EasyChair Preprint

№ 5582

Experimental Study on Bending Machine for Elastic Material

Sudarshan Bhalshankar

EasyChair preprints are intended for rapid dissemination of research results and are integrated with the rest of EasyChair.

May 21, 2021

Experimental Study On Bending Machine for Elastic Material

Sudarshan Dilip Bhalshankar

Mechanical Engineering [CAD/CAM]

Zeal College Of Engineering And Research, Pune, Maharashtra, India.

Sudarshanbhalshankar111@gmail.com

Abstract

In a modern engineering era, various machines, technologies, processing techniques and manufacturing processes are helpful to the creation of a new world. As the beginning of engineering, there are very complicated and difficult methods and processes or techniques used, but, as the past time over manufacturing processes or methods is quite simplest. manufacturing is the production of work pieces having defined geometric shapes. It is one of the most important production technologies, other technologies are process technology (production of chemical act.) and energy technology (production of electricity). Bending is one of the most important commonly used things in manufacturing processes and methods are available in an existing market. In that, a certain amount of magnitude bending force is specially applied to a specified point or surface. Due to the Bending force, the Bending operation is performed at a particular point or surface area. The various types of Bending operations, methods or processes of existing procedures or manufacturing techniques are applied to the various types of material properties such as Plasticity, Rigidity, Durability, Ductility and so on. The Bending process or operation is doesn't carried out and Performance on the Elasticity based material such as rubber, steel cables, spring and so on. The heating process is also performed or used for a Bending operation in a Bending machine. The heating of the metal pulley, rollers or bending surfaces. The surface is heated at a predetermined temperature. The benefit of heating is easily bend elastic materials. And it does not need any extra cooling methods or it can cool at surrounding room temperature itself. Nowadays, we can produce a bending machine which can be helped to a bend of elastic material also such as rubber and so on. It is easier with the help of the heating process.

Keywords - Manufacturing, Processing, Technology, Heating, Elastic, Production, Material.

Introduction

As the name suggests this project is about fabrication of a machine that is used for bending of pipes. My project is to design and construct a bending machine. This machine is used to bend steel into curve or other curvature shape. The size of the machine is very convenient for portable work. It is fully made by steel. Moreover it is easy to be carried and used at any time and any place.

A bending machine is a forming machine tool (DIN 8586). Its purpose is to assemble a bend on a workpiece. A bends is manufactured by using a bending tool during a linear or rotating move. The detailed classification can be done with the help of the kinematics. (M. Weck, p. 112)

In various fabrication works as well as in architectural work pipes are used in artistic ways. To bend these pipes into these artistic forms is not easy thing to be done manually. Using a particular machine specially developed for bending of pipes helps. To build this machine many equipment or machine is used. By using all this equipment, process for making the project is faster and easier. I had also learned a proper method for operating all this machine and equipment. Choosing component material is very important, because it will affect the overall cost of the machine and the product quality. With this consideration, I had design this machine with the maximum quality and low in cost.

All bends without an extraordinary geometry belong to standard bends. The distance between a bend and the material end is quite high providing an adequate bearing area. The same with one bend to the next. Typical tools are a so-called bending former. combined with a prisms with electronic angular measurement or an ordinary prism.

• U-Bending :- For U-bends where tight and narrow bends are necessary, the bending former is replaced by a bending mandrel. A bending mandrel has a narrow geometry.

• Offset Bending :- Offset bending tools are used to assembly two bends with a small distance between in one step.

• Edgewise Bending :- Edge bending tools are used, if the bending axis is placed parallel to the tight side of the work piece. Tools for bending on edge may include electronic angular measurement allowing a high bending accuracy.

• Torsion Bending :- Torsion tools are able to rotate the workpiece on the longitudinal axis. Alternatives are complex assembly groups with standard bends.

