

ONE INCH PIPE *BENDING* MOMENT ANALYSIS USING PIPE *ROLL BENDING MACHINE*

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ABSTRACT

In small-scale industries, there are still many production support technologies that are still run manually, one of which is the rolling machine. The process of forming pipes with *roll bending* has been widely applied to industrial manufacturing activities. The process of *bending* or bending is commonly found in the manufacture of canopies and fence ornaments made from pipes using a pipe *roll bending machine*. Currently, there have been many developments in the manufacture of canopies and fence ornaments that use pipes as the basic material. Specifications of pipe *roll bending machine* designed to perform the *bending process* with good results on one inch diameter pipe, Using a DC electric motor in question is a car wiper motor as the main mover, using a hydraulic system as a *roll drive*, a transmission system using a chain.

Keywords: *bending process*, *roll bending*, *bending machine*, hydraulic jack

INTRODUCTION

In this era of development, everything is demanded quickly and precisely, especially in the industrial sector [1] [2]. Therefore, the industrial world is demanded to have high-quality human resources in balancing technological advances [3] [4], especially in the industrial sector. One must have an expertise in a certain field, so that one can find oneself and be useful. In addition, technological advances are also very influential on production [5].

In general, steel materials are applied to large industries such as machinery and transportation industries [6] [7] [8]. However, along with the times, currently steel material has been widely used in residential infrastructure [9] [10] [11]. One application that is commonly found is in the manufacture of canopies, stairs and fence ornaments in residential buildings [11] [12]. In the manufacture of canopies and fence ornaments, pipe material is the most frequently used material [13]. In the process, the pipe material which was originally straight is converted into a circular shape, semi-circular or a combination of shapes with a certain radius variation. This formation process is commonly referred to as the *rolling* process [13]. To carry out this process, a special tool is needed called a *roll* ing machine or a pipe *roll bending machine*.

roll bending machine refers to the working principle of the rolling process by formulating all influential aspects related to the function, process, availability and strength of the designed product [14]. The process of forming the material in question is more emphasized on the formation of pipe material, which is a process carried out by giving changes to the shape of the workpiece. This change in shape can be done by applying an external force so that plastic deformation occurs in the material. The formation process depends on the *plasticity* of the material, namely the ability to flow as a solid without

destroying its properties. The method used in the pipe bending process is the *bending* or *rolling process*.

The process of bending pipes (*bending*), is usually done a lot to make industrial components, as well as households, such as making chairs, fences, canopies, and other equipment that uses pipes as the basic material. This bending is done by applying a compressive force to the pipe material between the two *rolls*, namely the base roll and the *pressing or forming roll* that rotates in opposite directions so that it can move the pipe. "Pipe *roll bending* machine by utilizing a hydraulic jack system" shows that the need for products is getting higher and higher with good quality and is the same as equipment (machinery), so now many small (household) and medium industries are starting to develop and compete for these opportunities [15]. Where along with With the development of these industries, simple equipment is needed at a low cost and capable of producing good quality products [16] [17].

This shows that the need for products is getting higher and higher with good quality and the same is the case with equipment (machines), which are increasingly being demanded to develop and develop again, at an affordable cost this pipe *bending machine* can help industry small and medium-sized economies, so that research can be carried out that can assist industrial parties in producing a quality product. For this reason, research related to the pipe *roll bending machine* was carried out.

THEORETICAL FRAMEWORK

A. Analysis

System Analysis as the decomposition of a complete information system into its component parts with a view to identifying and evaluating problems and opportunities [18]

B. Bending

The definition of bending test (bending test) is one way of testing to measure the quality of a material by visual observation. The process of applying a load using a pressure mandrel of a predetermined size in order to push the center of the test material or specimen bent between two supports separated by a predetermined distance [19].

C. Pipe

Pipe is an object in the form of a cylindrical hole with a hole in the middle made of metal or other materials as a means of flowing or transporting fluids in the form of liquid, gas or solid in the form of powder.

D. Bending

Bending or bending (English: **bending**) is the process of plastic deformation of a metal about a linear axis with little or almost no change in surface area with the help of pressure forming pistons and molds.

E. Bending Machine

Bending machine is one of the many machines in the industrial world which process itself by bending or bending the workpiece (which is metal).

