

An Extensive Review on Advance Forming Methods

Praveen Kumar^{1*}, Tushar Gandhi² and Vaibhav Chandra¹

¹Mechanical Engineering Department, Delhi Institute of Tool Engineering, Delhi, India, ²Engineer, PPAP Automotive Limited, NOIDA, UP, India.

*Email: praveen.jbm@gmail.com

ABSTRACT: Giving it a shape and making it a useful component defines the process of forming. Years of research has given new methods to this process. In various industries like automobile and aeronautics the goal is to achieve com-plicated shapes with properties like high energy absorption, high rigidity at a lower cost. These aspects can be achieved by Advance Forming Methods (AFM), major work is being done on hydroforming process as this process provide shapes which otherwise requires a greater number of processes. The idea of flexible forming is something where the efforts are reduced along with number of trials by introducing rubber pads into sheet metal forming process and the complexity of tool design automatically reduces. Other than these processes, the process of rapid prototyping which is incorporated in laser forming process is being used in fabrication of metallic com-ponents. The areas of work which is being done is to reduce the amount of failures by optimizing the process parameters to achieve better results at a low cost.

Keywords: Advance Forming, Laser Forming, Hydroforming, Rubber Pad Forming, Sheet Metal, Automobile

I INTRODUCTION

In current scenario the industry needs revolution in every domain and the basic of industry is machining and how comfortably it can complete the process. It requires to reduce the number of processes which can we done by the new methods of forming. The process of forming is used in most of the operations. The forming process of using a polyurethane pad is developed which provides high flexibility which can surpass the conventional method for the process of prototyping [1] [2] [3]. In recent years new ways of forming are investigated in the form of laser bending in which the forming is contactless [1] [4] [5].

The Process of hydroforming is widely used and the limits are increasing so that it can more fit into the industry. The process is used in automobile industry because of its applications and the part we gets are usually defect free. The process of hydroforming is used in automobile industry to make part of a car used in A-Pillar, in this process the failures like wrinkling, buckling and bursting can be prevented by working on die design and feeding procedure [6] [7] [8] Other than that tube hydroforming can develop products like exhaust system at lower costs, the exhaust system components are Y shaped as shown in Figure 1 are made with this process [9] [10].

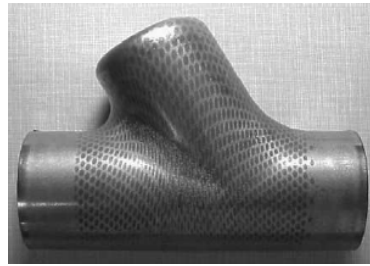


Fig. 1. Y Shape Hydroformed made up of Stainless Steel [9]

In automobile industry the use of aluminum increased widely because of weight reduction which will eventually help in fuel economy, there in process of rubber bending to produce space frame in a single setup which can be done in by directly bending the extruded tube of aluminium [11] [12]. The rubber pad bending process is one of the major advancements in forming process in which we change the lower part of die with rubber pad and many studies has been carried out to achieve better results [11] [13]. The optimization of process is being done by varying the process parameters like punch radius, material of rubber etc. In rubber pad bending the product surface finish is better [11] [12].

II LITERATURE REVIEW

The advance forming methods can be categorized in the following categories:

- Flexible Forming/ Rubber Pad Forming
- Hydroforming
- Laser Forming

There are few more methods which are sub categories of above-mentioned topics.

Flexible Forming/ Rubber Pad Forming

Generally, press forming is done by a die consisting of both male and female parts of metallic nature. These types of dies require a higher accuracy in machining and longer set-up time. Additionally, sheet is subjected to localized deformation which may result in some imperfection such as bulking, wrinkles, thinning, cracks, etc. [14].

An alternative to these problems is rubber pad forming; this process has several benefits over the conventional sheet forming process (using metal dies). Just one rigid part is required in the process. Better formability is achieved due to the flexible interface between the two halves of the die. A single rubber pad maybe used in producing different components Far less precision is required in this method than the counterpart while assembling the components, meaning less time and money consumed in machining in assembly [14] [15].

In forming process using rubber pad, as the rigid metal punch/die comes in contact of rubber, the latter encounters elastic deformation and applies counter pressure to the punch by filling the die cavities. Blank placed between the two gets deformed into the desired shape.

