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Design and Development of Bicycle Integrated Pipe Bending Machine

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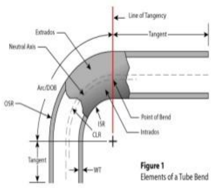
ABSTRACT: *A bicycle integrated pipe bending mechanism has been designed and developed. The machine consists of a chain drive, compound gear train, that is utilized for bending steel pipe of outside diameter 25mm and having 2mm thickness. The kinematic synthesis of bending mechanism is carried out. The dimensional analysis is done. Relation deduced predicts the performance of bicycle integrated pipe bending mechanism and all the parameter needs to be optimized to get the best performance of the machine. Bent pipes finds its application in frames for furniture, handle of bicycle, barricade etc. or as passage for carrying fluids or gases like hydraulic lines, fuel lines, exhaust pipes, water lines, etc. Industries using bent pipes are boiler, air conditioning, ship building, furniture, power generation, recreational vehicle, railroad, automotive, off-road and farm equipment, aircraft etc.*

Keywords: *mechanism, machine, bicycle.*

I. INTRODUCTION

Bicycle integrated applications that flour mill, washing cloth, potter wheel, wood turning lathe, bamboo sliver cutting machine, forge cutter, water lifting pump. Alexandrove 1981 stated that to power any machine by human energy, its driving power should be less than 75 watts but if any machine or process requiring more than 75 Watts and if process is intermittent without affecting and product, it can also be operated by human energy with the provision of intermittent energy storing unit such as flywheel. The angle of bend is 90°. The mechanism is designed for single bend. Fig 1 shows the terminologies related to pipe bending and application.



II. CONSTRUCTION

i) Energy unit, wherein a rider sits on saddle of stationary bicycle to pedal the unit .
ii) Transmission unit, consist of speed increasing chain-sprocket pair and further increase in speed is done by torque amplifying gear train.
iii)Process unit, consists of crank-rocker four bar kinematic chain which incorporates the mechanism to bend the pipe using compression bending method. The 4-bar kinematic consists of crank, coupler and rocker with one fixed link. On one end the rocker is pivoted to coupler and on the other end it is connected to pressure die. With the oscillation of rocker, the pressure die moves on fixed bend die. The pipe is fixed on one end and passed between the pressure die and bend die. With the movement of pressure die on bend die and pipe between them, the pipe get bend.

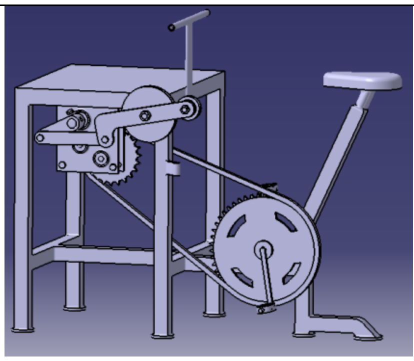


Fig.2 Bicycle Integrated Pipe Bending Machine

III. WORKING

(Refer fig No.2)

A person pedals the conventional bicycle chain-sprocket drive at a speed of 50rpm for 1 min to convert the oscillating thigh motion into rotational motion of bigger sprocket. The chain drives increases the speed in the smaller sprocket. The power through the shaft of small sprocket is transferred to gear train. The power through clutch transferred to torque amplification gear pair where the speed reduces and torque increases. This high torque is fed to the bending machine mechanism. The bending machine operates to bend the pipe at angle of 90°.

Design of Transmission System:
Average speed of pedal crank = 50 rpm
Average weight of rider = 50kg
Length of pedal crank = 170mm
Input power = 44.5 W
Speed increasing chain-sprocket pair
Teeth of bigger sprocket = 43
Teeth of smaller sprocket = 27
Speed at smaller sprocket = 80 rpm

IV. DESIGN AND KINEMATIC SYNTHESIS OF PIPE BENDING MECHANISM

Synthesis has three steps (Refer Fig. No.3)
i) Type Synthesis: It refers to the kind of mechanism selected. The linkage mechanism (Crank-Rocker 4-bar Chain) is selected for pipe bending.
ii) Number Synthesis: It refers to the number of links and joints to get desired mobility. Number of links = 4, Number of joints = 4, Mobility = 1
iii) Dimensional Synthesis: It refers to the dimension of kinematic links.
iv) Function generation: y = f (x), y is output rocker motion at an angle of 90° . x is input crank rotation of 360°.
v) Path generation: Path generation of rocker (Output) is circle arc.
vi) Body guidance: Circle.

