Design parameters and analysis of Hydraulic Rod Bending Machine

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ABSTRACT

Nowadays the world is focusing into automation. Each and every work of human is reduced by a machine, but few areas like construction the usage of machines for bending rods for stirrups which are used to withstand loads in beams and columns are not done by machine because the cost of machine is high and need skilled labours to operate it. So this project is aimed to do bending operation for stirrups using hydraulics and named as hydraulic rod bending machine. The main objective of our project is to implement the hydraulic rod bending machine in the construction sites with less cost compared to the existing bending machines, and increasing the productivity of the stirrups. Hydraulic rod bending machine consist of Double acting cylinder, P-40 Direction control valve, Hoses, Motor, Pump, Rack and Pinion, Free wheel, Fixture. The rod is bent by the hydraulic cylinder piston with holding the rod in the fixture. The main advantage of our project is the square shape of the Stirrups is bent continuously without repositioning the rod in the machine.

KEYWORDS: *Hydraulic Rod Bending Machine, Kinematic Mechanism, Hydraulic Operation*

I. INTRODUCTION

This project is to bend the rod at the specified dimensions which is used in the building construction which called as Stirrups. Stirrup is an important reinforced element which acts as a shear reinforcement. Presently, stirrups are made manually, which suffers from many drawbacks like lack of accuracy, low productivity and resulting into severe fatigue in the operator. In manual stirrup making process, operators not only subjecting their hands to hours of repetitive motion, but in many occasions it results into several musculoskeletal disorders (MSDs).

The project is designed based on the principle of Hydraulic system. The hydraulic load has more power compare to the other type of loads like pneumatic and electric. By using heavy loads we can increase the productivity of the product. The manual stirrup making process suffers from the many drawbacks. The construction worker not only subject their hands to hours of repetitive motion but also sometimes suffers internal injury to his body organ i.e. disorder carpal tunnel syndrome CTS, slipped disc problem etc.

II. WORKING PRINCIPLE

The system that we propose is that bending of square and circular stirrups. The rod is bent with the help of hydraulic force, because the power of hydraulics is very large the main aim of our project is to increase the productivity so with the help of hydraulic force we can able to bend 3-6 rods depending upon the diameter. The drawbacks in the

older machines are rectified. If we place a rod for bending in the existing system we have to reposition the rod for every bend, but in our system once the rod is placed we need not reposition the rod for all bends. This is done by a special attachment of coupling the pinion wheel of a rack and pinion set to a freewheel, the function of the freewheel is to change the position of the table to 90^0. When the hydraulic cylinder in the forward stroke the freewheel slips and hold the fixture table at the time the rod is bent. In return stroke of the cylinder the rack rotates the pinion which is connected to the freewheel turns the table to 90^0

III. DESIGN CALCULATION

A. Hydraulic assembly and working

The hydraulic circuit used for bending operation has been designed and shown in the Figure the components that are used in the construction of the kit are listed in the Table 1.1.

Table 1.1 List of the components

S.No	Description
1	Tank 40 litres
2	Filter
3	Vane pump
4	Electrical motor 2hp
5	Pressure relief valve
6	Pressure gauge
7	Double acting Hydraulic cylinders
8	Hoses
9	Direction control valve-4/3 (P-40)

The Hydraulic oil employed in this process is initially stored in a tank of 40 litres capacity. A filter air breather is mounted on the tank for filling the air passing into the reservoir and straining the oil while filling the reservoir. In addition a suction strainer is used to suck the oil into the system. An electrical motor of 2HP is coupled to vane pump to drive the fluid. When the motor runs, coupling that connects motor and the pump causes the rotation of the pump in turn. Depending upon the speed of the rotation of the pump, a vacuum is created which make the oil to be sucked and raised into the system. The pressure of oil depends upon the speed of the system. The pressurized oil passes through an inline check valve that prevents the return flow of the oil into the pump. This is followed by a pressure line filter to filter the oil from dust partials. A Pressure Relief Valves is connected parallel to the output line of the filter This relief valve is used to prevent the system from the effect caused by excess pressure this limit, the valve get activated and releases the excess pressure. The flow from these valves is measured using a pressure gauge mounted on the pipe line and it can be adjusted. The pressurised oil then enters the Directional Control Valve (P-40). The DCV used here is a P-40 4/3 Joystick operated spring centred DCV. At other end of DCV is connected to a Double acting cylinder. This cylinder is involved in the bending operation. When the left spool is activated, the oil flows into the piston end the of the cylinder causing the extension of the cylinder. The extension force of the cylinder is used for bending operation. Once the bending is completed, the right spool is activated. This causes the retraction of the cylinder. This process is repeated for bending stirrups controlled manually.

