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DESIGN OF MECHANICAL CRUSHING MACHINE

Senthil Kannan.N[1], Naveen Prasad.D[2], Nirmal Kumar.R[2], Premvishnu.R.S[2]

[1] Assistant Professor, Dept of Mechanical Engineering, Sri Ramakrishna Engineering College, Tamil Nadu, India
[2] U.G. Student, Dept of Mechanical Engineering, Sri Ramakrishna Engineering College, Tamil Nadu, India

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Abstract - ***The paper is about fabrication of mechanical crusher which would help to crush the used juice cans, paint cans and punched sheet metal waste. This paper aims to design a crusher that could be installed anywhere and would aid crush of used wastes. This paper involves the process of designing the crusher considering forces required for crushing and ergonomic factor that an operator needs. The design of this machine is such that it would require optimum load to crush metals and will not strain the user or operator. After the completion of design process, it is manufactured and transformed into a machine that would help in waste management. The crushing of used cans will also ensure that the cans are not used beyond the self-life of the metals. Therefore this paper will prove to be a useful asset in many ways. We have designed the crushing machine using Modelling software's. The crusher is designed based in the simple principle or a mechanism which is Crank and Slotted Lever Mechanism where the rotary motion from the motor is converted into reciprocating motion by the crank which is in-turn connected to the piston that crushes materials. The Designed components were then assembled and analyzed using an analysis software and the required dimensions of the crusher for the optimum performance have been found. These data's were then transformed into a real time model by manufacturing it. The designed crusher was then checked and the crusher effectively crushed all the components with ease and with reduced human effort.***

Key Words: *crusher; crank and slotted lever mechanism; reciprocating motion*

1. INTRODUCTION

In a country like India, waste management and disposal of the waste seems to be a tedious task where a huge amount of wastes has been generated due to enormous consumption. There also lies an issue in transporting the wastes to the recycling plants, wherein a huge amount of effort, time and money needs to be put in for transporting the wastes which are clustered and are not in uniform shape or size. The waste materials needs to be made into a uniform shape for easy and effective transportation. This paper aims in producing a mechanical crusher which would be a helping hand for waste management. This crusher can be used for crushing sheet metal wastes, paint cans, cool drink cans, machining scraps for reducing the space occupied by these while carrying it to the recycling plants. Cans and tins are made in such a way that there are lot of hollow space within them to carry whatever it has been designed for. These materials if carried just like that, would occupy more space and would require huge containers and transportation cost becomes an issue. These materials needs to be arranged properly to increase the carrying capacity of the vehicle and as the cans being an indefinite shape needs to me made into uniform shape and size for easy disposal. This is where the mechanical crusher comes in to play. The crusher would crush the cans thus reducing the gap between them and make them to uniform size and shape so that the materials can be baled up according to the size of the crushing bin. The uniform size and shape of the materials can be obtained by providing a bin onto which the material is to be crushed. The crusher is designed to operate by both mechanical and electrical means. This crusher is designed in such a way that it is simple to construct and would require minimum effort for operating in both mechanical and electrical types of operation.

2. WORKING PRINCIPLE

The crusher is designed to operate on a crank and slotted lever mechanism and the power for the electrical operation of the crusher is taken from an electrical motor. It is designed to use a 3 phase induction motor for the electrical operation of the crusher as the power required for crushing the sheet metal is high as compared to that of a normal paint or cool drink can. The distance between the motor and the larger pulley commonly called as the Centre distance plays a major role in the fabrication of the crusher as this distance is the critical parameter for maintaining the crushing force [1]. The Centre distance is fixed in such a way that the torque is more and the speed of the rotation is less. By increasing the Centre distance higher force can be obtained and motor running speed can be reduced. The basic structure or frame of the crusher is to be built using a flat rod of mild steel material. The

power transmission from the motor is by means of a pulley and the pulley is to be attached to a main shaft. The main shaft is supported at the Centre by means of ball bearings as the distance between the pulley and the crank is more. This bearings eases the power transmission and reduces the transmission losses [2]. These bearings also reduce the friction on the rotating shaft and also prevents bending or torsional stresses acting on the horizontal rod. The main shaft houses the crank plate. The crank plate made up of mild steel in circular shape is a solid thick plate onto which the piston rod is to be connected. This is the one which plays a key role in converting the rotating motion of the motor to the required reciprocating or oscillatory motion. If the diameter of the crank plate is small, then the speed of reciprocating motion will be high and this reduces the crushing force. If the diameter of the crank plate is high, then the piston reciprocates slowly and the crushing force exerted by the piston will be really high thus damaging the bin which is at the end of the piston. Therefore, optimum diameter of the crank plate should be maintained for the effective operation [3]. Three holes are provided in the crank plate to connect the piston rod according to the material needed to be crushed. Their distances are arranged in such a way that the crushing force and the speed of operation can be varied to some extent for crushing different materials [4]. The main shaft is a circular rod made up of mild steel and round thick plate is used as a crank