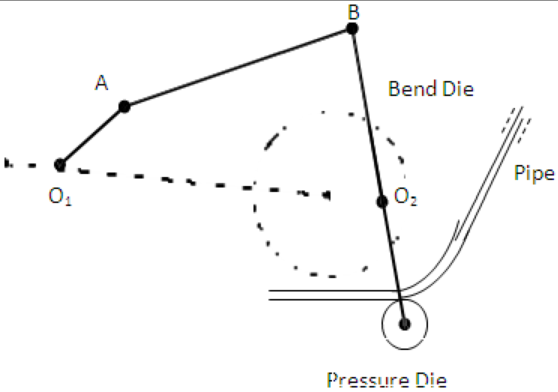


Fig.3 Pipe Bending Mechanism

Using Two-Position Synthesis of Crank and Rocker Mechanisms the dimensions are as shown in the table No.1.
Table 1:Dimensions of Link

Link	**Length (mm)**
Crank	210
Coupler	490
Rocker	525
Fixed	294
Diameter of bend Die	150
Diameter of Pressure	50

Bending Moment And Bending Stress

Using Equation of Pure Bending

$$M/I = \sigma_b/y = E/R$$

Where: M: Bending Moment (N-m)
I: Moment of area of pipe cross section (m4)
σb: Bending strength of pipe material (N/m2)
y: Distance of neutral axis from outermost fiber (m)
E: Modulus of Elasticity of pipe material (N/m^2)
R: Radius of Bend (m)
Properties of pipe:
Outside diameter of pipe, d=25mm
Thickness of pipe = 2 mm
Radius of Bend = 50mm
Standard Tangent =150 mm
Standard tangent is the distance between clamped point and start of bending.
Angle of bend = 90°.
Modulus of Elasticity of pipe material=200 MPa.
Yield Strength = 215MPa.
Using the above equation, M=141N-m.
Force on the pipe = M/ Standard Tangent= 940N.

Dimensional Analysis

The mathematical model of this man-machine system needs to be obtained, which will indicate the quantitative relationship among various dependent and independent parameters. This model is useful in obtaining the optimum human energy to be supplied to the system. For this the experimental data based model should be formulated [5].For formulating the data base model all the independent parameters will be varied one by one or in a group and the response of dependent variable will be observed. To study this, methodology of experimentation will be applied.

As suggested by Hilbert Schenck Jr (1961) the method adopted for formulating generalized experimental model was indicated as follows: independent, dependent and extraneous variables are identified; reducing of independent variables using dimensional analysis; Test planning comprising of determination of test envelope, test points, test sequence and experimentation plan; Physical design of an experimental set-up; Execution of experimentation; Purification of experimentation data; Formulation of model; Model optimization; Reliability of the model.

The first six steps mentioned above constituted the design of experimentation. The seventh step constituted model formulation while eighth and ninth steps were respectively optimization and reliability of model. Independent, dependent variables were identified and mention in Table 2.