The authors describe the design of a bendable robotic tip for semi-autonomous colonoscopy called COLOBOT. It is a flexible robotic manipulator made of silicone rubber in view of the compact size and biocompatibility. The outer diameter of the tip is 17 mm which is lesser than the average diameter of colon (20 mm). Three servo-valves are used to control the pressure of each chamber of this tip to obtain its flexible movement. The experimental results of this new prototype show that it can bend until 120 degrees under the pressure of 2 bar. Based on the geometric deformation and a nonlinear analysis of the silicone behavior, a direct kinematic model analogous to the forward kinematics of a conventional industrial robot kinematics chain has been put forward. The proposed kinematic model of this bendable tip is an extended model of classical models found for such a mechanism. At first a polynomial approximation is used to characterize the non linear behavior of each chamber of the actuator. Next the coupling phenomena between each chamber are highlighted through experimental tests. A new correction parameter is then proposed to take into account these interactions and a non linear optimization is made to compute this coefficient. [1]

The component of the compressive force arising from the bonded condition at the loaded surfaces is obtained from a pressure distribution within the block, given by the solution of the corresponding torsion problem. The bending of blocks is treated in a similar way, the pressure distribution in this case being derived from the corresponding bending stress function. The apparent shear of relatively thick blocks is then treated as a combination of shear and bending displacements. The location of an internal rupture and the deformation at which it occurs are also derived from a critical (negative) value of the pressure developed within the block, at which a small cavity increases indefinitely in size. The corresponding critical deformations are calculated for extension and bending displacements. The shear stresses developed at the bonded surfaces under extension, compression or bending displacements are also evaluated.[2]

This study aims at development of a multi-directional bending mechanism with thin and long body driven by fluidic rubber actuators. Generally bending mechanisms with fluidic rubber actuators can have advantages of smooth and continuous motion, however because of their low stiffness it is difficult to generate high output force. To solve this problem, we have proposed a novel bending mechanism combined with contracting and extending rubber actuators. By bundling rubber actuators with different types, the developed bending mechanism can have the high stiffness. In this report, optimized extending and contracting rubber actuators are made basis on a McKibben actuator, then they are combined to be the bending mechanism. Experimentally stiffness of the mechanism is measured and is compared with a bending mechanism bundled with same motion type actuators. Resulting high stiffness can be recognized by the proposed mechanism. Additionally, a very long bending mechanism, which is 7m in length, is developed and its motion is demonstrated.[3]

Problem Statement

1. It is observed that lot of research is done for the bending machine with different parameters like diameters and permanent bending preferred.
2. This work consist of elastic material bending with heating technology specially rubber pipe diameters of 5 – 10 cm.
3. The designing is done with CAD software and theoretical analysis and then actual experimentation is carried out to validate theoretical analysis.

Objective

1. To determine the problem associated due to elastic material bending and preparation of CAD Model of existing bending machine.
2. Modeling and analysis of bending machine for heating the roller or pulley using ANSYS software.
3. To perform heating the elastic material like rubber for bending purposes
4. Comparison of existing methods and experimental results.

Methodology

Step 1:- Exhaustive literature survey to study existing work and to find research gap for project work with necessary parameters which are studied in detail.

Step 2:- Finding the gap in the previous research to define the problem statement to carry out research work.

Step 3:- After deciding the components, the 3 D Model and drafting is done with the help of CAD software.

Step 4:- According to the theoretical analysis actual component is manufactured and then assembled together.

Step 5:-The experimental testing is carried out on prototype with the ,help of heating and bending analyzer and results are compared.

Construction & Working

Construction

In the constructional part of the project work, a base frame structure is fabricated using Mild Steel bars.

1 Frame :- A flat platform is formed on the top of this base structure. On this platform two mounting points are fixed. These mounting points are kept very robust in nature as they have to withstand huge lateral forces during working of the device. Set of combination of two numbers of affix-able meshing pulleys of various diameters are fabricated or machined.

2 Supporting Pulley :- The peripheral cross sectional area of pulleys in pairs in any set is kept same either semicircular or half square depending on the pipe to be bent like circular or square cross section. Other pipes can also be bent but for that special pulleys have to be made.

3 Hydraulic Jack :- Hydraulic jack with Semi Circular pulley as shown in figure is fixed on the frame in between two pulleys and below it by calculating working distance . Provision for Adjustment of jack should be there to achieve any type of shapes and curvature.

4 Springs :- Quick retraction springs are attached to hydraulic jack upper end for easy and fast retraction of jack shaft. Springs should be designated in such way that it will not add more pressure or force for upper movement of the hydraulic jack.

