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Review of Stress analysis & fabrication of circular and non-circular tube bending machine

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***Abstract*—**The paper aims at review of literature in regard to pipe bending operation, different machines, design approach and process, different type of pipe bending machines, methods to increase the efficiency of bend. Bending metal tubes was never an easy task. It requires a machine which is able to generate a bending stress which is more than the yield strength of any given material of which the tube is made of our main focus is to maximize the quality and efficiency of the machine and minimize the manufacturing cost of the machine. The crucial study of various literature related to this topic is discussed in this paper. This will help the future researchers working in this area to have a consolidated literature study.

1. INTRODUCTION

Before Jerry Huth developed the first automotive pipe bender in the 1950s, fitting exhaust pipes was a difficult job that was beyond the means of many shops. Mechanics had to cut and weld pipe sections, making small bends manually. By 1958, Huth had developed the first prototype of the portable pipe bender. Soon, Huth was supplying benders to shops across the country. Huth Benders continue to lead the field more than 50 years later due to ongoing research and development, a strong commitment to quality, and responsiveness to the needs of a changing industry. With the gradual opening up of machine in the market, advanced manufacturing methods from abroad began to be introduced and hydraulic technology was applied to pipe bending machines. This also enabled the bender to solve the problem of high noise and low efficiency. With the development of intelligent technology, fully automatic pipe bending machines began to appear. The bender series uses a VDU touch screen operating panel, under the precise control of the industrial control machine, the three-movement coordinates Y, B, C can achieve a fully automatic mandrel. Inspite of tremendous development many of the vendors follow the practice of trial and error for achieving a good accuracy in bend. S. M. Moinur Rahman and A. N. M Mizanur Rahman

[19] has mentioned some issues like wrinkle formation and springback which are very common and are solved on the basis of trial and error. Li Heng, Yang He-Zhan Mei, Sun Zhichao and Gu Ruijie[13] has done a 3D FEM analysis of the pipes after bending which woul help to study the stress analysis of the pipes. Besides these ther are many researches done on the introduction of wiper die which also reduces the chances of wrinkle formation.

2. LITERATURE REVIEW

Smith et al [3] Published a paper saying that bending process is based on modern technology. In the process the dies and the design software and computer control with bending machine. The concepts of bending tubbing are same. The consideration of tube is rectangular, round and square material. The similarities of round and rectangular tubbing is degree of bond, arc length, radius of bent. In the process all the methods are computer generated programs. Maier et al [45] said that This process conducted using s newly designed rig and which is capable then applying the loads. This loads are the torsional and bending loads. The two different loading paths are considered and the examine mechanical properties and the bar in both region. The region is elastic region and plastic region. The material of the specimen was mild steel with carbon and all the specimen were made as required material. The level of initial constant torque, initial slopes of the bending load versus deflection curves are the nearly same. The values of yield point corresponding slopes are sameand constant. In this process strain hardening is more noticeable. The stiffness of thmaterial remains unaffected in the elastic region. Cimpoeru et al [1] Published a paper which discusses the collapse caused due to the bending moment of mild steel pipes containing plain or gouged dents. Five laborotary size pipes were machined with their geometry given as, Outer diameter/ wall thickness (D/T)=40, Length /Outer