Which is in turn attached to the piston rod and the piston. A rectangular bin of mild steel is constructed to withstand the high crushing force that the piston exerts on the bin while crushing the waste materials. The bin shape, material and design of the bin varies according to the crushing material. This is so because the crushing force required for crushing the tin is not same as that of the force required for crushing a sheet metal waste or a metal scrap. The material is put into the crusher using a hopper and the bottom plate of the bin can be removed as to the crushed waste can be taken from the bottom part. The removed waste is in the shape of the bin and holds together as a single solid model and is easy to transport.

3. OPERATING MECHANISM

This crusher works on the simple mechanism called crank and slotted lever mechanism. When the motor is excited using a power source (i.e.3-phase power supply in this case) the shaft starts to rotate which in turn rotates the pulley which is connected to the motor by means of a belt drive. This pulley gives rotary motion to the transmission shaft which in turn rotates the crank plate that is attached to the main shaft. The bearings in between the crank plate and pulley ensures smooth power transmission. The crank converts the rotary motion to the reciprocating motion of the piston. The piston rod is adjusted to deliver optimal crushing force required to crush the material and as the piston reciprocates inside the bin onto which the materials are placed or fall one by one with the help of a hopper gets crushed and acquires the shape of the bin [6]. This crushed material can now be removed from the bin from the bottom part by removing the base plate of the bin and can be transported just as it is to the recycling plants.

4. CRUSHERS

Nowadays, waste management is one of the areas which is gaining importance day by day. The amount of waste coming is in a tremendous quantity. Aluminium cans and Tin cans are the important products which are being recycled on an increasing scale. For carrying out this process mechanical crushers are used. For recycling of these cans, large crushers are being used in industries, which is not suitable for small scale industries as the machines cost high. In order to crush the cans in a less time, a can crusher machine using crank and slotted lever mechanism having high crushing ability can be employed. A mechanical crusher machine is used for crushing aluminium cans and punched sheet metal wastes for recycling purpose and also for easy storage and transportation. The crank and slotted lever mechanism converts the rotating motion into reciprocating motion, this is the principle which is used in the mechanical crusher.

4. METHODOLOGY

4.1 Existing Methods

The existing crushers are heavy ones and these crushers are excessively used for crushing materials at big industries and manufacturing plants for crushing cars, stones, metal components, etc., Moreover, these crushers are hydraulically and pneumatically operated and is feasible if very high amount of crushing forces are required for crushing a material [8]. The operating costs of these crushers are very high as it requires continuous power, continuous maintenance as this involves hydraulic fluid or compressors kits, etc., these type of high end crushers are not necessary for small recycling plants and is not affordable to many people. It requires proper maintenance as the hydraulic fluid needs to be changed constantly on time basis. It also requires skilled labor for operation [9].