RESEARCH METHODS

The research method is a research design that provides direction for the implementation of research so that the necessary data can be collected. To find out how the pipe bending process is carried out to form a circle or semicircle. The composition of this research method includes the object of observation, namely *PIPE BENDING ANALYSIS 1 INCHI USING A PIPE ROLL BENDING MACHINE* with the methodology as following :

1. Field observation
Is the first step used by to obtain information related to the object of research.
2. Literature Study
The literature study includes the process of finding and studying library materials related to all problems regarding the planning of *pipe roll bending machines*. Using the steps of writing and reviewing reference books, to add broader theoretical.
3. Consultation
Consultation with supervisors and other lecturers to get instructions on the analysis of *pipe roll bending machines* against bending moments.
4. Data retrieval
In the completion of this research there are several stages carried out from the beginning until the results are obtained. The stages - the stages carried out in the study of the flow chart.
5. Literature review
In addition to getting data from places of observation, a library search was also carried out through book references, where there was data that could not be obtained from the field. This literature review is also useful to obtain a supporting formula for the data processing of this final project.
6. Activity Flow Chart
The description of the research steps can be translated into a research flow chart, to facilitate writing in the preparation of the final project as follows:

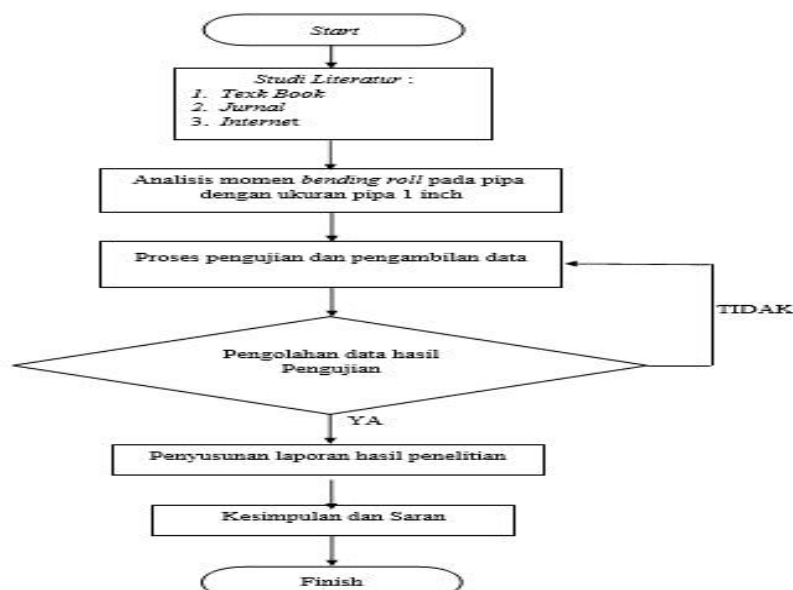


Figure 1. Research Flow Chart

DISCUSSION AND RESULTS

A. Analysis of the Loading Force on the Pipe

In calculating the magnitude of the force on the pipe loading, we can make a comparison between the thickness of the pipe and a smaller radius than the width of the distance between the bottom rolls. So, to find the loading force of the pipe, you can use the following equation:

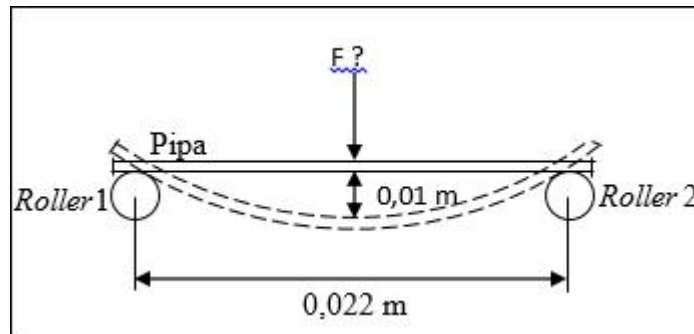


Figure 2. Loading Force on Pipe

$$Y_{\max} = \frac{F \times L^3}{48 \times E \times I}$$

So the formula used to find the loading force on the pipe is as follows:

$$F = \frac{Y_{\max} \times 48 \times E \times I}{L^3}$$

Information :

- Y_{max} = Deflection in pipe (m)
- F = Load/force (N)
- L = Support distance (m)
- E = Modulus of elasticity (Gpa)
- I = Moment of inertia (kg 2⁴).
- M = Mass of pipe (kg)
- Inside diameter of the pipe (m)
- O = Outside diameter of pipe (m)

to find the moment of inertia (I) in the pipe can use the following equation:

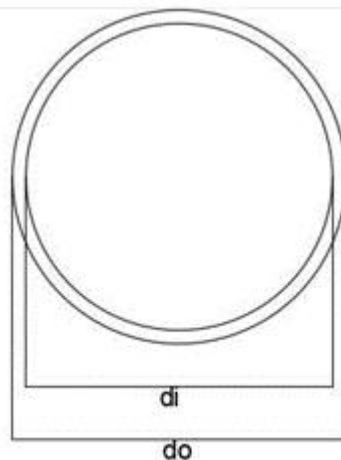


Figure 3. Pipe Diameter

$$I = \frac{m}{8} (d_i^2 + d_o^2)$$

$$= \frac{0,7}{8} (0,0234^2 - 0,0254^2)$$

$$= 0,087 (0,00055 - 0,00065)$$

$$= 0,087 (0,012)$$

$$= 0,0010 \text{ kg}^2$$

➤ Galvanic pipe bending force (F) with pipe loading with a distance of 1 mm.