Working

The pipe is inserted between the pulleys and the Hydraulic jack pulley as shown in figure. The Bending Force is applied with hydraulic Jack when the handle is operated. Thus pipe is bent. For desired diameter of bending curve the pulleys are changed or altered

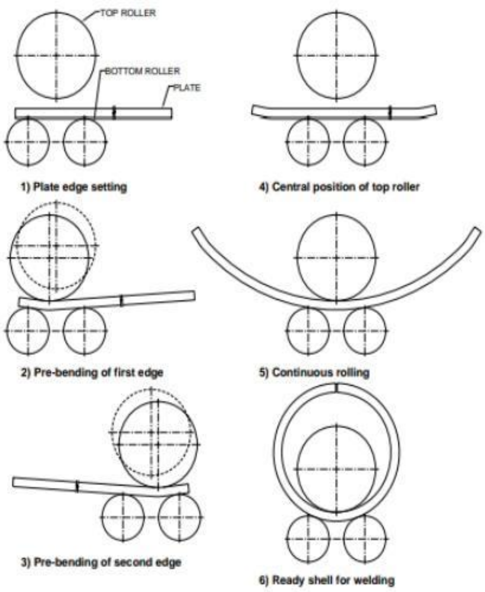


Fig.-1 Pulley sequence for fixed upper pulley gap

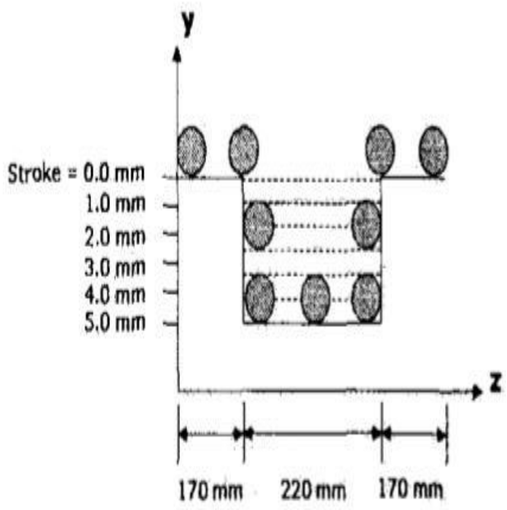


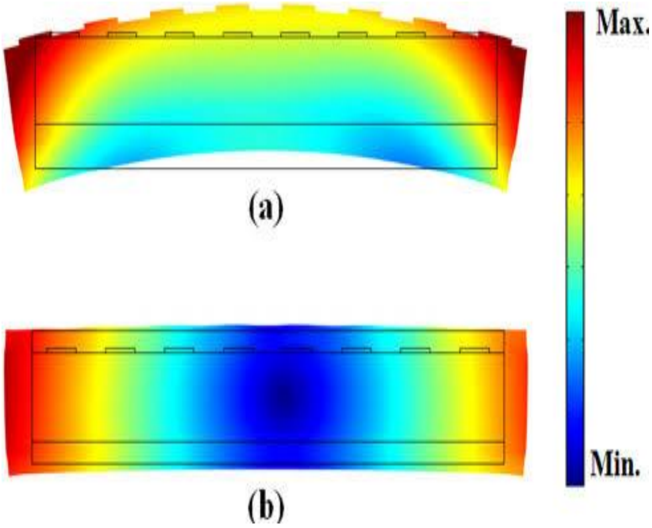
fig.-2 Pulley path in bending experiment

Factor	Unit	Level
Roller/Pulley outer diameter	mm	70/120
Hydraulic jack stroke	mm	0.5 - 5.0
Bending cycle	Cycle	1/2
Bending velocity	mm/s	20
Elastic material section geometry	mm	Fixed
Temperature	°c	20 - 35

Table-1 Process parameter in the experiment.

Parameters	Elastic Material (Rubber)	Structure Steel
Density	7.85*10-60 kg/mm3	7.85*10-60 kg/mm3
Young's modulus	200Gpa	200Gpa
Passion's ratio	0.3	0.3
Yielding strength	250Mpa	1034Mpa
Ultimate strength	435Mpa	1558Mpa

Table-2 properties of Elastic material and Steel.