diameter(2l/D)=12. Defects in first 4 pipes had a depth to wall thickness ratio as 0.47, the length to outside diameter ratio was nearby 0.25. Heng et al [5] Published a paper which comprises of investigation on influence of mandrel on stress distribution. The mandrel plays an important role in improving the bending limit and to achieve a good quality bending. In this paper a mandrel has been established and some reference formulas have been deduced in order to select the mandrel with proper parameters. These parameters mainly inclide mandrel diameter, mandrel extension, no. of balls, thickness of balls, space length, etc. 3D FEM elastic plastic model of mandrel and NC bending have been developed to study the stress distribution. The conclusions were as follows, If the distance between the bi axial membrane stress is more then the possibility of wrinkling is more. Mandrel of larger dimensions reduces the chances of wrinkling. If the mandrel is having more extension length then the bended tube will have a thin surface at bending portion Rahman et al As the increasing in globalization the the demand of productivity is more that why, they made this machine. This tube bending machine is satisfy the needs of lightweight and high strength product form both the material and structure aspects. they can made a urgent requirements of high performance complex bent components is difficult to deform and lightweight weight material in aviation and aerospace fields they making The development in this machine. It is working on the advance studies of the common topic in tube bending are wrinkling. Ahmed et al [10] Published a paper discussing that, the manufacturing using 3-roller bar bending machine are circular rollers are used in the balancing of wind tower assembly. The 3 roller bending machines are widely used in many industries. The two rollers are connected to the shaft and driven by gears. The motor is used and motor consist 0.75 kw and 1200 rpm of speed. Okafor in his paper mentioned that In this bending machine research paper they improved there defects of manually operated machine, it is ensures that the design a smooth operation of bending process during the shape length of the pipe is bent. The required bending force is provided with help of gear assembly, powered by a 2Hp electric motor. This machine is work on the mechanism of worm and flywheel gear assembly and the bend dies of different size (Between 18mm to 28 mm). This machine can be used in rural areas where no electricity or power supply. The bending fork is disengaged from the flywheel and the detachable handle is connected to manually turn the fork. The test result shows a smooth pipe bending operation up to a pipe thickness of 2mm. Baraiya et al [11] Published a paper explaining about the machine which was manufactured with fixed die and lever operated manual tube bending machine, that tube bending machine can bend a pipe upto19mm outer and 17mm inner diameter with the angle of 90 degree and 180degree without any defect and failure with help of this machine. Shim et al [14] Published a paper having a main focuses on rectangular pipes and their bending process and discusses about the parameters would improve the bending process. When a pipe is bent with a large radius of curvature, the cross section gets shrinked at the bending part. This paper focuses on rectangular pipes and their bending process and discusses about the parameters that would improve the bending process. When a pipe is bent with a large radius of curvature, the ipe cross section gets shrinked at the bending part. Zhao et al [6] Had published a paper with a conclusion that, the rotary draw bending of a rectangular cross-sectional Tube is a complex forming process involving material mono linearity, geometry non-linearity. Solving the practical problems originating in the painting process becomes a very hard task. For solving the theoretical analysis experimental analysis don't give us a complete knowledge problems that he will face while the building process. Compare to these both methods numerical analysis play a very important role for solving a major part of issues. Deshmukh et al[15] Published a paper talking about the bar bending which was done manually or used bending machine. The bending of bar by using hydraulic system. The use of principle of hydraulic system is To increased the productivity. The various of bar bends like U, V shape and many more. There are different types of bending bending, offset bending, torsion bending. The MS for hydraulic materials selected. Dhende Published a paper describing that A bending machine bends a variety of bend and to shape for desired form. They used a rotary draw bending method for this machine. They used mild steel pipe for testing so, it's concludes that the pipes of a softer than mild steel can be bend used this machine. To reduce a capital cost uses a three phase motor. using this machine both bending and rolling of pipe upto19 mm outer dia. and with 1mm to 2mm is possible. Bilstona et al [37], This paper explains the observation and results of a numerical simulation conducted on the thin walled automobile bumper and investigated the effect of the shape of section taken on energy absorption and concluded that circular tube have the highest energy absorbing capacity. Kut et al [44] Had published a paper which consists of the results of the box profile bending process to determine the magnitude of impact of cross-sectional shape and bending moment on the whole bending process. When bending of thin walled tubes we can generally observed that section of the tube is distorted this have a significant impact on bending moment characteristics and values of allowable bending stress. Mane et al [35]. In this research paper they gave the information about the bending machine. The manufacturing of different types of bending pipe used in today's life like a aerospace, ship building, automobile, furniture & decorative works. The pipe bending machine can be used to bend a different types of pipe. They can be made by the automatic, semi- automatic or manual bending machine. But manual bending machine used where the small diameter of pipe bend and small production also where the rare electricity and other power not available. Chitnis Published a paper which is subjected to the making of a new design of a manual and hydraulically

