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Development Of A Simple Gasket Punching Machine

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Abstract: *This research presents the design of a simple manual gasket punching machine applying the concept of shear force mechanism fabricated using mild steel material, chrome rod and load spring.The machine has a disk of six punching tools capable of punching through 19mm diameter hole with six hole places on rubber gasket material of thickness 3mm installed on a table top.The punching machine developed has the following dimensions: height 1.5m, width 6m and length 8m with an overall assembled weight of 65kg. The machine could be used in pipe fitting and is economically advantageous and easy to operate.*

Keywords: *Punch, Gasket, Spring, Force, Shear steess*

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I. INTRODUCTION

The gasket punching machinesemploy punching tools to perforate and create impressions with respect to the shape of the punch edge through the application of shear force.A convectional gasket punching machine require a torque arm, punch tool and die as frictional part for its operation. Gasket punching machines are classified according to their driving mechanism and automation, the air driven press adopt pneumatic system, the hydraulic press adopt fluid system and manual press adopt hand or manual magnification of force either by screw or lever(Vukota 2004; "50 COINS IN 2,500 YEARS" 2017). The principle of gasket punching machine is also synonymous to stamping, shearing, bending, blanking, and perforating operation(Vukota 2004). Survey has revealed that portable, affordable and easy-to-use gasket punching machinesare not available in the Nigerian market and this is the focus of this paper. The paper is therefore aimed at presented the development of a gasket punching machine using basic concept of welding and fabrication, principle of press torque arm, die design and spring. This principle was paramont in the design of the punching press by using second class lever principle of machining. Notably the simple gasket punching machine makes use of second class lever principle where load is placed between the fulcrum and effort as shown in figure 1. Invariably, the punching effort comprises of the press torque arm and spring principle with the aid of welding and fabrication concept.

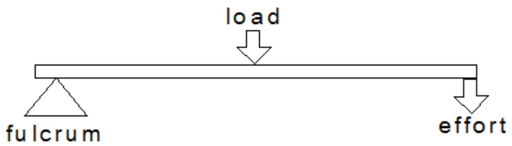

Figure 1 A Simple Second Class Lever

II. DESIGN CONCEPT AND CALCULATIONS

Design concept of manual gasket punching press based on the principle of shear mechanism by the application of punch force causing materialfailure leading to material seperation.The design functions on the following parameters:

2.1 Punch force

Punch force is the shearing force required to punch the material thereby generating shear stress and shear strain on the material. To obtain the punch force,P. The following mathematical expression is employed(Vukota 2004):

$$P = S\pi Dt \quad (1)$$

Where$P$ is the punching force; S is the shear strength of cycolac rubber; D is the diameter of each hole; t is the thickness of material.

The coefficient of shear strength, S of cycolac rubber is given as 6000 psi($\equiv$ 41340 KPa or 41.340 N/mm^2); hole diameter, D as 19 mm, thickness, t as 3 mm.

From equation (1), the Punch force is obtained as 44.4KN (≡4.99 tons) for 6 holes.

2.2 Shear Stress

The shear stress is expressed as the ratio of punch force per unit area. It is represented mathematically as(Vukota 2004):

$$\sigma = \frac{P}{\pi r^2} \quad (2)$$

Where Punch force, $P = S\pi Dt$

From equation (1), Punch force, P was obtained as 44422.5 N

Area is the area of punched hole, πr^2 = 358.26mm^2

$$\sigma = \frac{44422.5}{358.286} = 128.97N/mm^2$$

2.3 Factor of Safety

The Factor of safety,(Fs) was obtained from the relationship(Vukota 2004):

$$Fs = \frac{Ultimate\ Tensile\ Stress\ (UTS)}{Working\ stress, \sigma} \quad (3)$$

Whereσ = $128.97N/mm^2$, $UTS = 247.94N/mm^2$

Therefore , employing equation (3), Fs =2

2.4 Work Done

The Work done, is the product of punching force and the perpendicular distance move by the punch expressed as (Vukota 2004):

Work done = punch Force × distance

Mathematically, $Work\ done = (S\pi Dt\ x\ d)$ (4)

Where Punch force, $P = S\pi Dt$; $d$is the distance (mm)

The work done was obtained as $2.66kN/mm^2$

2.5 Spring Load

The spring load (W) is expressed mathematically as(Vukota 2004):

$$W = \frac{G\ x\ d^4}{8D^3n} \quad (5)$$

Where W = Spring load; D = diameter of the spring; G = modulus of rigidity (G=90 × 109N/m^2); n = number of coil; d = diameter of wire; x = distance between the coil

For gradual loading on the spring, Equation (5) is obtained as 64.78

2.6 Punch Clearance

The required punching clearance (C) ,which is the space between the punch and the die opening is obtained using the mathematical expression(Vukota 2004):

$$Clearance = \frac{Diameter\ of\ die(D_m) - Diameter\ of\ punch\ (D_p)}{2} \quad (6)$$

Where die diameter (Dm) =20mm; punch dia (dp) = 19mm

Therefore C = 0.5mm

III. CONSTRUCTION DETAILS AND PROCEDURES

Table 1 show the material requirements for the construction of the gasket punching machine.