IV. INDIVIDUAL COMPONENT DESIGN CALCULATION

A. Hydraulic power

Cylinder specification   = 76 mm

    Bore diameter   = 2.84

    Wall thickness   mm = 186

    Length   mm = 27

    Piston thickness   mm = 150

    Stroke length   mm

        Max. $= 175 \times 10^5$

Pump specification: Pressure N/m^2

Force calculation: Area, A $=$ -3 2

Force or load $= 4.53 \times 10^{-3}\ m^2$

                                              $= \times$

$$= 175 \times 10^5 \times 4.53 \times 10^{-3}$$
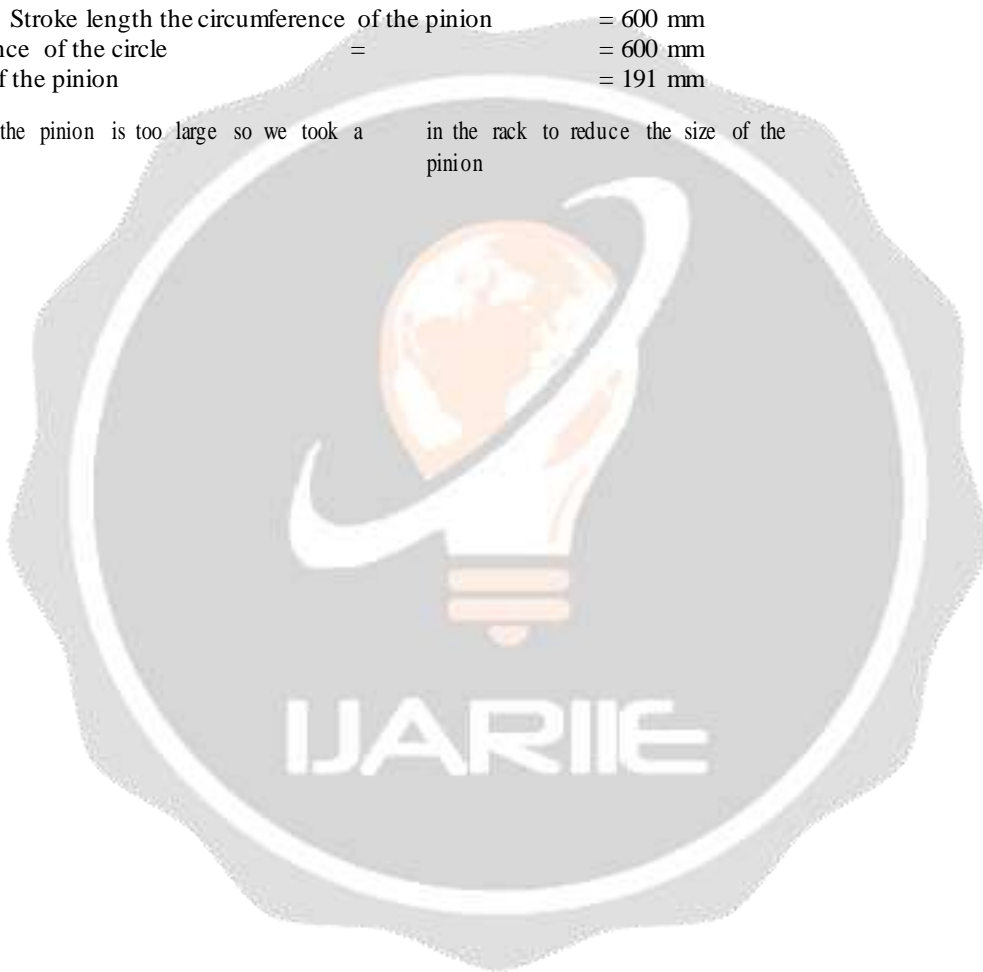$$= 79.275 \ \text{kN}$$

This maximum load helps to find out how many rods can be bent in the single operation the specimen of rod is tested in the Universal Testing Machine and observed

B. Rack and pinion

The need of rack and pinion in our set up is to turn the table to 90^0 for this arrangement the pinion circumference for the
pinion is calculated based on the stroke length of the piston

For 150mm Stroke length the circumference of the pinion   = 600 mm
Circumference of the circle   =   = 600 mm
Diameter of the pinion   = 191 mm

The size of the pinion is too large so we took a   in the rack to reduce the size of the
groove   pinion

The standard pinion of diameter is taken		= 100 mm
Groove length in the pinion		= 72 mm
The Design of the rack and pinion gear		
No. of teeth of Pinion Z_1		=37 teeth
Module (m)		=3 mm

Dynamic Beam Strength calculation

Lewis factor(y)	= 0.175-(0.841/Z_1)	=0.175-(0.841/37) =0.1522
Velocity (V)	= Stroke Length / Time in sec	= 150 / 7 = 0.02147 m/ sec
Velocity factor (C_v)	= 3/(3+V)	=3/(3+0.02147) =0.99
Face width (b)	**= 3πm**	**=3 x π x 3** =28.27 mm
Load in the pinion	=5.9 kg	=59 N
		(P.S.G data book)
Permissible static stress (σ_b)	=56 N/mm^2	

Dynamic Beam Strength

FDB   **=[σ_b] x C_v x π x m x b x y.**   **=56 x 0.99 x π x 3 x 28.27 x 0.1522**
=2248.19 N > 59 N

Hence the design is safe.