operated pipe bending machine. This machine is used to operate on different angle and different thickness as per requirement of work and also, this machine is light weighted and fully portable type. It is easy to assemble and disassemble the can operate any unskilled operator. And analysis of different stresses acting on pipe using ANSYS workbench. Beulich1 The three- roller pipe bending machine used in industry for bending pipe. The requirement of industry is to bend more than one pipe at a time. The multistage pipe bending needs to developed for increasing the production. These are different types of bending machines. The sheet of pipe bending operation are very commonly used in industry. This machine have three roller. One roller is fixed and other two roller are adjustable. In the automated tube bending machines consist of bending die, pulleys, chuck bed, linear motion led screw, timing belt, base, sensor and computer. This machine is portable and the human efforts are less. mild steel used in the machine. The machine can be adjusted according to the need of the industry. The pipe bended are wrinkle free an affordable to user. This pipe bending including different types fabrication, stresses and different bending theories. RAO et al [23] Had published a paper in which, an attempt is made to investigate the effect of bend angle on spring back by varying the thickness of square pipe. Also, an effort is made to reduce the wrinkling effect occurring in square pipes during bending process. The studies reveal that spring back increases with increase in bend angle and with increase in pipe thickness spring back decreases. Chowdhury and Ali [4] Published a paper saying that tube bending process are widely used in automotive industry. The includes of extrusion, forging, bending and rolling. The various simulation models are developed and the experiment. To analyse the production process and It is based on a graphical construction interface with autocad. The number and geometry are dependent on the desired profile and material properties. The sheet metal and the roll formed tube without calibrations. This calibration stands on built on circle with the dimensions. The roll forming and the resulting the stress state in semi-finished product. In one step solution the tube behaviour are same. The sheet materials are used in the tube bending. In the process the bending geometry are constant. Raja et al. Designed and fabricated a mobile hydraulic pipe bending machine. They proposed that the hydraulic bender has higher productivity. Sometimes heat treatment is used during bending the pipe but the technique is unsafe because it causes many problems in the produced pipes namely wrinkles, curve formation, reduced thickness, hole forming, reduction in strength, makes it break easily. The hydraulic pipe bending machine based on press bending has superior characteristics as compared to one based on heat treatment methods. This type of bender is suitable for application in both industrial and domestic purposes. Olafimihan.E. O Developed a bending machine based on hydraulic operation. He found the range of the levels up to which pipes were found to be oval to be in between 3% to 5%. The process of bending is economic when used for low & medium quantities due to less amount of tooling required. Portable bending machines make it convenient to perform multiple works on work pieces in the constructional areas. The workforce involved in this field is not equipped with proper machine so as to provide uniformity in work piece instead they are using the tools which are harming as they are not able to provide the proper stress on the work piece. Ankit Vyas et al. Designed and fabricated a hydraulic pipe bending machine. They proposed in order to achieve high quality bends pipe can be heated, sand packed and also use of pipes of larger thickness can be important factors. More accurate and acceptable bends are obtained using the proposed machines as compared to bending operation performed manually. Considering higher factor of safety and provision for automation makes the design highly safe. Vikash Patial et al[40] Designed and manufactured a pneumatic pipe bending machine. They proposed that the bend angle is dependent upon the displacement which the die horn travels. With increase in the angle of bending increase in spring back angle is also observed irrespective of what the material of pipe is. The same kind of change is observed for spring back angle in relation to brittleness of material. S. A. Krishna Mohan et al[36]Designed and fabricated a hydraulic pipe bending machine which is portable and compact. As proposed by him in such benders the pipe is placed between the rollers. Force is applied using hydraulic jack and the pipe is bent to the required vale of angle depending upon the die used. Such is economic, portable and has higher flexibility. Hence, it is a better alternative in comparison to bending machines which are manual. Girish Gharat et al [41]. Designed and fabricated a pneumatic punching and bending machine. They developed automated pneumatic press by using a simple C-frame press due to its lesser space requirement & ease of operation. The machine finds its usefulness in washer production industry for producing washers having thickness less than 1mm.

3. CONCLUSION

The study of research papers from 1993 to 2021 has shown a tremendous growth in the technology of tube bending machine. It has been observed that the time consumed for a bend has reduced to seconds and requirement of skilled labour has been decreased. Even in the current era there are many researches which are being done to constantly increase the efficiency of the bends.

With the gradual maturation of industrial technology, the social demand for pipe bending machines is also increasing. Because the bender has a series of characteristics such as easy to use, compact design, high safety, and intelligent operation. So many characteristics make the pipe bender the primary choice for many companies. In addition to bending, it can also remove the bending components as a separate hydraulic jacking machine use. Some experts predict that, according to future market demand, there will be more and more types of pipe benders, 3d tube bending machine, hydraulic tube bending machine.

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