Given: Ymax = Deflection In Pipe (1 mm) = (0.001 m)

E = Modulus of Elasticity (83 Gpa) = $(8,3 \times 10^{10} / 2) \text{ N/m}^2$

I = Moment of Inertia = (0.0010 kg²)

L = Support Distance (22 mm) = (0.022 m)

Wanted: F = Load/Force (N)

$$F = \frac{Y_{\max} \times 48 \times E \times I}{L^3}$$

$$= \frac{0,001 \text{ m} \times 48 \times 8,3 \times \frac{10^{10} \text{ N}}{\text{m}^2} \times 0,0010 \text{ kgm}^2}{0,022 \text{ m}^3}$$

$$= \frac{0,00039 \times 10^{10} \text{ m}^3}{0,022 \text{ m}^3}$$

$$= 0,0177 \text{ N}$$

Then the loading force in 1 press produces a weight of 0.0177

➤ Bending force of black iron pipe (F) with pipe loading with a distance of 1 mm

Given : Ymax = Deflection in Pipe (1 mm) = (0.001 m)

E = Modulus of Elasticity (83 Gpa) = $(1,9 \times 10^{10}) \text{ N/m}^2$

I = Moment of Inertia = (0.0010 kg²)

L = Support Distance (22 mm) = (0.022 m)

Wanted: F = Load/Force (N)

$$F = \frac{Y_{\max} \times 48 \times E \times I}{L^3}$$

$$= \frac{0,001 \text{ m} \times 48 \times 1,9 \times \frac{10^{10} \text{ N}}{\text{m}^2} \times 0,0010 \text{ kgm}^2}{0,022 \text{ m}^3}$$

$$= \frac{0,00091 \times 10^{10} \text{ N/m}^3}{0,022 \text{ m}^3}$$

$$= 0,0414 \text{ N}$$

Then the loading force in one compression produces a weight of 0.0414

➤ Bending moment

= × _ _ _

Information :

M = bending moment (Nm) L = bending distance (m)

F = Loading force (N) Galvanized pipe

= × _ _

= 0.0177 × 0.0195

= 0.00034

$$\begin{aligned}
 & \text{black iron pipe} \\
 & = \times \quad \text{---} \\
 & = 0.0414 \times 0.0195 \\
 & = 0.00080
 \end{aligned}$$

B. Force and torque analysis on *roll*

1. Force and Torque Analysis

The force acting on the pipe will result in friction F_s and Torque T on the roller. The magnitude of the force and torque on the roller can be calculated by the following equation:

$$= \times \text{---}$$

$$= \times \text{---}$$

Information :

F = Friction (kg)

= Coefficient of friction between steel and steel 0.74 N = Normal force

T = Torque (Nm)

r = radius of roller (m)

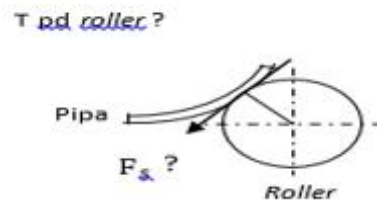


Figure 4. Simulation of Style on *Roll*

a. Frictional force (F) on galvanized iron pipe

$$\begin{aligned}
 F & = \times N \\
 & = 0.74 \times 0.0177 N \\
 & = 0.013 N
 \end{aligned}$$

Roll torque

$$\begin{aligned}
 & = \times \text{---} \\
 & = 0.013 \text{ Nm} \times 0.06 \\
 & = 0,00078 \text{ Nm}
 \end{aligned}$$

b. Frictional force (F) on the black iron pipe

$$\begin{aligned}
 F & = \times N \\
 & = 0.74 \times 0.0414 N \\
 & = 0.030 N
 \end{aligned}$$

Roll torque

$$\begin{aligned}
 & = \times \text{---} \\
 & = 0.030 \text{ Nm} \times 0.06 \\
 & = 0,0018 \text{ Nm}
 \end{aligned}$$

C. Pipe Analysis

The angle produced by the *roll bending machine* against the galvanized pipe and black iron pipe in 10 times the compression reduction or 10 times the *bending process*. To find the angle of curvature of the pipe use the following formula :

$$\frac{\alpha}{360} = \frac{AB}{2\pi r}$$

$$\frac{\alpha}{360} = \frac{AB}{2\pi r}$$

$$\alpha = \frac{AB \times 360}{2\pi r}$$

$$= \frac{1000 \times 360^\circ}{2 \times \pi \times 970}$$

$$= \frac{360.000}{6.091,6}$$

$$= 59,09^\circ$$

The result of 10 times *bending process* on galvanized pipe is 59.09° and close to 60° , so in one pressing process the bend angle of the pipe reaches 6° .

