Design and Development of a Plastic Bottle Crusher

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Abstract—**A crusher is a machine designed to reduce large solid material objects into a smaller volume, or smaller pieces. Crushers may be used to reduce the size, or change the form, of materials so they can be more easily and efficiently used in the purpose intended to. Crushing is the process of transferring a force amplified by mechanical advantage through a material made of molecules that bond together more strongly, and resist deformation more, than those in the material being crushed do. The aim of this work as the title suggests is to design and manufacture a crusher which will minimize the volume of commercially used mineral water plastic bottles. This project would help the people to crush commercially used plastic Bottles conveniently. This project aims to design and manufacture a plastic bottle crusher that is portable and can be installed at multiple public places, which will aid in crushing of used bottles.**

Keywords—Crusher, Bottle Crusher, Can Crusher, Crusher Design, Jaw Crusher

I. Introduction

A. Tentative Design of the Mechanism

The design process was accomplished in many stages. At first, we chalked out the objectives of the design and the basic mechanism of the machine. The ideas and innovations about the working of project were implemented in this stage of the Project.

The Portability and compactness of the machine were the major objectives of design, so that the designed machine could be stationed easily at multiple public place. Also the machine had to be simple in design and construction such that its maintenance and repair could be convenient. The bottle crushing machine is a hand operated machine and thus it is important to have an optimum usage of effort. Accordingly, the mechanism was designed. This conceptualized machine should also have the agility to crush bottles of different dimensions and hence the dimensions and other design aspects were chosen accordingly.

B. Final Design

Once the objectives and basic mechanisms of the machine were decided, the process of design of various components was initiated. In the process of design, various configurations of the components were analyzed and the almost compact and efficient were chosen. This design has a gear train housed in between the two flywheels. The Gear train transmits the power from the hand driven wheel to the flywheel and cutter. The flywheel then transfers the rotary motion to the reciprocating mechanism which will crush the bottle. The Cutter mechanism was incorporated to cut the bottle and make an exit path for the fluid trapped inside a closed bottle without which the closed bottle cannot be crushed. Also an escape path for the crushed bottle was made. A 3-D model of the final design is as shown in fig.1

The various components were designed based on the principles of design. Various calculations were done and the dimensions of all the components were calculated. The force required for crushing a Plastic Bottle was calculated and the force that can ergonomically applied by an average human was also obtained from the ergonomic table. Based on these, the gear ratio was calculated. Further, the Forces and Stress on each element were analyzed and thereafter the safe dimensions for all the components were calculated.

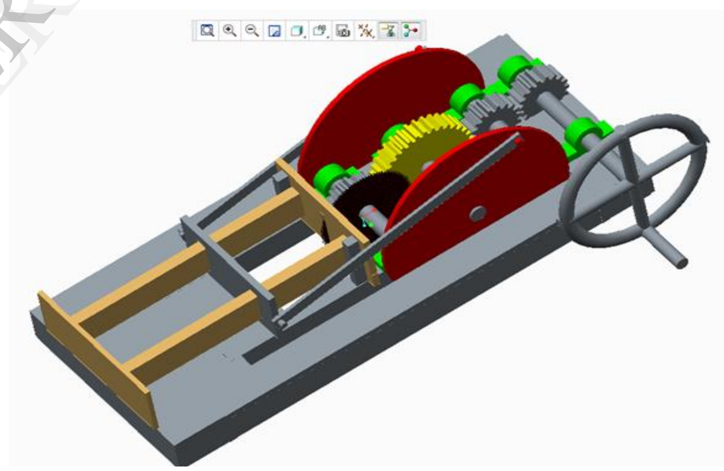

Fig. 1. Final Design

II. Steps in Fabrication

Fabrication of the bottle crusher was divided into 4 stages. It consists of the fabrication of base structure, its components, transmission system and the reciprocating system. The different processes followed in the fabrication of these components is elaborated under the following heads

A. Fabrication of Base Structure

The steel structural bar that has an L-shaped cross section of 2*2 inches were taken and were cut into 4 pieces as per the dimensions of the structure plate, out of which 2 steel bars were of longer length and 2 were of shorter length. These steel bars were welded to form the base plate of the machine.