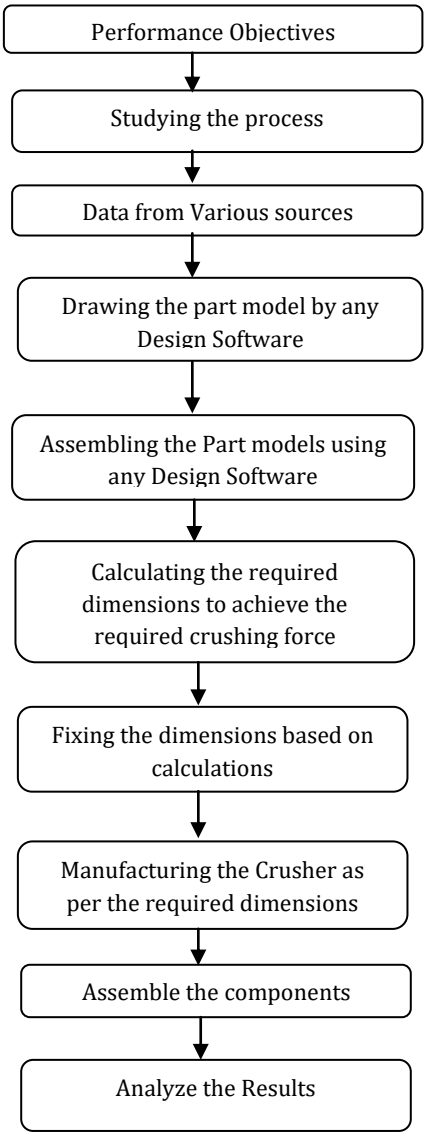

Chart-1: Work Methodology

4.2 Proposed Method

The crusher that is designed is done in such a way that even a layman can operate it. The current crusher uses crank and slotted lever mechanism to crush the materials. The construction is simple and manufacturing of this does not cause much pain. The manufacturing cost as well as the maintenance cost is very less as compared to that of hydraulic machines. This crusher can crush the waste effectively and also the operating time is very less as compared to the existing ones. This crusher would best suit the small recycling plants and small industries and also shopping malls for crushing small and simple materials like paint cans, soda cans, aluminium tins, machining scrap, sheet metal waste, etc.,

6. LITERATURE REVIEW

1) B.P.Numbi, X.Xia and J. Zhang, have presented an optimization technique for the vertical crushing machine. The paper presents the optimal control model to improve the operation efficiency of a vertical shaft impact crushing machine. They have proposed optimum methods to reduce the power consumption by varying the conveyor feed flow rate, the vertical shaft impact crusher rotor feed rate and the bi-flow or cascade flow rate.

2) Department of Design and Technology, Loughborough University, has presented a paper emphasizing the need for recycling the wastes particularly the metal can wastes. The paper insists that the requirement for environment accountability has become a feature of consideration for the engineers, especially for mechanical engineers. The various design methodologies have been discussed in the paper for the construction of a can crusher which would be helpful in waste management.

3) M.Lindqvist and C.M.Evertsson, Department of Applied Mechanics Chalmers University Of Technology, Sweden have presented a paper to develop a wear model for the cone crushers which are used to crush the rocks minerals which are in the form of ores in mines. Disagreements between predicted and measured geometry and several effects were suggested to explain the discrepancy in the model. The model is of complex construction and it has some of the real time shortcomings which reduces the efficiency of the machine drastically. The various drawbacks have been studied and the measurements have been done to predict the efficiency.

4) ZHAO La-la, WANG Zhong-bin and ZANG FENG of China University of Mining And Technology, have presented a paper on the Multi-object Optimization design for differential and grading toothed roll crusher using genetic algorithm. The crusher blends the efficiencies of toothed roll crusher and also the jaw crusher to possess great crushing ability and high breaking efficiency [10]. Crank rocker mechanism forms the basis of the machine. Thus the construction of the machine becomes complicated and as a result the cost of the machine increases.

5) OLALEYE B M Department Of Mining Engineering, Federal University Of Technology, Nigeria, has proposed a paper on Jaw Crusher performance in the granite quary.The paper determines the Effect of Rock Strength on Crushing Time and Grain Size Distribution of the rocks. Investigation was conducted with five sample rocks and the performance and drawbacks were spotted out. Various tests have been performed and the results have been tabulated and plotted in the form of graphs.

7. WORKING PRINCIPLE

The machine has been constructed in such a way that it can be operated by both electrical and mechanical means. The drive unit consists of an electrical motor of 0.5Hp. The motor is fitted with a smaller pulley of 0.05m diameter.

The power from it is transferred to the larger pulley of 0.41m diameter by means of a V-belt drive. The larger pulley drives the main shaft which houses the crank. The main shaft is supported on the machine frame by means of two ball bearings housed inside Plummer blocks to prevent vibrations. The presence of bearing also reduces friction over the shaft. The crank is rigidly fixed to the shaft. The connecting rod is fixed to the crank by means of temporary fasteners to provide rotational motion to it. The connecting rod is fastened to the piston rod which is in turn connected to the piston. The piston reciprocates inside a bin in which the wastes are placed it also acts as a guide way for the piston. The power from motor in the form of rotation is converted to reciprocating motion by means of crank and slotted lever mechanism. Thus the cans and other wastes are crushed efficiently.

