RESEARCH ARTICLE OPEN ACCESS

Experimentations and Productivity Analysis of Power Operated Sheet Bending Machine

Dr. P. G. Mehar*, V. D. Dhopte**
**(Assistant Professor, Mechanical Engineering Department, K. D. K. College of Engineering, Nagpur*
*** (Assistant Professor, Mechanical Engineering Department, K. D. K. College of Engineering, Nagpur*

ABSTRACT
The power operated sheet bending machine is shown here. The importance of it is discussed. The theoretical formulae to calculate number of passes to manufacture pipe is given. Also formula to calculate time required to manufacture pipe is given. Experimental results of number of passes and time required are tabulated and given here. One parameter among thickness of sheet, diameter of pipe and width of sheet are varied by keeping other two parameters as constant. Then its effect on number of passes and time required to manufacture pipe is studied. Both theoretical and experimental results are compared and observed that they follow each other. Hence, it can be concluded that the theoretical formulae can be used for studying productivity of power operated sheet bending machine. Productivity analysis is given.

Keywords – Bending, Deflection, Diameter, Passes, Thickness, Time, Width

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Date of Submission: 23-02-2021 Date of Acceptance: 07-03-2021

I. INTRODUCTION

There are many companies, which are engaged in production of sheet metal pipes. These companies produce sheet metal pipes of various diameters and thicknesses. Some of the companies produce sheet metal pipes by using manually operated sheet bending machines. The manual process causes fatigue to labors, lowers the efficiency of labors and there by lowers the working efficiency of sheet bending operation. Therefore, to increase the productivity, the industry requires automation. Hence the manually operated machine is converted into power operated sheet bending machine [1] by using gear box, motor and adjustable screw. Thorough experimentation is carried out on the power operated sheet bending machine. The results of experimentation are analyzed to understand the experimental results and theoretical results. Also productivity of the machine is studied.

II. POWER OPERATED SHEET BENDING MACHINE

Power operated sheet metal bending machine as shown in fig. 1 consist of Roller, adjustable screw arrangement, motor, gear box, and gearing arrangement as shown in fig. 2. Here motor supply the power to the gear box, which transmits the power to the gears and at last power, is transmitted to the roller. In the process the sheet is inserted in between the lower rollers and upper roller. Adjustable screw is provided to adjust the thickness of metal sheet. The sheet needs to be passes number of time through rollers to manufacture pipe as shown in fig. 3.

Figure 1: Power operated Sheet Metal bending machine showing roller and adjustable screw arrangement

Figure 2: Power operated Sheet Metal bending machine showing gear arrangement with motor

Figure 3: Product of power operated bending machine

III. THEORETICAL CALCULATIONS

Theoretical number of passes and time required for forming pipe out of metal sheet are compared with the corresponding experimental results. The theoretical calculations are carried out to calculate the required number of passes and to calculate time required. The following formulae are used.

3.1 Theoretical number of passes

Theoretically, the number of passes required for manufacturing pipe is calculated by using following equation [1][2].

$$No.of\ Passes = \frac{\delta_{Total}}{\delta_{pl}}$$

Where,
δ_{Total} = Total deflection
δ_{pl} = safe deflection

3.2 Theoretical time required

The time required for manufacturing pipe is calculated by using following equation [1][3].

Total Displacement, X = length of sheet = $2\pi r_{as}$
Peripheral velocity,

$$V = \frac{\pi dN}{60}$$

Where,
N = Speed of roll
d = Diameter of roll
Rolling time,

$$t_1 = \frac{X}{V}$$

Machine idle time, t_2
Time for positioning, welding & rumoring pipe, t_3
Total time, $t = t_1 + t_2 + t_3$

IV. EXPERIMENTATION

Experimentation is carried out on the power operated sheet metal bending machine. For the purpose of experimentations, various diameter, thickness and width of sheet metal are considered. The collected data is presented in table 1 and graph for these parameters are also plotted which are shown below.