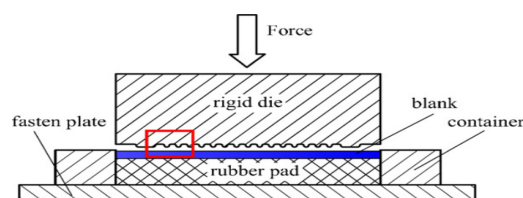


Fig. 2. Rubber Forming Equipment [16]

In a study done by Liu and Hua [16], rubber pad forming process was used in fabrication of aluminium bipolar plates it was found that small radii should be avoided in the rigid punch because it may cause problem in rubber

filling the die cavity. Same problem may be avoided by appropriate draft angles. Thinning of plate is noticed at sharp edges of the profile. Rubber Pad forming is not suitable for mass production reason being short life span of rubber pad.

In a similar study Jin et al. [17] fabricated titanium bipolar plates using the same process. Numerous experimental variables were chosen for the process as shown in Table 1. As rubber pad thickness was increased counter pressure of pad to punch also increased simultaneously losses to surroundings were reduced.

Table 1. Variables in experiments [17]

Parameter	Value
Rubber Thickness	10, 20, 30, 40 mm
Rubber Hardness	20, 25, 35 Shore A
Punch Velocity	10, 20, 30 mm/s
Punch Pressure	15, 25, 35, 45, 55 MPa

Channel depth increase with decrease in rubber pad hardness, reason being easier elastic deformation. Increase punch descent speed resulted in higher rate of elastic deformation and prevented losses to surroundings thus increasing the channel depth of the plates. Similar results were achieved with punch pressure variation. Effect of changing draft angle, speed and pressure were much more effective than changing rubber pad specifications.

Whether it's conventional or rubber pad forming spring back is a major issue in bended components. It was found that in conventional forming processes, spring back reduces with increase in sheet thickness and increases with increase in bending radius. Optimum ratio of bending radius to sheet thickness was found to be less than 2 i.e. $r/t < 2$ [18]. At die clearance of 0.75 times the sheet thickness value of spring back is observed to be minimum [19].

Belhassen [20] in a study predicted numerically spring back in aluminium alloys rubber-forming. Lower half of die was taken rigid while upper half was made up of rubber. Simulations were done on different combinations of dies. Thickness distribution in sheet decreases with increase in rubber hardness. For constant hardness of pad spring back increases with sheet thickness.

In a study was conducted in order to find a better method to make food packaging containers using sheet metal [21]. Simulations and actual components were produced using rubber pad. It was observed that clearance between the pad and cavity walls should be less than 1 mm in thickness, otherwise rubber extrusion may occur. Thin 'Throw pads' of 90 shore. A hardness should be used on top of rubber pad. Former is harder than the latter. It prevents the pad from being damaged.

Rubber pad forming can be classified in two parts i.e positive and negative. In positive pad is used with a male punch while in negative type female die is employed along with the pad. Vents should be provided in negative type to preclude pad from sticking to metallic surface.

Hydroforming

Hydroforming process was majorly developed to receive better products with less number of processes. The process improves the stiffness and strength of component. The working of process can be seen in figure 3. In this process we form a pre bent in bending machine and then the part can be put into hydroforming die to complete the process. Better performance and part are delivered if the parameters are chosen carefully [6]. The

process is efficient as thinning of tube is less in the bend. If we analyze the process using FE Technique, then optimum process parameters are found which can reduce failures in the process [22] [23].

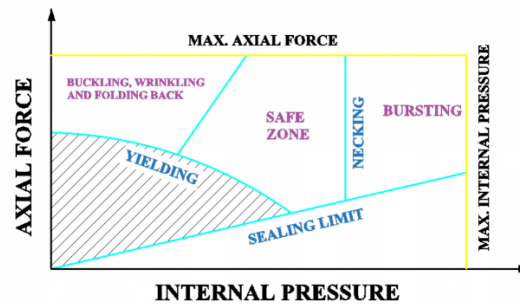


Fig. 3. Hydroforming Process Working Diagram [6]

While using the process of hydroforming, the critical geometries can be formed either a three way connector out of a single tube or a square cross-section out of a round tube. The process parameters governed for these are basically the axial load and internal pressure while for the case of three way connector used in exhaust system of automobile the counter punch is also important. By using the condition of better lubrication, the wall thickness distribution can be controlled [9] [24].