Four more bars were cut and were welded to support the frame to bring it to a particular height i.e. which acted as the legs of the frame as shown in fig.2

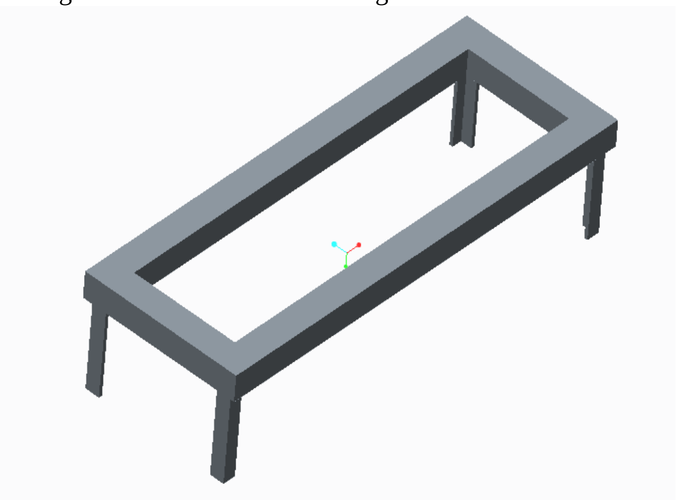

Fig. 2. Base Structure

B. Fabrication of Various Components

A long MS shaft was cut into 4 pieces of appropriate dimensions with the help of acetylene gas cutter, after which the edges were made round by grinding. Then the shafts were turned on the lathe machine for its proper fitting into the pedestal.

For the spur gears, the bushes were manufactured on the lathe machine. The bushes were faced from both sides and then turned so that it matches the inner diameter of the gear. These bushes were then press fitted into the gear and a hole of the diameter same as that of the shaft was drilled. Then a vertical hole was drilled in the bush for the grub screw. The grub screw was tightened over the flat notch. The same procedure was followed for the rest of the gears. The gear assembly is shown in fig. 3

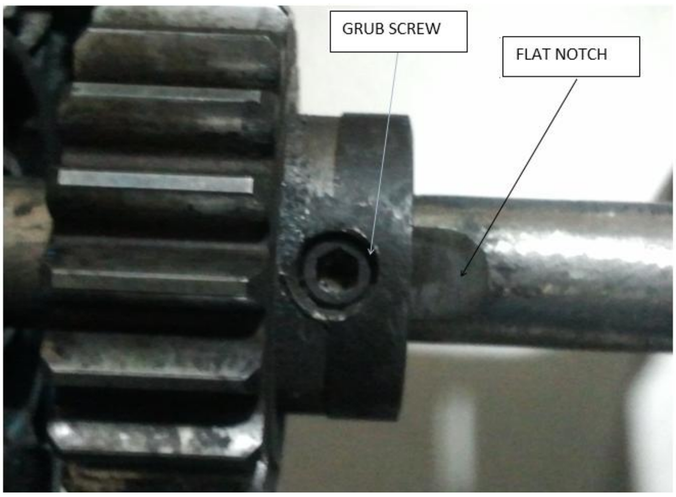

Fig. 3. Gear Assembly

For the cutter, a bolt was welded to the side of the cutter and then the drilling was done in the perpendicular direction to its axis of rotation for same locking arrangement as that in gears. Fig 4 shows the position of cutter on the shaft

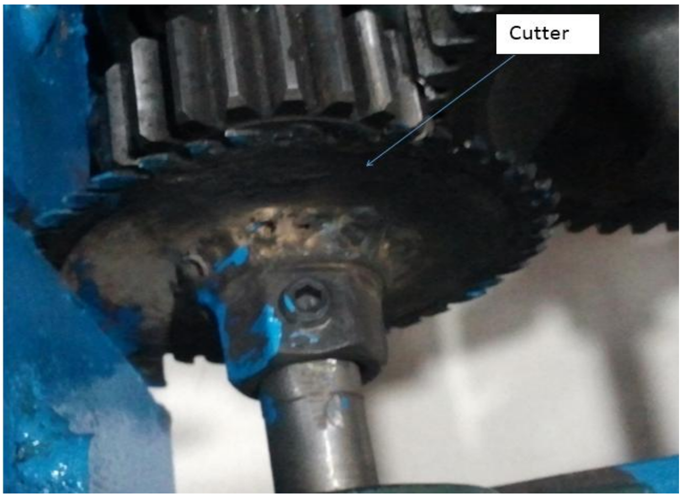

Fig. 4. Cutter

For flywheels, two square plates were taken having size larger than the flywheel dimension after which they were cut into the required circular shape by acetylene-arc cutter. Flywheels were then machined over the lathe machine. A bush was welded at the center of a flywheel and a hole was drilled. After that, a shaft was attached to the flywheel with the help of a grub screw. One more hole was drilled near the outer edge of both the flywheels for the insertion of pin. Now, a bolt was inserted into the hole. To provide an offset to the link, we had introduced a nut between the flywheel and link and then an outer nut for locking the links. Fig. 5 shows flywheel arrangement.