Table 1: Theoretical and experimental results

Sr. No	Thickness 'to' (mm)	Width 'w' (mm)	Dia. 'd' (mm)	Safe deflection in plastic 'δ_{pl}' (mm)	Total deflection 'δ_{Total} ' (mm)	Theo. No. of Passes (Nos.)	Actual No. of passes (Nos.)	Theo. Time required ('sec')	Actual time required ('sec')
1.	06	1200	600	85	98.64	02	03	983.4	1280.58
2.	10	1200	600	50.84	92.59	02	04	1102.2	1664.68
3.	16	1200	600	31.77	91.67	03	05	1560	2120.7
4.	20	1200	600	25.42	82.19	04	05	1897.8	2177.3
5.	50	1200	600	10.17	92.64	10	-	4860	-
6.	10	1000	600	50.86	92.59	02	04	1102.2	1664.68
7.	10	1500	600	50.84	92.59	02	04	1102.2	1664.68
8.	10	1900	600	50.86	92.59	02	04	1102.2	1664.68
9.	10	1700	600	50.86	92.59	02	04	1102.2	1664.68
10.	10	100	600	50.86	92.59	02	04	1102.2	1664.68
11.	20	1200	425	25.42	112.47	05	07	2026.74	2525.38
12.	20	1200	700	25.42	70.37	03	04	1669.82	1966.4
13.	20	1200	2700	25.42	15.55	01	03	2739.57	4018.71
14.	20	1200	900	25.42	54.05	03	04	1892.7	2223.6
15.	20	1200	1800	25.42	25.78	02	03	2470.48	2955.72
16.	20	1200	1200	25.42	39.87	02	03	1964.7	2347.05

V. PRODUCTIVITY

Productivity is relationship between the result obtained and the factors employed to achieve the result. Thus productivity is relationship of outputs to input. It is an indication of an enterprise capability.

In case of power operated sheet bending machine the output highly depends upon the working skill of the employed persons.

As per the definition of productivity we have a simple relation for it and it is given by

Productivity = (Output)/(Input)

5.1 Productivity Analysis of Power Operated Bending Machine

To directly compare the productivity in terms of capital required, the ratio of output in terms pipe manufactured per hour to the inputs in terms of capital assets employed is considered [4].

Thickness = 5 mm
Width = 1000 mm
Diameter = 500 mm
Labor required = 03
Operator required = 01
Time required for bending pipe = 20 min
Cost of welding rod = Rs.12/ps
Electricity consumption = 4 unit
Labor salary per day = Rs. 300
Operator salary per day = Rs. 500

Expenditure for making one pipe on m/c
Labor charge: Rs. 37.5
Operator charge: Rs. 20.83
Welding rod: Rs. 12.00
Electricity consumption: Rs. 60
Overhead Expenses: Rs. 25
Misc. cost: Rs. 10
Total: Rs. 165.33

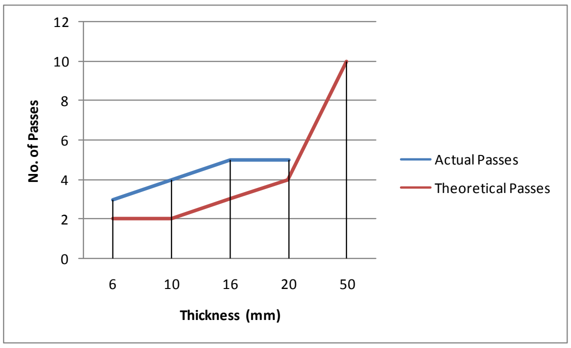
Productivity
= (Price in Rs./piece of pipe)/(Expenditure per pipe)
= (868/165.33)
= 5.25

VI. RESULTS AND DISCUSSION

The results obtained in table 1 from theoretical calculations and experimentations are analyzed. The observations are discussed here.

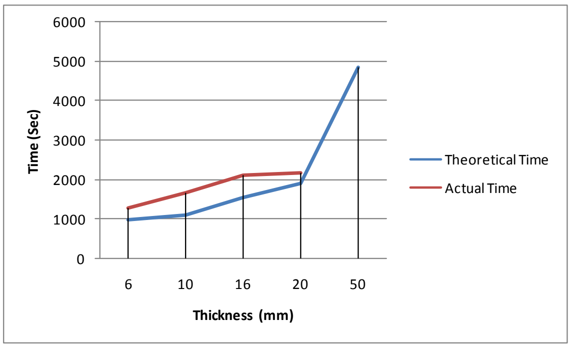
a. Graph 1 is plotted by varying thickness of sheet metal against number of passes. The diameter of pipe and width are kept constant. From graph 1, it is evident that the theoretical and actual number of passes required for forming pipe is increases as thickness of the metal sheet increases.

