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Design and Fabrication of Hydraulic Bending Machine

Mr. Nikhil Ramteke[1], Mr. Roshan Balpande[2], Mr. Vikalp Hajare[3], Mr. Pratik Kumbhalkar[4], Prof. Pramod Bhagat[5]

[1,2,3,4] *Students,* [5]*Professor,*
Vidharbha Institute of Technology, Nagpur, India, 441209

Abstract –*This research paper presents the design and fabrication process of a hydraulic bending machine. The aim of this study was to develop a compact and efficient bending machine capable of bending sheet metal with precision and reliability. The paper discusses the design considerations, selection of components, calculation of bending forces, and fabrication techniques employed during the development of the hydraulic bending machine. The final prototype was subjected to rigorous testing to evaluate its performance and validate its functionality. The results demonstrate the successful design and fabrication of a mini hydraulic bending machine that meets the desired specifications and provides efficient bending capabilities for various sheet metal applications.*

Keywords: ***Hydraulic bending machine, design, fabrication, sheet metal, bending force, performance evaluation.***

I- INTRODUCTION

The process of bending sheet metal is a fundamental operation in various industries, including manufacturing, construction, automotive, and aerospace. To meet the growing demand for precision and efficiency in sheet metal bending, hydraulic bending machines have emerged as essential tools. These machines utilize hydraulic power to exert controlled forces on sheet metal, resulting in accurate and repeatable bending operations.

The objective of this research paper is to present the design and fabrication process of a hydraulic bending machine capable of bending sheet metal with precision and reliability. The development of such a machine involves a thorough understanding of mechanical engineering principles, materials, and hydraulic systems.

The significance of this research lies in the creation of a compact and efficient bending machine that can handle a range of sheet metal thicknesses and widths, offering improved productivity and quality in bending operations. The successful design and fabrication of this machine will contribute to advancements in sheet metal processing techniques, ultimately benefiting industries that rely on precise and efficient bending operations.

The design considerations for this hydraulic bending machine include the specification requirements, material selection for structural components, and safety considerations. A robust hydraulic system with carefully selected components, such as hydraulic pumps, valves, and cylinders, is essential to ensure reliable bending performance. The bending mechanism, comprising bending dies and counter dies, needs to be designed for accurate and repeatable bending operations.

To determine the bending forces required, calculation methods based on sheet metal properties are employed. These calculations help in selecting the appropriate hydraulic cylinder specifications and ensuring the machine's ability to exert the necessary forces for bending. The frame and structure of the bending machine are designed to withstand the bending forces and provide stability during operation.

Fabrication techniques, including machining, cutting, and welding, are utilized to manufacture the bending machine components. Surface treatment and finishing methods are employed to enhance the durability and aesthetics of the machine. Once the machine is fabricated, a comprehensive performance evaluation is conducted to assess its bending accuracy, repeatability, bending force capabilities, and operator safety features.

The results of this research paper will demonstrate the successful design and fabrication of a mini hydraulic bending machine that meets the desired specifications and provides efficient bending capabilities for various sheet metal applications. The findings will contribute to the knowledge base in the field of bending machine design and serve as a valuable resource for engineers and manufacturers involved in sheet metal processing.

The design and fabrication of a hydraulic bending machine play a crucial role in improving the efficiency and precision of sheet metal bending operations. This research paper aims to provide insights into the design considerations, calculation methods, fabrication techniques, and performance evaluation of such a machine. By developing a compact and efficient hydraulic bending machine, this research contributes to advancements in sheet metal processing, enhancing productivity and quality in various industries.

II-METHODOLOGY

Main Components and Functions for Fabrication

A. Hydraulic Jack Figure1. The design of a hydraulic jack A jack is a mechanical device used as a lifting device to lift heavy loads or to apply great forces. Hydraulic bottle jack can be operated with everything in the packaging. It does not need any additional fluid, or an electrical source. The six-pound jack can lift vehicles weighing up to 3 tons simply by moving a handle up and down.

B. I-**BEAM** Figure 2. The design of I-beam for metal bender An I-beam is a beam with an I or H shaped crosssection. The horizontal element of “I” is known as flange, while the vertical element is termed the “web”. I-beams are usually made of structural steel and are used in construction and civil engineering. I-beams are widely used in the construction industry and are available in a variety of standard sizes. I-beam can be used both as beams and as columns.