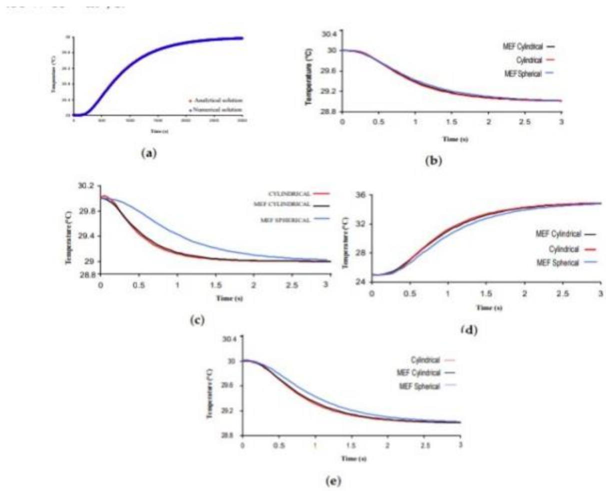


Fig.3 – Finite element simulation of heating process. **Fig. 4- Analysis result**

Testing

When figuring out thermal problems, engineers can draw from a variety of solutions. These include finite element analysis (FEA), finite different approaches, 1D thermal networks and thermal analysis within computational fluid dynamics (CFD) solutions. This article concentrates on the FEA methods with an emphasis on thermal analysis used in support of, or in conjunction with a structural FEA analysis. The extension from a structural FEA solution to a thermal FEA solution is quite straightforward as there are direct analogies between the variable we are solving for—displacements become temperatures, and the terms in the matrices we are building—stiffness becomes thermal conductivity, and the full analogy between structural and thermal modeling.

As mentioned, in many cases, the thermal analysis objective is to provide the temperature distribution for subsequent stress analysis. In a typical uncoupled thermal and structural solution, a steady-state temperature distribution is mapped from the thermal model to the structural model. Mapping can be direct within the same physical mesh, or interpolated between dissimilar mesh models. Either approach will result in thermal strains throughout the structure. The thermal strain is proportional to the temperature change from initial conditions and the coefficient of thermal expansion. If a component such as a bar is allowed to freely expand under a uniform soak of temperature change then it will have a constant thermal strain throughout and there will be no stresses induced. However, if both ends of the bar are held, then the thermal strains are opposed by induced mechanical strains—the bar is not free to expand naturally. In practice components will have a more complex temperature distribution and distribution of thermal properties as well as mechanical boundary conditions and will develop thermal stresses throughout, even if nominally free to expand. A simple example of this is a bimetallic strip.

Material structural properties can be temperature dependent, but still allow a linear static solution and steady state. The temperature dependency is essentially a lookup table for each material structural property at a specific temperature. It does not matter if the actual temperature dependency is linear or nonlinear.

A nonlinear static solution may be required if the thermal loading means that linear structural responses are exceeded. This could include regions of plasticity or material nonlinearity, or geometric effects such as large displacement, buckling or contacts (as seen in Figure 5). A judgment is needed here to decide whether a fully coupled solution should be attempted—where both thermal nonlinearity and structural nonlinearity are updated throughout the analysis. A simple example would be opening or closing of contacts changing the thermal load distribution.

Experimental Procedure

1. Initially the designed according to existing boundary conditions as per FEA result.
2. In a linear solution the material thermal properties do not change with time or temperature and there is no radiation.
3. The steady-state in a thermal event occurs when the temperature distribution and all thermal flows stabilize and remain constant through time. The steady-state can be calculated directly by performing an energy balance assuming this stabilized condition.
4. In the experimental setup upper pulley/roller are headed with permissible temperature (20 -35 °C) and the elastic material (Rubber) are placed in between upper portion of machine (pulley) and hydraulic jack . So that the pressure are induced to the specific portion of the elastic material and it is bend at particular curveture.

5. Four set of experiments are carried out with the help of new modified bending machine and results are compared.
6. For calculating the radius of curvature of existing bending machine and experimental bending machine is shown below.