Diameter = 600 mm
Width = 1200 mm



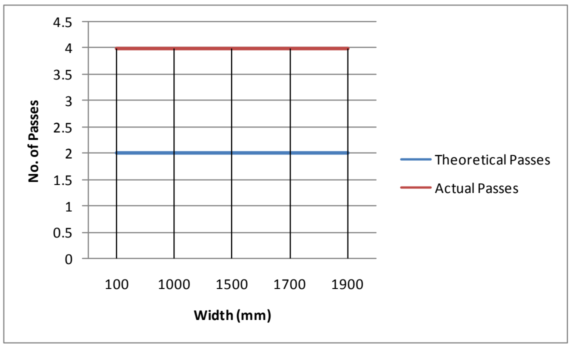
Graph 1: Thickness vs no. of passes

b. Graph 2 is plotted by varying thickness of sheet metal against time required. The diameter of pipe and width are kept constant. From graph, it is evident that the theoretical and actual time required for forming pipe is increases as thickness of the metal sheet increases.
Diameter = 600 mm
Width = 1200 mm

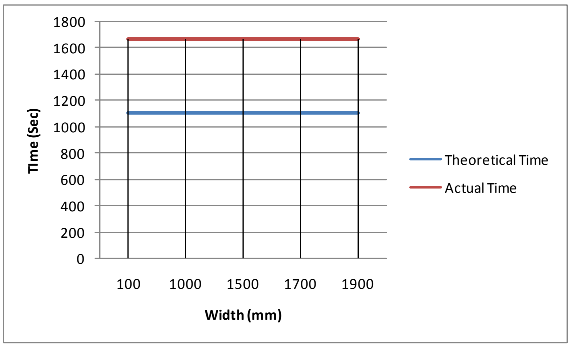


Graph 2: Thickness vs time required

c. Graph 3 and 4 are plotted by varying width of sheet metal against no. of passes and time required respectively. The diameter of pipe and thickness are kept constant. From graph 3, it is evident that the theoretical and actual number of passes required for forming pipe is constant as width of the metal sheet increases. From graph 4, it is evident that the theoretical and actual time required for forming pipe is constant as width of the metal sheet increases.
Thickness = 10 mm
Diameter = 600 mm

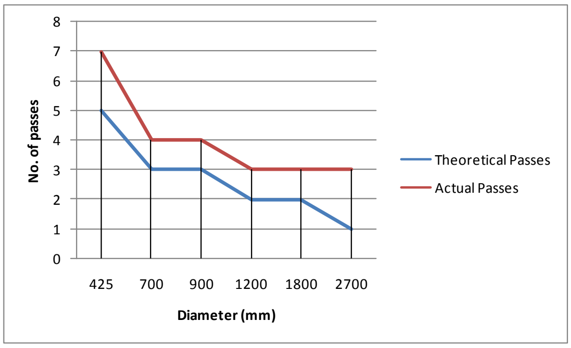


Graph 3: Width vs no. of passes

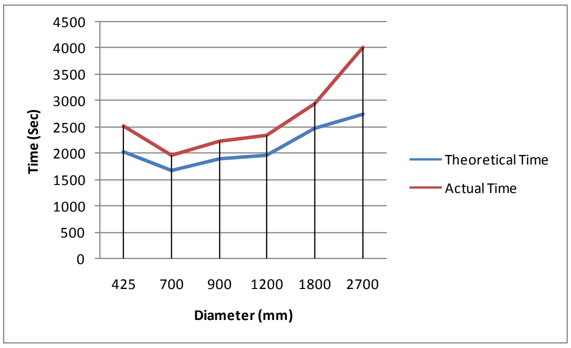


Graph 4: Width vs time required

d. Graph 5 and 6 are plotted by varying diameter of sheet metal against no. of passes and time required respectively. The width of pipe and thickness are kept constant. From graph 5, it is evident that the theoretical and actual number of passes required for forming pipe is decreasing as diameter of the pipe increases. From graph 6, it is evident that the theoretical and actual time required for forming pipe is increasing as diameter of pipe is increases.
Thickness = 20 mm
Width = 1200 mm



Graph 5: Diameter of pipe vs no. of passes



Graph 6: Diameter of pipe vs time required

VII. CONCLUSION

From the above results and discussion it can be observed that the theoretically calculated result follows the experimentally obtained results. The three parameters as thickness, diameter and width of pipe are considered. Out of these three parameters one parameter is varied by keeping other two parameters as constant. Effect of varying parameter on number of passes and time required for manufacturing pipe is studied, which is discussed in results and discussion. These theoretical equations are useful for companies working in the area of pipe manufacturing. Also the productivity analysis is carried out.

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Dr. P. G. Mehar, et. al. “Experimentations and Productivity Analysis of Power Operated Sheet Bending Machine.” *International Journal of Engineering Research and Applications (IJERA)*, vol.11 (3), 2021, pp 17-21.