Table 2: Dependent And Independent Variables

Sr.No.	Description of variable	Type of Variable	Symbol	Dimension
1	Bending Moment for bending pipe	Dependent	M	$[M^1 L^2 T^{-2}]$
2	Processing Time per pipe bend	Dependent	T	$[M^0 L^0 T^1]$
3	Speed of input crank of bending mechanism	Dependent	N	$[M^0 L^0 T^{-1}]$
4	Outside diameter of pipe	Independent	d	$[M^0 L^1 T^0]$
5	Pipe thickness	Independent	t	$[M^0 L^1 T^0]$
6	Length of Tangent	Independent	l	$[M^0 L^1 T^0]$
7	Radius of Bend	Independent	R	$[M^0 L^1 T^0]$
8	Angle of bend	Independent	θ	$[M^0 L^0 T^0]$
9	Modulus Elasticity of Pipe Material	Independent	E	$[M^1 L^{-1} T^{-2}]$
10	Acceleration due of gravity	Independent	g	$[M^0 L^1 T^{-2}]$
11	Coefficient of friction between pipe material and die material	Independent	μ	$[M^0 L^0 T^0]$
12	Torque Amplification Gear Ratio	Independent	G	$[M^0 L^0 T^0]$
13	Speed of big sprocket	Independent	n	$[M^0 L^0 T^{-1}]$
14	Speed ratio of Chain drive	Independent	C	$[M^0 L^0 T^0]$
15	Input Energy	Independent	Y	$[M^1 L^2 T^{-2}]$
16	Yield strength of pipe material	Independent	S_y	$[M^1 L^{-1} T^{-2}]$

Buckingham's Pi Theorem is used for dimensional analysis. Outside diameter of pipe (d), speed of big sprocket (N) and Modulus Elasticity of Pipe Material (E) is taken as repeating variable. The 15 π-terms for dependent and independent variables are as given below.

$\Pi_1=M/E*d^3$	$\Pi_2=T * N$	$\Pi_3=t/d$	$\Pi_4=l/d$	$\Pi_5=R/d$	$\Pi_6= \theta$	$\Pi_7=g/E*N^2$
$\Pi_8= \mu$	$\Pi_9=G$	$\Pi_{10}=N/n$	$\Pi_{11}=C$	$\Pi_{12}=Y/d^3* N$	$\Pi_{13}=S_y/E$	

Combining the above Π- terms to manageable extent to form test points and test envelop, the following reduced Π- terms are obtained.

Πo1: Geometric property of pipe
Πo2 : Pipe Material.
Πo3 : Energy transmission unit.
Πo1 = (t*l*R*θ)/ d3;
Πo2 = (μ* Sy)/E ;
Πo3 = (Y * Sy* G * g)/ (d4 *N3 * E2)

V. CONCLUSION

A new type of compression bending mechanism is designed and developed which unlike pipe other electric motor operated bending machine will work on non conventional energy source. In countries like India having ample human power, such human powered man- machine system will help to a great extent to improve the economical condition and employability of such countries. Such system are of utmost importance in Asian countries as almost all Asian countries are facing electricity scarcity which results in ten to twelve hours load shedding in rural areas. The machine is economically viable, can be used by unskilled worker. It does not require electricity for its operation. This machine will help maintaining the environment green and as it has no negative repercussion on the atmosphere and help reducing the problem of unemployment. Because of its numerous advantages bicycle integrated machines are finding the importance in the rural side of developing countries like India. And hence it is necessary to optimize its performance parameters. The effect of multiple operators with alteration in the mechanisms such as gear ratio can also be analyzed as future work for the pipe bending machine. Thus the dimensional equations are established in reduced or compact mode in order to make the complete experimentation process less time taking having generation of optimum data. The test points and test envelopes will be found with combinations of constant and varied variables and it is found that the data of test points and test envelopes was sufficient for design of experimentation.

References

Modak J.P, Moghe S.D "Design And Development Of Human Powered Machine For The Manufacture Of
Zakiuddin Syed Kazi, Jayant P. Modak, "Design and Development of the Human Energized Chaff Cutter",
Moghe, S. D., and J. P. Modak. 1998. Design and Development of a human powered machine for manufacture of lime –flyash-sand bricks, Human Power. Technical journal of the IHPVA,13 (2): 3-7
B. Bolund et al. / "Flywheel energy and power storage systems" Renewable and Sustainable Energy
Modak, J. P., and R. D. Askhedkar. Hypothesis For the extrusion of lime flash sand brick using a manually driven brick making machine. Building Research and Information, 22 (1): 47 – 54.
Modak J.P, Bapat A.R. "Various Efficiencies Of Human Powered Flywheel Motor" Human power number.