8. CAD MODEL

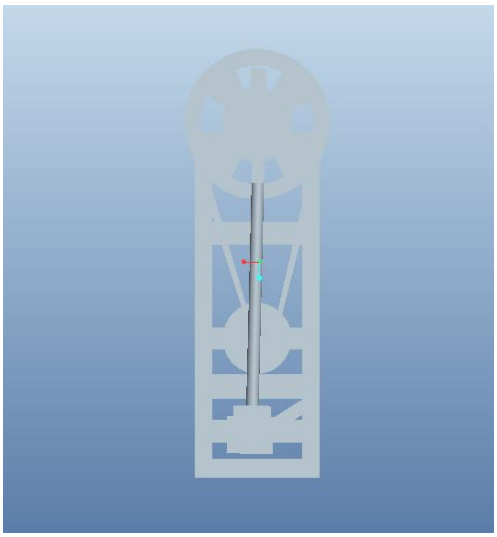

Fig –1: Front Assembled View

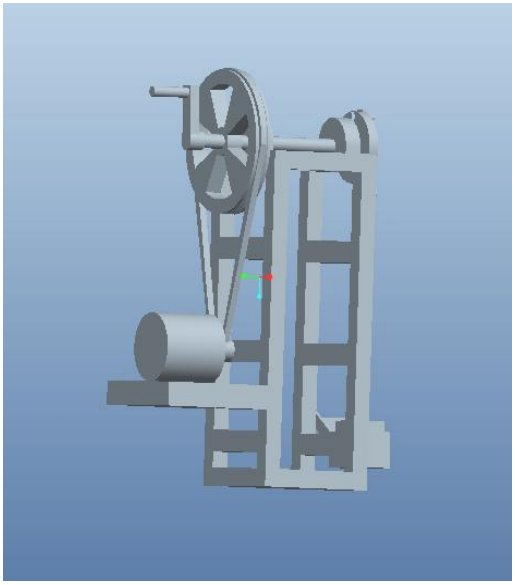

Fig – 2 : Side Assembled View

9. DESIGN CALCULATION

Crank diameter = 20cm

Motor power = ¾ HP

= 0.566025 kW

Length of connecting rod = 20 cm

Speed of the Motor = 1440 rpm

Mass of ram = 2 Kg

Force exerted (F) = m*g

= 19.62 N

Motor speed is transmitted to crank, with the help of V-belt drive.

$N \alpha 1/T$

Diameter of Pulley 1 = 6.35 cm (d)

Speed = 1440 rpm (N1)

Diameter of Pulley 2 = 40.64 cm (D)

Speed = ? rpm (N2)

D/d = N1/N2

N2 = 225 rpm

Centre distance of pulley = 2 (D + d)

C = 94 cm

P = (2πNT)/60

T = 0.94 Nm

S = V = (πDN1)/60000

= 0.47 m/s

Arc of contact

= $180^o - (D - d)/C * 60^o$

= 179^o6^o

= 2.78 radian

We Know That,

$(T_1 - mv^2)/(T_2 - mv^2) = e^{((\mu\alpha) / \sin\theta/2)}$

m = 0.106

v = 0.47 m/s

Assume, $\mu = 0.9$

$\theta = 40^o$

$\alpha = 2.78$ radian

But,

$$P = (T_1 - T_2)\, V$$

$$5.66 = (T_1 - T_2)\, 0.47$$

$$T_2 = 1.213 \text{ N}$$

$$T_1 = 13.21 \text{ N}$$

Stress $\sigma = T_1$ / Sectional Area

From PSG Design Data Book,

$$A = 80 \text{ mm}^2$$

$$= 13.21 / 80$$

$$\sigma = 0.165 \text{ N/mm}^2$$

10. PROPOSED COST OF THE MACHINE

TABLE – 1 : Cost Table

S.NO	MATERIAL	COST
1	Mild steel angle rod	RS.300
2	Circular rods (25mm dia. , 13mm dia)	RS.320
3	Bearings 2Nos	RS. 260
4	Circular and square plates	RS. 280
5	Pulleys	RS. 800
6	Belt	RS. 200
7	Welding Cost	RS.2000
8	Total Cost	RS.4160
6	Belt	RS. 200
7	Welding cost	RS.2000
8	Total cost	RS.4160

11. FUTURE SCOPE

The future scope of the paper is to upgrade the machine with lot more facilities. That is to equip the machine with automatic loading facility, sensors and microcontrollers to detect the material input to switch on and off the machine automatically in order to reduce the power consumption.

12. RESULTS AND DISCUSSION

The crushing machine was successfully fabricated and the machine was tested. The machine crushed multiple cans simultaneously with ease both during electrical as well as during mechanical modes of operation. While crushing the cans manually, the cans got crushed with minimal human effort and reduced the fatigue factor of the worker.

13. CONCLUSION

The crusher is constructed in such a way that even a layman can operate it without much effort. It is made efficient and the cost of production of this crusher is very less. The crusher has been designed accordingly keeping in mind about the minimum power requirements and minimum effort to the operator. This crusher upon fabrication would serve its purpose the small scale recycling plants and does not require power for operation and can also be operated manually without much physical effort.

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