Beam Strength:
^{F}BS   **= [σ_b] x π x m x b x y**   **=56 x π x 3 x 28.27** x 0.1522
=2270.9 N > 59 N

Hence the design is safe

Bottom clearance (C)	= 0.25 x m	= 0.25 x 3	= 0.75 mm.
Addendum	=1x m	=1 x 3	=3 mm.
Dedendum	=1.25 x m	=1.25 x 3	=3.75 mm.
Working Depth	=2 x m	=2 x 3	=6 mm.
Tooth Depth (h)	=2.25 x m	=2.25 x 3	=6.75 mm.
Fillet Radius	=0.4 x m	=0.4 x 3	=1.2 mm.
Tooth Thickness	=1.5708 x m	=1.5708 x 3	=4.521 mm.

C. Parts and Assembled Diagrams

The Frame is the main part of the machine it is the base of the machine. The hydraulic cylinder is attached to the frame. The Fixture which is the main part of the project is also designed in the modelling software and is shown in the Figure 1.4. The assembled model of the components used in the project is shown in the Figure 1.5.

Figure 1.4 Part model of Fixture   Figure 1.5 Assembled model of the machine

V. FABRICATION PROCESS

A. Process Description

The purpose of the project is to bend rods for making it as stirrups. The motor is switched on the pump is pumping the hydraulic oil. When the left spool is activated, the oil flows into the piston end the of the cylinder causing the extension of the cylinder. The

extension force of the cylinder is used for bending operation. Once the bending is completed, the right spool is activated. This causes the retraction of the cylinder. The 4/3(p-40) DCV is actuated manually in the forward side this operation makes the piston in the cylinder to move forward and the process of bending the rod is done. Then the DCV is actuated backward the piston in the cylinder retracts back. When the cylinder moves back the freewheel which is coupled to the pinion rotated. The rack is connected to the piston as the piston moves the rack also slides in forward motion the freewheel slips and does not make the table to rotate. When it is in return stroke the table is rotated 900 counter clocks wise for making the machine ready for next bending operation without repositioning the rods. After the rod is bent it is removed and the next set of rods is placed for next cycle of operation.

A. *Photos of Fabricated model*

The project is fabricated and the photo of the fabricated model is shown in the Figure 1.6, the mechanism used in the project is shown in Figure 1.7 and Figure 1.8. The purpose of the project is bending rods and the illustration of the working model is shown in Figure 1.9.
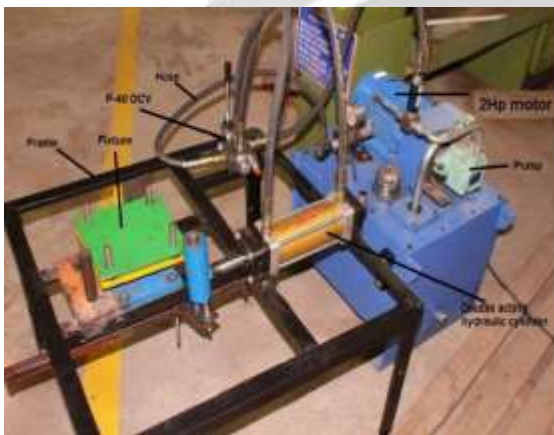

Figure 1.6 Fabricated Model Model
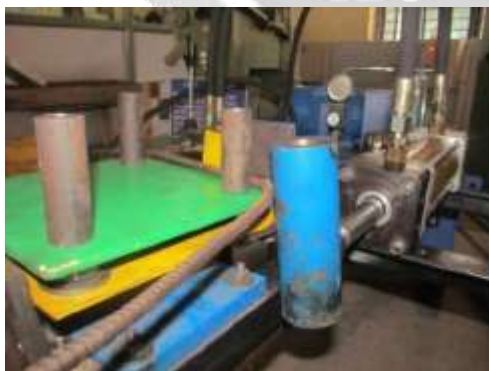

Figure 1.7 Front View Of Assembled

Figure 1.8 Working model

Figure 1.9 Stirrup bended by the machine

VI. CONCLUSION

In latest attempt a successful solution for the manual stirrup making is obtained. By changing the fixture in the table we can obtain various sizes of the stirrups. Instead of complicated designs the simple kinematic system is used.

In this system bending of stirrup wire can extended to its length against workstation is possible. The rate of production is around 1000 to 1250 stirrups in 8 hours of effective working per day. The system can be handled by any operator very easily.

Due to low cost and simple design this can be marketed to any of the nation.

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