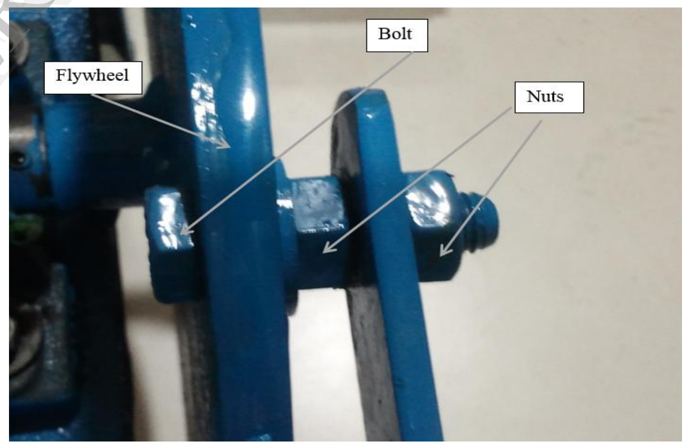

Fig. 5. Flywheel Arrangement

C. Fabrication of Transmission System

The gears were fitted over the shaft and were locked in their respective position with the help of grub screws. On the first shaft, a cutter was fixed in its appropriate position. Pedestals were attached on both the sides of the shaft. All the pedestals were placed at their respective location in accordance with proper meshing of gears. Marking was done for holes to be drilled over the base for fitting the pedestal.

The pedestals were bolted over the base and all the shafts were place at their respective locations in accordance with proper meshing of gears. The flywheels were attached outside the frame over the second shaft, which were then tightened with the help of grub screws. Both the flywheels were aligned such that both the pins were in a same line. The power transmission system is as shown in fig.6

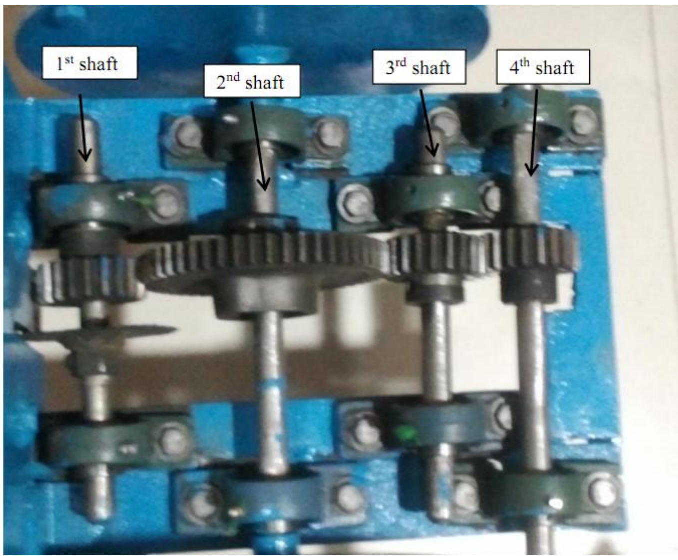

Fig. 6. Transmission System

For the driving handle, a long plate was cut with the help of acetylene cutter, after which grinding was done to make its edges smooth. After that,a nut was welded on one side of the plate and a hole was drilled on the other side. The handle was then attached with the help of nut and bolt. The handle was then attached to fourth shaft on its outer side as shown in Fig. 7.

Fig. 7. Driving Handle

D. Fabrication of Reciprocating System

In this part, a C.I. flat plate was cut into three parts of required dimensions by arc cutter, out of which, two were used as fixed plates which will act as the support and one is the moving slider plate which crushes the bottle.

On all the flat plates, marking was done with the help of punch and two holes were drilled on each plate with the help of drilling machine, whose diameter was same as that of the bright bars to be inserted. These bright bars acted as a guide for the moving plate. The second fixed plate was welded at a calculated distance. The rectangular slot was cut in the first plate by arc-cutter so that the cutter can cut the bottle.

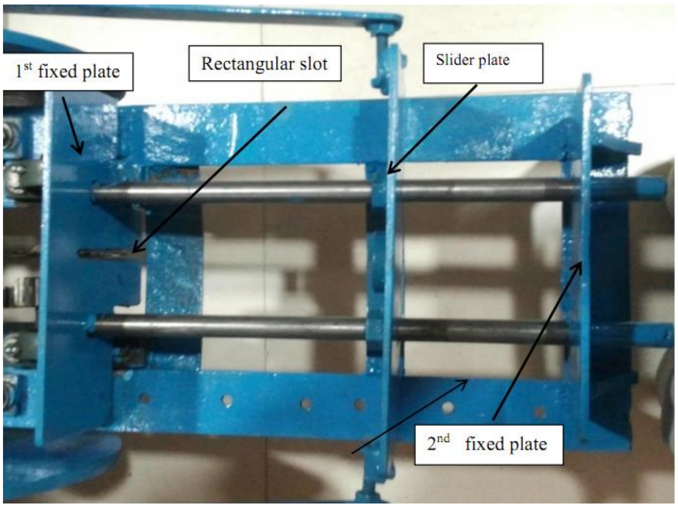

Fig. 8. Reciprocating System

The second plate was supported with the help of two ribs. After that, the slider was kept between the two bright bars and were inserted into the holes passing through the first plate, then through the slider and finally through the second plate as shown in Fig.8

