Design and Construction of Manually Operated Soap Cutting and Scraping Machine for Small Scale Industries

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***Abstract* - The design and construction of manually operated soap cutting and scraping machine for small scale industries is an attempt to solve the problems encountered by the previous machine such as power failure, inefficient and skilled personnel for their operation and no room for producing different sizes of soaps on a machine etc. This machine was constructed using affordable materials and is manually operated, and also it permits the production of different sizes of soap by merely adjusting the cutters, lastly it requires no or little special skill for its operation. Results obtained show that the machine has efficiency of 85%. From the performance test, the soap cutting and scraping machine was able to cut ten (8) bars of soap in one revolution of the handle in three (3) seconds, therefore, for the machine to cut and scrape twenty five (25) bars of soap and above It will depends on the mould size and the number of cutter blades used, which will also take the same number of revolution of the handle.**

Key words:Scraping, shearing, sprocket, chain, rotatory motion, reciprocatory motion, welding

1.0 INTRODUCTION

Soap is commonly used domestically or industrially. During production process, soap arrives in loaves or in blocks form, therefore, the need to cut the soap into bars arises. Soap cutting and scraping machines is a machine designed to be used in cutting and scrapping of soap at the same time. [7].

Although, it is believed by many that, soap cutting and scraping machine has being in existence since time immemorial in Babylonia. The Ancient soap cutting techniques make use of their hands and a long knife to cut their soap, but as time progresses, the use of hand and knife became ineffective, they later started using pasty scrapper to cut their soap, the pasty scrapper is made up of wooden handle and they have long life and less likely to bend. During the industrial revolution a wooden miter box and a cutting blade were developed for cutting soap, the wooden box acts as the guide. The straight edge of the box ensures straight cut. The miter box was designed in such a way that, you can insert a saw into the straight cut and finish sawing the notch all the way down to the base of the miter box. [7]

Currently, soap cutting and scraping machine are designed and constructed in different form and types, such as, air power soap cutting machine, rotary soap cutting machine, loaves cutting machine, manual soap cutting machines. but most of them are not manually operated and they are very huge that is bulky, expensive to be purchased by small scale industries , they require special skills for their operations, in a nutshell they are not easily set up by small scale industries most especially in rural areas, based on these reason, we carried out this project, to design and construct a simple soap cutting and scraping machine that is manually operated, simple and affordable which requires little or no special skills for its operation and can be easily set up by small scale industries even rural areas, that will also overcome the challenges of power failure which is alarming in our country today. The machine is more convenient to use, more efficient and cleaner production process.

2.0 MATERIALS AND METHODS

2.1 Design considerations and machine components

Selection of material depends on many factors such as availability, Toughness, machinability, strength, corrosion resistance and economics considerations. The following were put into consideration when designing the machine

- The type of stresses which the components are to be subjected to or experienced,
- The type of manufacturing processes and Corrosive action of the materials.
- The machine should be efficient, simple and easily operated.

The materials selected during the design and construction of manually operated soap cutting and scraping machine include the following

i. Tension steel cable
ii. Sheet of metal (Galvanize sheet)
iii. Solid shaft (steel)
iv. Angle iron (steel)
v. Iron rod (steel)
vi. Bolt and nut (steel)
vii. Steel pipe
viii. Bearing
ix. Handle cover (rubber)
x. Chain and sprocket (steel)