Table 1. The results of the *roll bending process* for galvanized pipes and black iron pipes

Press Processes	Pipe Type	Pipe Curve Depth (mm)	Angle -	Processing Time (seconds)	Pipe Bending Results
1	Galvanized Pipe	19.5 mm	174°	15.72 seconds	
	Pipe Iron Black	19.5 mm	174°	26.04 sec	
2	Pipe Galvanized	39 mm	168°	14 sec	
	Pipe Iron Black	39 mm	168°	26.81 sec	
3	Pipe Galvanized	58.5 mm	162°	14.59 sec	
	Pipe Iron Black	58.5 mm	162°	32.43 sec	

4	Pipe Galvanized	78 mm	156°	18.11 sec	
	Pipe Iron Black	78 mm	156°	27.80 sec	
5	Pipe Galvanized	97.5 mm	150°	24.94 sec	
	Pipe Iron Black	97.5 mm	150°	37.99 sec	
6	Pipe Galvanized	117 mm	144°	19.13 sec	
	Pipe Iron Black	117 mm	144°	31.79 sec	
7	Pipe Galvanized	136.5 mm	138°	25.45 sec	
	Pipe Iron Black	136.5 mm	138°	31.26 sec	
8	Pipe Galvanized	156 mm	132°	24.60 sec	

	Pipe Iron Black	156 mm	132°	39.71 sec	
9	Pipe Galvanized	175.5 mm	126°	25.31 sec	
	Pipe Iron Black	175.5 mm	126°	42.31 sec	
10	Pipe Galvanized	195 mm	120°	23.79 sec	
	Pipe Iron Black	195 mm	120°	33.66 sec	

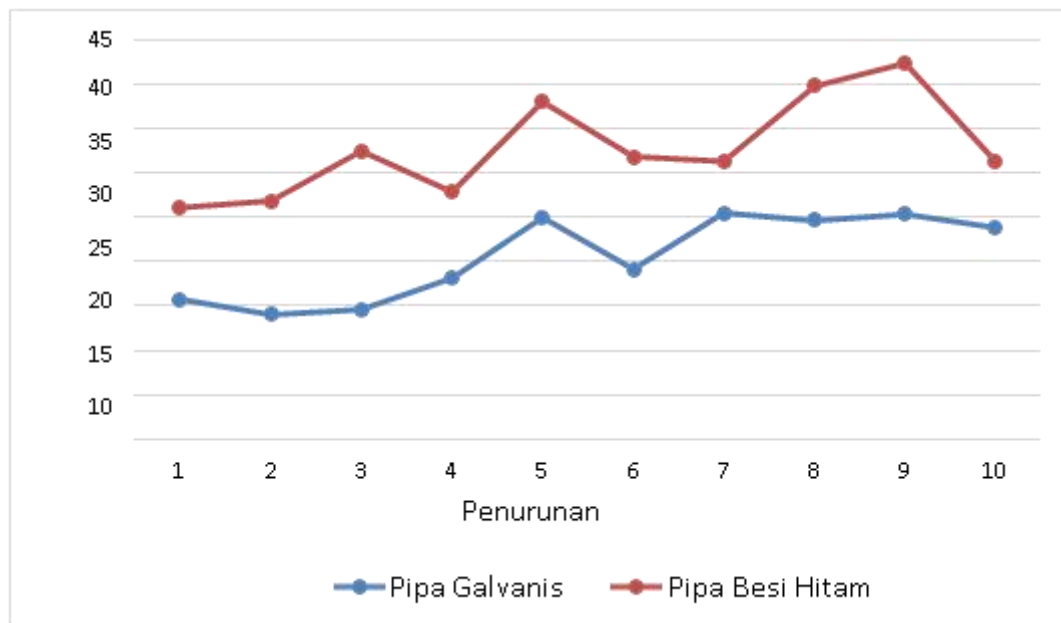


Figure 5. The difference in the rolling process time between galvanized pipes with black iron pipe

CONCLUSION

The conclusions obtained in the analysis of pipe *roll bending machines* by testing galvanized pipes and black iron pipes are as follows: a). The bending moment for 1 inch galvanized pipe with a pressure drop distance of 0.001 m is 0.0195 Nm and for black iron pipe it is 0.00177 Nm. b). The magnitude of the friction force that occurs during the process of *bending* the galvanized pipe roll is 0.013 N for the *roll torque* of 0.00078 Nm and the magnitude of the friction force during the process of *bending* the black iron pipe roll is 0.030 N for the roll torque of 0.018 Nm . c). The difference in *bending* results on 1 inch galvanized pipe and 1 inch black iron pipe is found in the processing time, where the *bending process* for galvanized pipe is 15.72 seconds and black iron pipe is 26.04 seconds. For the difference in the bending process time of 5 seconds.

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