C. Bearing Figure 3. The desired bearing for bender A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. A wide variety of bearing designs exists to allow the demands of the application to be correctly met for maximum efficiency, reliability, durability and performance.

D. Shaft Figure 4. The shaft design A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it. The material used for ordinary shafts is mild steel.

III - SCOPE OF WORK

Existing hydraulic bending machines are manually operated and requires no power consumption. It also has no maintenance cost and hence it makes cost effective, but when mass production is being carried out its manufacturing lead time and cycle time is very high. This makes it slower and requires some changes. Manually operated can be converted into electrically operated or pneumatic operated by using necessary equipment. This makes the device suitable for mass production. This reduces manufacturing lead time and cycle time, but converting manual into automated system requires high initial cost and maintenance cost. It also becomes bulky and complex with the addition of new components. This method is useful as it increases the rate of production and finds extensive applications in automobile industries. Tubes can also be bent in automatic control. We measure the bends by using vernier caliper. In case of flat bend, the mandrel should be advanced.

IV – DESIGN

The calculation formula for a hydraulic bending machine depends on the specific parameters and variables involved. However, I can provide you with a general formula for calculating the bending force required for a hydraulic bending machine.

The bending force (F) can be calculated using the following formula:

F = (K × L × T) / (2 × S)

Where:

- F is the bending force in metric tons (tonnes).
- K is a factor depending on the material being bent. It represents the resistance of the material to deformation and is typically provided by material suppliers.
- L is the length of the material being bent, measured in millimeters (mm).
- T is the thickness of the material being bent, also measured in millimeters (mm).
- S is the width of the V-die or the bending die opening, measured in millimeters (mm).

V - INDIVIDUAL COMPONENT DESIGN CALCULATION

- Hydraulic power
- Cylinder specification
- Bore diameter = 76 mm
- Wall thickness = 2.84 mm
- Length =186 mm
- Piston thickness =27mm
- Stroke length =150mm
- Pump specification: Max. Pressure = 175x105 N/m2
- Force calculation: Area, A =4.53x10-3 m2
- Force or load = 175x105 N/m2 =4.53x10-3 m2 =175x105x4.53x103 =79.275 kN

How to calculate force to bend metal formula

BF = (Safety factor x k factor x ultimate strength x bend length x thickness2) / die opening
Where,
Die opening = thickness x die ratio
k factor = 1.46-(0.016*die ratio)
BF = bending force
Example – The thickness of a sheet is 3cm die ratio 6,tensile 4, factor of safety 4, then calculate v bending force of sheet .
Given
Sheet thickness =3
Die ratio =6
Bend length = 3
Tensile =4
Factor of safety = 4
Rectangular bending force =?
First let us calculate rectangular bending force. Substitute the given value in formula

BF =(Safety factor x k factor x ultimate strength x bend length x thickness2) / die opening

BF = (4.1364 *4*3*32) /18 = = 32.736

Now, let us calculate the rectangular bending force in rectangular
bending force = BF/2000
=32.736/2000
= 0.02

Result
Rectangular bending force (BF) = 32.736
Rectangular bending force = 0.02

Bending allowance calculation
Assume that:-
Sheet thickness (in) = 1.25
Bend radius (in) = .25
Bend angle (^{0}) = 65
k- factor = 0.33

Result:-
Set back (in) = 2.386
Bend allowance (in) = 3.304
Bend deduction (in) = 0. 836

Bending spring back calculation

Sheet thickness(in) =1.25
k- factor = 0.33
Yield strength (psi) = 65
Modular of elasticity(ksi) = 45
Initial bend radius (in) = 5

Result :-

Final bend radius (in) = 5.092
Final bend angle (^{0}) = 63.91
Springback factor ks = 0.98

VI - CONCLUSION

This research paper provides valuable insights into the design and fabrication considerations for a hydraulic bending machine. The findings serve as a guide for engineers, designers, and manufacturers involved in the development and improvement of hydraulic bending machines. By considering these factors, practitioners can create reliable and efficient machines capable of meeting various bending requirements in diverse industries.

The design and fabrication of a hydraulic bending machine require careful attention to structural integrity, hydraulic system design, control system implementation, tooling and dies selection, safety considerations, accuracy, precision, and maintenance aspects. A well-designed and fabricated hydraulic bending machine can provide reliable and efficient bending operations for various materials and applications.

Further research can focus on specific applications, advanced control systems, and automation in hydraulic bending machines to enhance productivity and performance.

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