Parameters	Case -1	Case -2	Case -3	Case - 4
Moving pulley radius (mm)	15	17.5	20	22.5
Maximum Stress of fixed pulley(MPa)	919.02	937.08	938.49	937.52
Maximum Stress of moving pulley(MPa)	929.80	912.29	901.88	889.63
Life cycle of fixed pulley	253142	220805	219207	221223
Life cycle of moving pulley	299961	329584	412335	892055
Bending curve(cm)	9.25	14.05	16.80	21.95

Table – 3 Life Of Existing Bending Machine Model

Parameters	Case -1	Case -2	Case -3	Case -4
Moving pulley radius(mm)	30	35	37.5	40
Maximum Stress of fixed pulley (MPa)	939.25	939.26	938.95	937.52
Maximum Stress of moving pulley (MPa)	457.79	285.98	230.64	211.57
Life cycle of fixed pulley	218000	219000	219000	223000
Life cycle of moving pulley	92500000	10000000	10000000	10000000
Temperature (°C)	10	14	22	34
Bending curve (cm)	10	15	18	22

Table – 4 Life Of Redesign Bending Machine Model

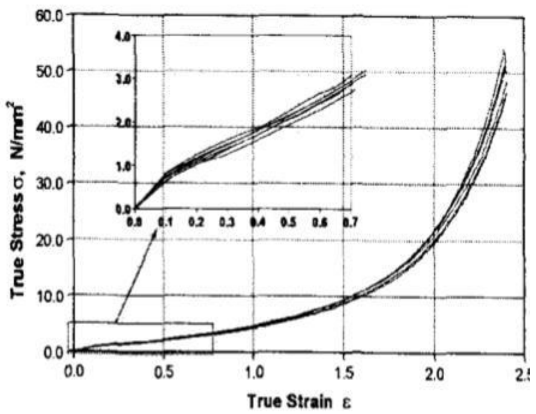


Fig. 5 - Stress & Strain Relation of Polyurethane Rubber used in the Experiment.

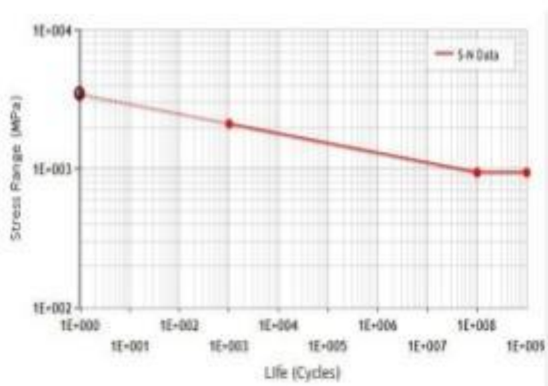


Fig. 6 – S-N Diagram of Structural Steel

The average percentage error in experimental and theoretical analysis is 0.7375 %

Hence, It's confirmed that the modified design of the bending machine is safe and has added advantage that it's also bending elastic properties of material like (Rubber , plastic etc.), Than the existing simple bending machine used in the market.

Conclusion

1. In present research existing bending machine is redesigned with the help of fatigue life cycle, supply thermal energy to roller or pulley , and consideration of bending curvature radius.
2. The average percentage error in the experimental and theoretical analysis is 0.7375 %. It is means that the bending rate is very high.
3. Due to heating the experimental procedure bending action is more faster than other existing and conventional bending machine it's indicated the average percentage error.
4. Heating the elastic material the molecular structure of Polyurethane is disturbed so that it's easily bend.
5. The elastic properties of material 10 to 15 cm diameter of rubber tube is easily bend with predetermined temperature. Specially experimental propose Polyurethane rubber used.
6. It is also applicable for transmaterial properties of material with chipset cost for bending.

Fig. 7 – Experimental Setup Of Elastic Material Bending Machine.

References.

1. Development and kinematic analysis of a silicone-rubber bending tip for colonoscopy. Gang Chen, Minh Tu Pham, Tanneguy Redarce 2006 IEEE/RSJ International Conference on Intelligent Robots and Systems, 168-173, 2006
2. Compression, bending, and shear of bonded rubber blocks AN Gent, EA Meinecke Polymer Engineering & Science 10 (1), 48-53, 1970
3. Long bending rubber mechanism combined contracting and extending tluidic actuators Koichi Suzumori, Shuichi Wakimoto, Kenta Miyoshi, Kazuhiro Iwata 2013 IEEE/RSJ International Conference on Intelligent Robots and Systems, 4454-4459, 2013
4. The bending of an aluminum structural frame with a rubber pad HC Kwon, Yong-Taek Im, DC Ji, MH Rhee Journal of Materials Processing Technology 113 (1-3), 786-791, 2001.