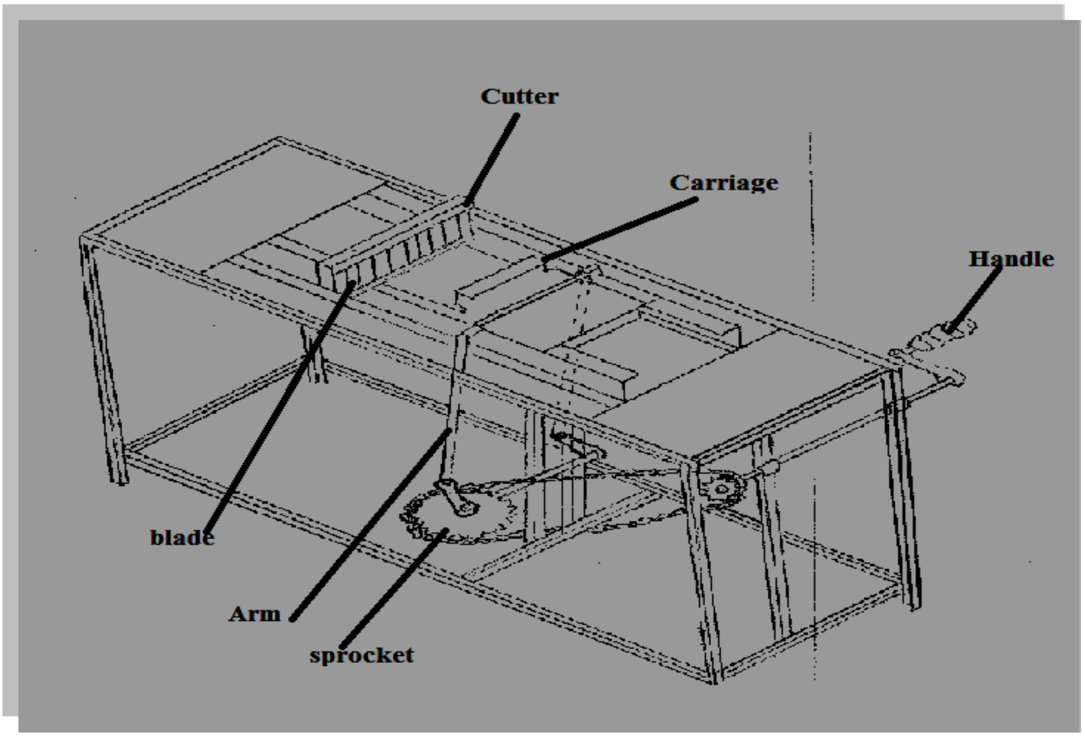

Fig.2.1. Manually operated soap cutting and scraping machine

2.1 Principle of operation

The soap cutting and scraping machine works on the principle of crank mechanism. The rotary motion of the handle is converted to a linear reciprocating motion; this is achieved by the use of chain and sprocket to transmit motion. The large sprocket is connected to the arm, which move the carriage in a backward and forward movement, The front side of the carriage was projected in such a way that it has a thick flat surface to be able to push the loaves soap pass the cutter. four bearings, two each were fixed on each side of the carriage and an angle bar was placed beneath, so that the bearing would be able to roll on it when the block soap (molded soap) is placed on the table, the carriage pushes the block soap passes the cutters, The cutter are made of steel tension wires, which are 1½ inches apart, and are fixed by the use of angular steel thus, Depending on the size of soaps needed, The cutter is designed in such a way that, it can be easily interchanged according to any specification of size. Two metal blades are inserted at the cutting zone, one is inserted in the table of machine while the other is mounted on the bar which carries the cutters, and the displacement of the arm by the connecting rod is proportional to the distance moved by the carriage which pushes the soap passes the cutters.

2.2 Design Analysis

Three main units were considered in the design of manually operated soap cutting and scraping machine, these are the chain and sprocket, carriage and cutting zone.

2.2.1 Length of single back sprockets chain

The chain is mostly used to transmit motion and power from one shaft to another, when the centre distance between their shaft is short such as in Bicycles, motor cycles, agricultural machinery conveyors, rolling mills, road rollers etc the chain may also be used for long centre Distance of up to 8 meter. The chains are used for velocity up to 25m/s and for power up to 110kw . In some cases higher power transmission is also possible.

Chain drive is used because of the following reasons

(i) It can be operated under adverse temperature and atmosphere conditions
(ii) It permits high speed ratio of 8 to 10 in one step
(iii) It gives high transmission efficiency (up to 98 %)
(iv) It may be used for both long as well as short Distance
(v) Since the chain are made up of metal, therefore they occupy less space in width than a belt or Rope Drive
(vi) As no slip take place During chain drive, Hence perfect velocity Ratio is obtained

An Open Chain Drive System Connecting the two Sprockets provides this formula to calculate the exact length of a simple in-line drive chain running between two sprockets:

$$L_{sd} = \frac{N+n}{2} + \varphi\frac{(N-n)}{180} + 2C^{*}cos\varphi \ldots 2.1[8]$$

where:

L_{sd} = the length of the single back sprocket drive chain (in pitches)

N= the number of teeth on the large wheel (generally the chain

n = the number of teeth on the small wheel (generally the back sprocket),

C = the distance between sprocket centres (in pitches)

$$\varphi = \sin^{-1}\left(\frac{(N\text{-}n)}{2\pi C}\right) \text{ in degree} \ldots\ldots\ldots\ldots 2.2[8]$$

2.2.1.1 *Velocity ratio of the chain drive*

The velocity ratio of a chain drive according to (Khurmi and J Gupta 1979) is given by

$$V.R = \frac{N_1}{N_2} = \frac{T_2}{T_1} \ldots\ldots\ldots 2.3[6]$$

Where;

N_1= speed of smaller sprocket in r.p.m

N_2= speed of larger sprocket in r.p.m

T_1= Number of teeth of smaller sprocket

T_2= Number of teeth of larger sprocket

Then the average velocity of the chain is given by

$$V = \frac{\pi DN}{60} \ldots\ldots\ldots\ldots 2.4\ [6]$$

D=pitch diameter of the sprocket in mm

N_1= speed of smaller sprocket in r.p.m

2.2.2 *Rate of change of momentum of the carriage*

Rate of change of momentum of carriage= $\frac{m(v-u)}{t} \ldots\ldots\ldots 2.5[2]$