Table 1 Materials list

Items No	Descriptions	Quantity	Size(mm)
1	Mild steel plate	1/3	12× 1000 × 500
2	Mild steel sheet		800 × 500 × 5
3	Shaft (chrome rod)		L 120 , D 32
4	Angular bar		T 2 , L 200
5	Bolts and nuts	18	19
6	Tyres	4	
7	Spring	1	
8	Miscellanous		
9	Paint		

3.1 Press Torque Arm

The Press torque arm provides the means by which required force needed for punching the gasket material is applied.The Press torque arm was cut out from mild steel of 12mm thickness and 800mm overall lenght as shown in figure 2

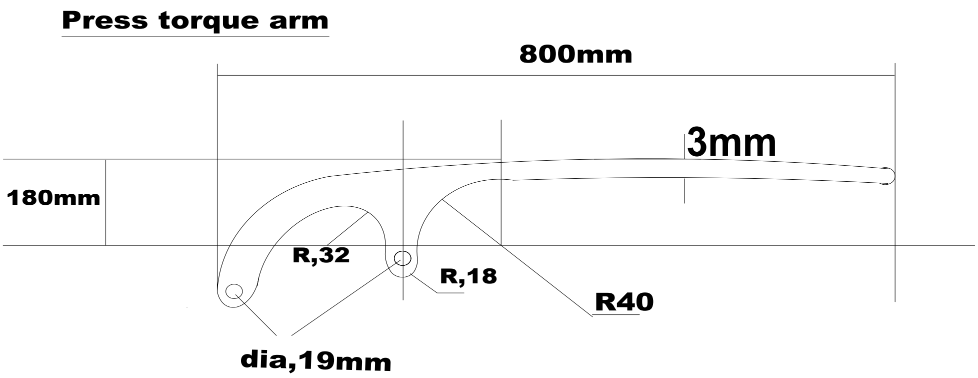

Figure 2 The Press torque arm

3.2 Shaft

The shaft rod connects the torque arm with the punch tool disk through threaded end and lock nut, which serves as a means of transmission of force on the gasket material. The shaft is made of chrome rod which allow slippery and smooth movement of rod with less frictional resistance force .The shaft is dimension as shown bellow.

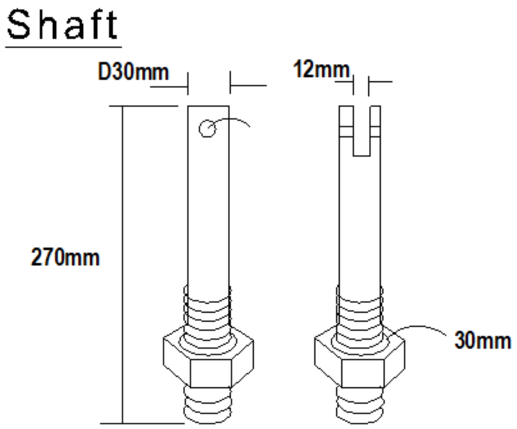

Figure 3 The shaft for power transmission

3.3 Tool Disk

The disk is circular in shape containing six holes which allow cutting tools to be fixed. The cutting tools are made of steel tube, they were chamfered at the sides of contact in other to extend punch tool service life span and enabling less punching force requirement. The tail end of each cutting tool is threaded inside to allow the cutting tool to be fixed on the disk by bolt. Figure 4 is the schematic representation of the tool disk.

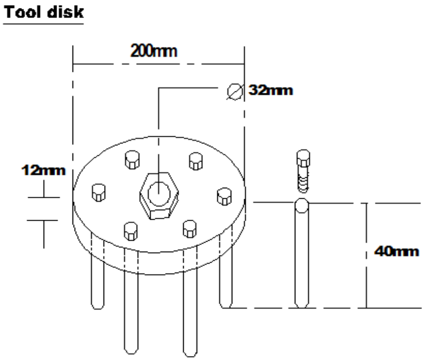

Figure 4The tool disk

3.4 Die

The die is designed by considering the strength, clearance for shearing and proper alignment with upper punching tools. The die is cut out from mild steel of 12mm thickness,made to square top of a box where two sides are open in order to allow removal of slug . The other two side are welded with angle bar and drilled so as to enable the die to be fixedto the table. Figure 5 is a representation of the die.

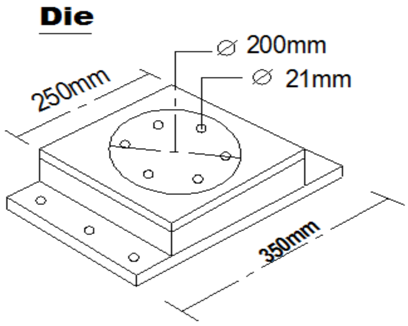

Figure 5 The machine die

3.5 Tyres

Tyres are fixed at the trolley platform for easy mobility as shown in the schematics of the full assembly in figure 10.