The square cross-section out of circular requires other parameters for consideration. The additional process parameters are stress ratio and friction coefficient. Similarly, the process even depends on material properties also [24] [25] [26].

Tube hydroforming which is being used in oil refinery and aerospace industry, it is been categories that the major defects which can be observed in this process are buckling, wrinkling and bursting. The process provides fine parts but to avoid the defects special design consideration need to be taken care of. Majorly the process of local buckling is even called wrinkling. When we have thick walls, buckling can be observed. Buckling is also found in long tubes along when there is low diameter to thickness ratio. With thin walls, wrinkling can be seen either in small tubes or long tubes [27] [28] [29] [30].

Laser Forming

The process of laser forming is one of the new emerging forming processes which is being developed without using the forming tools and yet the plastic deformation can be achieved [31] [32]. The process provides accurate parts which can be used majorly for prototyping. This process works on the principle of energy transfer with which plastic deformation can be achieved, this process is inherited from the technique of flame-bending [31] [33] [34].

While the laser can be used for many applications be it a cutting, welding or working on a complex surface, but in this process of laser forming, the laser is used for the purpose of bending and hence called laser bending. The lasers which are used for this process can be high power as well as low power, more work is being done on high power laser. The majorly used high power laser is CO₂ laser while for low power laser it is Nd: YAG laser [31] [35].

The complex shapes which can't be achieved from conventional techniques like the combination of positive and negative curvature or simply the double curvature can be achieved with this process [35] [36]. The principle of this process is basic as shown in Figure 4, that the workpiece can be clamped from one end using the fixture and laser to be passed at the bending area or through the points of bending angle. Double curvature can be achieved using two lasers simultaneously [31].

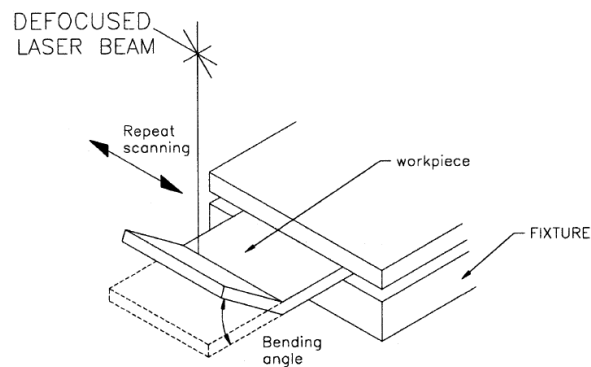


Fig. 4. The Principle of Laser Bending Technique [31]

The high power laser used are defocused laser otherwise they will cut the piece but in the case of low power laser, the defocused laser can't be used as it won't bend the workpiece. So, in low power laser it is needed to be focused which can cause slight melting at the surface [31].

The laser can be used for both bending inwards as well as outwards from the beam [37]. In the process of laser forming, it was found that both finite element simulation and analytical simulation are being done for the case of laser bending. The experiment results for the same are found similar to that of finite element simulation [35] [38] [39].

III CONCLUSIONS

The advance forming methods are developed to reduce the number of processes and the better parts can be achieved in terms of quality with relatively less efforts as compared to conventional methods. Three major advance forming methods are categories which are flexible forming/ rubber pad forming, hydroforming and laser forming. Hydroforming is used commercially as well as for experimental purpose while other two methods flexible forming/ rubber pad forming and laser forming are used specifically for rapid prototyping and experimental purpose only.

In flexible forming/ rubber pad forming process, the work is done on the process parameters and rubber material so that spring back effect can be reduced and to define the limits of the process. This process can't be used commercially because the life of rubber is less but it becomes economical and easy while using it for experimental purpose. The major result of the studies previously carried out are that the spring back effect increases with increasing sheet thickness, the gap to be provided at the bottom of rubber pad and the die. The small radii should be avoided in rigid punch.

In hydroforming the process improves the stiffness and strength of component. The process is useful to provide critical geometries to the component. It is needed to be taken care of process parameters while working on this process and considering optimum lubrication for better wall thickness distribution. The major defects of this process are buckling and wrinkling which can be controlled by optimum diameter to thickness ratio.

In laser forming the process is used for bending with the help of laser. The laser can be high power as well as low power. Majorly used laser are CO₂ laser and Nd: YAG laser. Geometries like double curvature and negative curvature are easily formed by this process which can't be achieved by conventional process. This process is currently used for rapid prototyping process and more work is needed to optimize the process for commercial purpose.

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