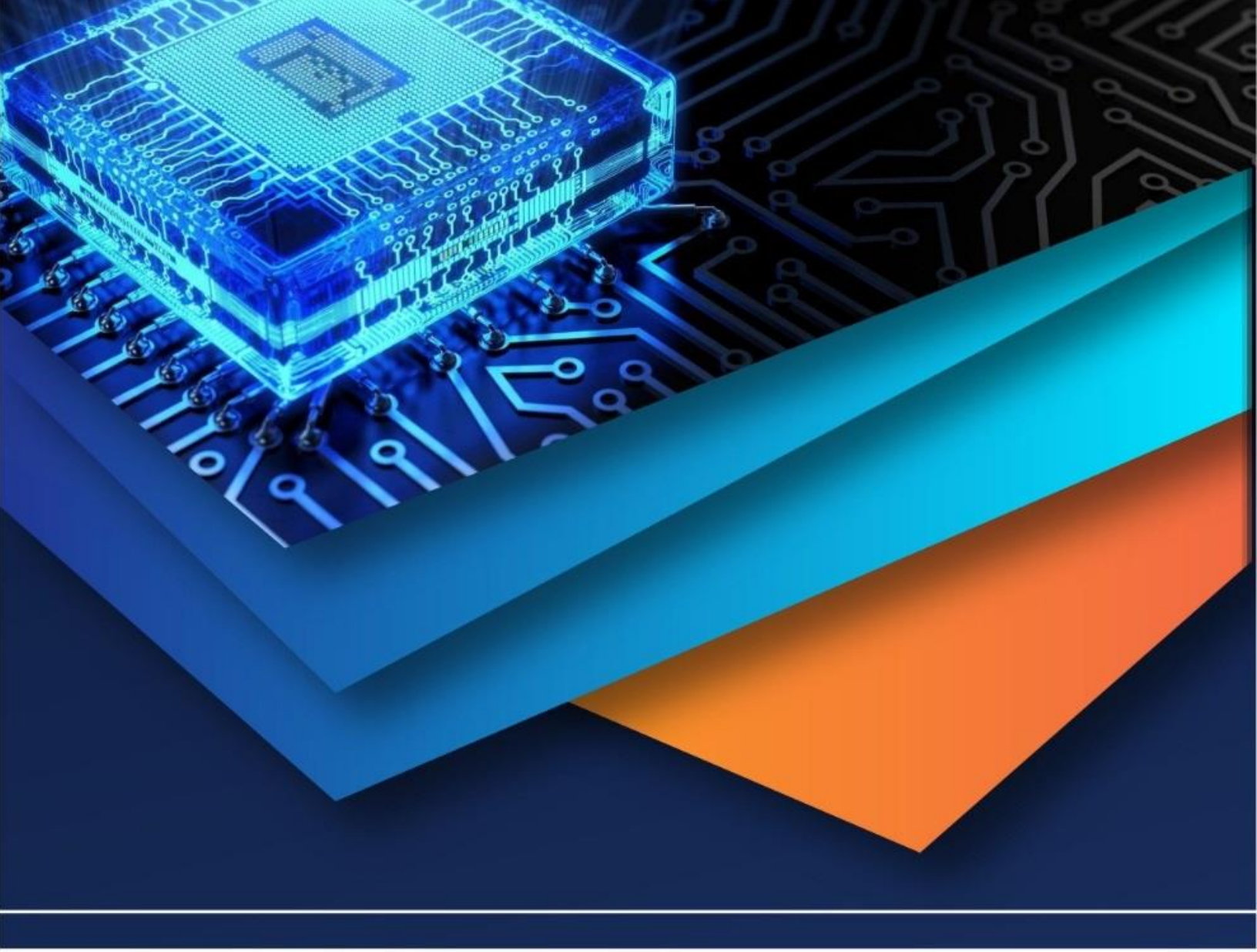
1) Process
2) Environmental
3) Economical
4) Time
5) Tooling
6) Design
7) Working fluid
8) Operating temperature
9) Effect on mechanical properties of material
10) And weight

We can say that, hydroforming has more advantages over hot stamping and it can be an excellent alternative for hot stamping process as it is a sustainable way of manufacturing.

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[1] Pereira, André Luiz & Freitas, Rodrigo & Marcial, Mauro & Yamada, William & Orfale, Eduardo. (2013). Sheet Metal Performance: Hot Stamping and Hydroforming Process Contributions for INOVAR Auto Program.
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