A small circular support was attached to the slider plate so that the bottle does not slip. Below the cutter, a plate was welded which acts as a support to the bottle during the crushing mechanism. Two bolts were welded on the slider plate over the holes through which the bright bars was passing, which acted as a support to the slider plate during reciprocating motion.

III. EXPERIMENTATION AND TESTING

The experimentation was conducted after the manufacturing process was completed. In this phase, the components of Machine were checked for smooth operation and movement. Then the experimentation on crushing was performed. The objective of design was to manufacture a Plastic bottle crushing machine to crush plastic bottles of different dimensions. Experimentation was also conducted to test the agility of machine. Thus Plastic Bottles of different dimensions and quality were collected and an experiment was conducted. The Experimentation data for Crushed Plastic Bottles is mentioned below in Table-I

TABLE I. EXPERIMENTATION DATA

Table Head	**Table Column Head in millimeters**			
	Brand of Bottle	***Length***	***Width***	***Length after Crushing***
1	Bisleri	275	80	140
2	Aquafina	275	86	140
3	Kinley	270	85	140
4	Oxyrich	270	84	140

The length of all the bottles were reduced to 140 mm for any input length and quality of material. Thus, it can be said that the Plastic Bottle Crushing Machine can crush bottles of different dimension. After that, the percentage of crushed volume was calculated. In the Crushing process, it was found that the circular cross section bulges out at some sections and deforms inwards at some. Thus the mean area of the circular cross section of the bottle will remain the same as before.

The percentage of reduction in length was calculated. For all the input dimensions and quality of plastic bottle, the length of crushed bottle obtained was 140 mm. In the subsequent stage the percentage reduction in volume was calculated for all the crushed bottles. Reduction in volume was calculated with the help of the following formula.

$$\textit{Percentage reduction in Volume} = \frac{\textit{Initial Volume} - \textit{Final Volume}}{\textit{Initial Volume}}$$

Thus, the initial and Final Volume was found out by the dimensions of the Bottles that were measured. The Following table-II shows percentage reduction in volume.

TABLE II. PERCENTAGE REDUCTION IN VOLUME

Table Head	**Table Column Head**			
	Brand of Bottle	***Initial Length (mm)***	***Final Length (mm)***	***Percentage Reduction in Volume***
1	Bisleri	275	140	49.09 %
2	Aquafina	275	140	49.09%
3	Kinley	270	140	48.14 %
4	Oxyrich	270	140	48.14 %

Thus, from the above calculations we can say that the Plastic Bottle Crushing Machine has the ability to reduce the volume of the plastic bottle up to 49%.

The next stage of Experimentation was performed to test the agility of Machine to crush cans. A Can of Mirinda Cold Drink was taken for the experiment. The can was placed on the Base and Piston was moved forward to press the can against the Cutter. The crushing stroke of Machine was then completed and Can was Crushed.

There were no abnormal vibrations nor wear of cutter observed in the crushing process of can. Thus we can conclude that the machines can also crush Cans.

IV. RESULTS AND CONCLUSIONS

The plastic Bottle Crusher thus designed and fabricated is a unique, compact and portable Plastic Bottle Crushing Machine. The final machine is an outcome of a series of processes, in which the first was analysis and study of requirements and conceptualization of machine, then the Design and Fabrication and finally the Testing of Machine. Thus all the mentioned processes were successfully executed for the Plastic Bottle Crusher.

The Plastic Bottle Crusher thus manufactured is portable and compact. The crushing force that is required to crush a plastic bottle as found experimentally, is well within the range of the force that can ergonomically be applied by an average human. The machine was then designed on the basis of the load required to crush the bottle. The tentative design and dimensions of machine components was then taken for fabrications. The Manufacturing difficulties brought further changes in the design. The model thus designed was fabricated and assembled.

In the next stage of process testing was carried out on the Machine. The Machine thus designed has the agility to crush Bottles of different dimensions as observed in the Testing and Experimentation phase. Experiments were also conducted on crushing of Cans.

On an average the Machine reduces the volume of bottle to 49% of the initial volume. It was found that the machine is capable of crushing Cans as well with some appropriate positioning of Can.

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