Momentum = mass x velocity

M = mass of the body

u = initial velocity of the body

v = final velocity

a = constant acceleration

t = time required to change velocity from u to v

change of momentum = mv – mu

2.2.3. *Tension of the steel cable/cutter*

The theoretical distribution of load in the cable can be calculated from the dimension of the triangle formed by the cable, and the table. The amount of tension in each cable segment will be proportional to the length arm of the triangle as follows where the triangle has the dimensions [4], the hypotenuse of the right triangle (length of arm “c”) is

$$\frac{\text{length a}}{\text{tension a}} = \frac{\text{length b}}{\text{tension b}} = \frac{\text{length c}}{\text{tension c}} \ldots. 2.6[4]$$

2.2.4 *Critical buckling load of the column (support)*

The load on the frame column is equal to the sum of weight of carriage, four-bearing, cutter zone, handle, two-sprockets and collectors.

$$F_t = W_{ca} + W_b + W_{cu} + W_H + W_s$$

W_{ca} = Weight of the carriage

W_b = Weight of the bearings

W_{cu} = Weight of the cutters

W_H = Weight of the handle

W_s = Weight of the sprockets

These columns fixed at both ends may be subjected to failure by buckling in order to determine the safe load, Euler formula is applied [J]

$$F_{CR} = \delta y\ A_t\left(1 - \frac{\delta y\left(\frac{Ls}{k}\right)^2}{4n\pi^2 E}\right) \ldots\ldots 2.7[1][2]$$

F_{CR}=Buckling load

E=Modulus of elasticity

M=moment of inertia

L_s = length of column

A_t=Area of the column

2.2.5 *Result of calculation*

V.R=2.3, L_{sd}=10.3567pitches, $\varphi = 0.1184$, V=4.7 mm/min, M=12.5kg, L=12.5kg, tension c=12.50001276, F_t=80.45N, F_{CR}=170565.87N

3.0 RESULT AND DISCUSSION

Table 1: Result of Cutting Capacity

Serial no	Size of block soap(mm)	No of cutter blades	No of bar cut	Time taken(sec)
1	650x650x80	7	8	3
2	650x650x80	9	10	3.75
3	650x650x80	11	12	4.5
4	650x650x80	13	14	5.25

Average number of bar cut= $\frac{8+10+12+14}{4}$ =11bar*s*

Average time taken= $\frac{3+3.75+4.5+5.25}{4}$ =4.125s

Cutting capacity of machine= $\frac{11}{4.125} = 2.667\,\text{bar/sec}$

After the construction/fabrication of the machine, it was tested. This was done as follows;

After molding the soap, it was placed on top of the table; the handle of the machine was turned in a clockwise direction. It was observed that, it took one turn of the handle for the carriage to push the block soap to pass the cutter; the rotation of the handle in one revolution took about three (3) seconds.

$$\text{Efficiency} = \frac{\text{mechanical advantage}}{\text{velocity ratio}} \times 100 \quad \ldots 2.8[4]$$

Thus,

$$\text{Mechanical Advantage} = \frac{\text{load}}{\text{effort}}$$

Load =mass of block soap x acceleration of the block soap

Mass of block soap = 12.78kg

effort=mass of the carriage x acceleration of the carriage

= 9.75 x 0.33=3.2175kg

Distance covered by block soap = 0.175 m

Time taken by block soap to reach cutters=2 sec

$$\textit{Acceleration} = \frac{v-u}{t} = \frac{.995-0}{2} = 0.4975$$

load=12.78x.4975=6.35N

$$\text{mechanical advantage} = \frac{6.35}{3.2175} = 1.97$$

$$\text{efficiency} = \frac{1.97}{2.3} \times 100 = 85\%$$

From the performance test, the manually operated soap cutting and scraping machine was able to cut ten (8) bars of soap in one revolution of the handle in three (3) seconds.

Therefore, for the machine to cut and scrape twenty five (25) bars of soap and above It will depends on the mould size and the cutter used, which will also take the same number of revolution of the handle.

The soap cutting and scraping machine was tested by using block soap which is about 650 x 650 x 80mm in length, width and height respectively and different cutters were interchanged. Cutters of 7, 9, 11, 13 blades were used, It was observed that the machine was able to cut and scrape the block soap (lump) to 8, 10, 12, 14 bars in 3, 3.75, 4.5, 5.25 seconds respectively as shown in table1, and cutting ability of machine was calculated to be 2.667bar/sec.

The efficiency of machine was determined by finding the ratio of mechanical advantage to velocity ratio of machine and is calculated to be 85%. it was also shown that less skill and energy is required to turn the handle and one operator is enough for operating machine. It was also observed that the cutting was uniform and smooth throughout the entire length of the bar soap.

4.0 CONCLUSIONS

The following conclusion can be drawn

- The machine is manually operated
- The machine has efficiency of 85%
- The bar soap cut are closely the same size.
- Little or no special skill required in operating machine.
- The cutters section of machine are interchangeable to allow various sizes of soap to be cut.
- The machine gives uniform and smooth surface of cut soap.

The following recommendation is drawn from machine evaluation

- The machine is recommended for small scale industries and
- Improvements should to be done on corrosion.

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