3.6 Head frame

The head frame component is designed and fabricated to carry the spring guide, press torque arm and shaft as shown in figure 6. The head frame is cut out from mild steel plate of 12mm thickness, the base is made up of flat plate of the same thickness, with drilled holes which allow the head frame to be bolted on table.

3.7 The spring

A spring with appropriate spring load was selected based on the impact load that will be exerted by press torque arm. The spring arrangement is as illustrated as shown in figure 7.

3.8 Torque Arm Guide

The Torque arm guide is made up of two mild steel flat bar of 2mm thickness and length of 350 mm with drilled fulcrum holes placed at the curved edge of the head frame purposely to enhance alignment. The Torque arm guide is shown in figure 8.

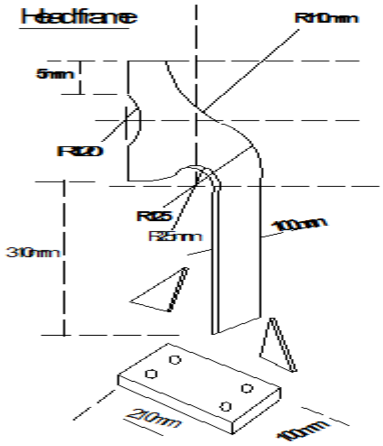

Figure 6The head frame of the machine

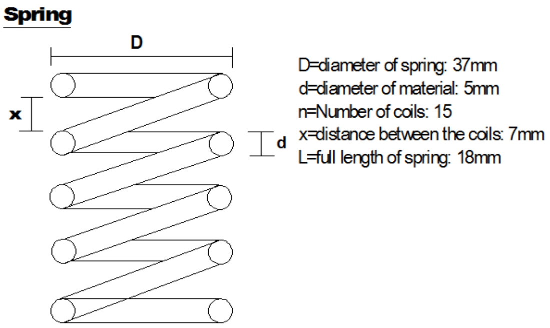

Figure 7The load spring

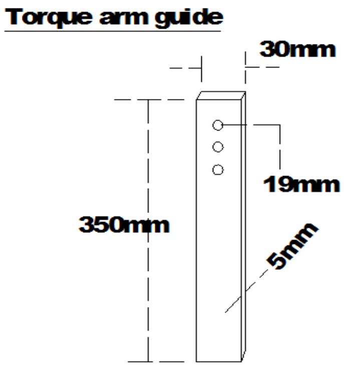

Figure 8The torque arm guide

3.9 Spring Guide

The upper and the lower spring guide are welded on the head frame to guideand restrict the movement of spring. The spring guide is a piece of pipe cut to an appropriate size as shown in figure 9

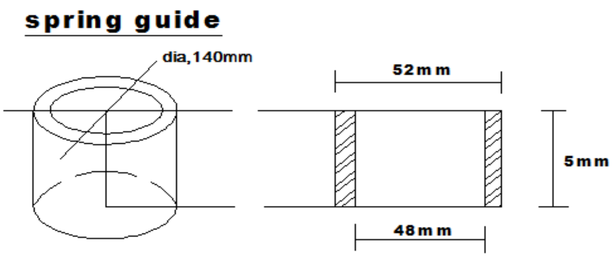

Figure 9 The spring guide

Figure 10 represent the complete assembly of all components that makes up the gasket punching machine. The tyre seatings are constructed and welded to the leg frame supporting the punching gasket table .

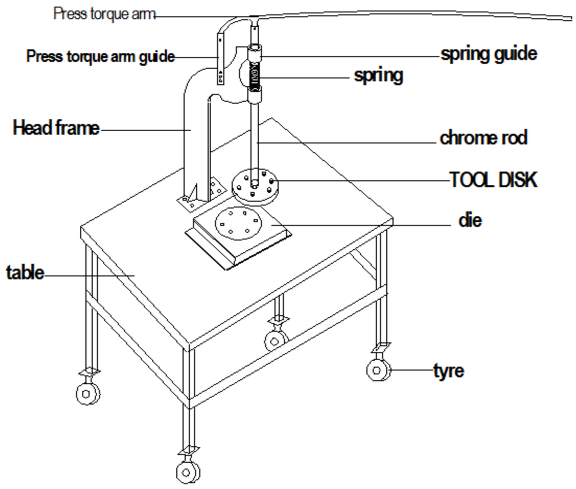

Figure 10. The complete assembly diagram of the Gasket Punching Machine

IV. CONCLUSION

The gasket punching machine developed in this paper was tested and results obtained showed it works perfectly and efficiently. It was deployed for mass production of standard rubber gaskets for flange joints with little or no variation in dimensions and shape of the products.Thereforethe design and construction is appropriate, affordable and easy to maintain.

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