Design and Manufacturing of Automatized Waste Management Bin

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Abstract - *One of the crucial issue of this modern age is poor waste management. This project is a path to achieve this good cause. In this project, smart bin is built on a microcontroller-based platform Arduino UNO board, which is interfaced with servomotor and Ultrasonic sensors. Ultrasonic sensor is situated at the top on inner side of the dustbin, which will measure the stature of the dustbin. The threshold stature is set at certain limit. When garbage reaches that threshold limit, ultrasonic sensor will trigger rack and pinion mechanism to compress the garbage. This process will be repeated 3 times after that the lid of the dustbin will be locked until, the dustbin is squashed. When these smart bins are setup on a large scale, by replacing our old bins present today, waste can be managed efficiently as it avoids unnecessary flooding of waste on roadside, foul smell from this waste that remain untreated for a long time, due to negligence of authorities and carelessness of public may lead to long term problems.*

***Key Words*: Smart Bin, Arduino, Servo Motor, Ultrasonic Sensor, Compactor, Waste management. Rack & Pinion Mechanism.**

1.INTRODUCTION

As we are progressing from a developing country to a developed country, everything is getting smart and modernized, so why not dustbins. We all might have once experienced or have seen even though there is the provision of dustbin in different areas but they are either broken or completely filled due to which people throw garbage besides the dustbin instead of inside the dustbin. Along with providing dustbins, waste management is also needed. Our government has recently started a cleanliness drive called 'SWACHH BHARAT ABHIYAN' for a good cause and being a citizen of this country, we should be the one taking care of our country's hygiene starting from our native places.

The waste management has been crucial issue to be considered. Poor waste management results in pollution; also from the burning of garbage, we are adversely affecting atmosphere. When the garbage is burned, it emits extremely poisonous gases into the atmosphere. If people breathe this air, it can hurt their lungs and if go untreated can result in cancer or even death. Even if we burry our garbage not all of it will decompose, as there are some materials that needs centuries to decompose, like plastic. It can seep into farming soil and even into our underground water, which can cause negative consequences.

We cannot overlook a thing which makes a country or say world a better place to live. Here before, everyone may have once thought to make our native places clean but haven't worked towards it sufficiently. As a modernized generation student, we have come up with slightly different idea of disposing bins. Using coding and different mechanisms we have tried to make such a modernized dustbin. Also, we have taken the current situation of COVID-19 under consideration and hence we thought to make an automatized dustbin which will allow people to throw garbage inside the dustbins without actually touching the dustbin lids. Also, the garbage collector does not need to touch the garbage directly during the disposal and could empty the bin with a great feasibility. Probably, there are hundreds of automatic dustbins out there but this dustbin will not only have automatic opening and closing but it will also consist of a compactor which will compact the garbage and increase the void spaces in-between which will allow more garbage to settle in. It also has electronic sensors, sensing the level of the garbage in the bin to avoid the overflowing of garbage.

1.1 PROBLEM STATEMENT

To implement a smart bin built on a microcontroller-based platform Arduino UNO board which is interfaced with AC Motor and Ultrasonic sensors which can sense the level of waste in the dustbin and compress it using a compactor mechanism also, it will alert the user when it is completely filled.

1.2 METHODOLOGY

Based on a market survey we have decided the dustbins dimensions as 400 mm × 400 mm × 810 mm. A single-phase motor of output shaft speed as 1500 rpm, output power as 0.12KW, Supply voltage of 230V, frequency as 50 H is selected as per the requirement. Motor is coupled to a worm & worm wheel gear box of gear ratio 30:1 for reduction of the speed as it is the requirement of the project. The output shaft of worm & worm gearbox is further connected to a rack & pinion gearbox. Which has a pinion of 18 teeth, 4mm module, PCD 72mm, acts as a driver to the rack which has a length of 465 mm, number of teeth ass 37 and travel of 400 mm. For the compression, a compacting rectangular plate is bolted at the end of the rack which is having dimensions slightly less than the opening of the bin so that the certain clearance is

maintained between the plate and the bin, while compactor will compress the garbage. So, compacting plate is of 30cm x 30cm. Now, using the dimensions of this whole assembly, we decided the dimensions of the enclosure as 640 mm × 606 mm × 1180 mm. The setup of motor and two gearbox is placed on a mid plate, which is at a distance of 175 mm from top of the dustbin. An electronic circuit is built using Arduino, opto-coupler, diode, resistor, capacitor and Arduino program to rotate the motor shaft in clockwise and anticlockwise, so as to get retraction & extension of ram. An ultrasonic sensor is used to detect the level of the garbage and activate the action of compression. This ultrasonic sensor is placed on the inner side of upper wall of the enclosure. The enclosure has an opening to allow people to put the garbage in the bin. Also, a door is given for emptying of the bin from enclosure when it is full.

1.2.1. Electric Motor and Enclosure

We used electric motor to power our proposed system. We have selected electric motor which operates at 1500 rpm and 230 V, 50 Hz single phase supply. It will provide 0.12KW power output at 50rpm.This output power of electric motor is connected to worm & worm wheel gearbox which is then connected to rack and pinion gear box for compression purpose. Also, we have provided enclosure around the dustbin. So that, the components of our proposed system remain unaffected from rain and other atmospheric conditions. This increases safety, reliability and durability of components.

1.2.2. Ultrasonic Sensors

The sensor head emits an ultrasonic wave and receives the wave reflected back from the target i.e. Garbage level. An optical sensor has a transmitter and receiver, whereas ultrasonic sensor uses single ultrasonic element for both emission and reception. We have used ultrasonic sensor for garbage level detection. As soon as garbage reaches the predetermined limit of ultrasonic sensor it will operate compactor through Arduino.

1.2.3. Arduino UNO

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs-light on a sensor, a finger on a button, or a WhatsApp message and turn it into an output activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

1.2.4. Servomotor

Servo implies an error sensing feedback control which is utilized to correct the performance of a system. It also requires a generally sophisticated controller, often a dedicated module designed particularly for use with servomotors. Servo motors are DC motors that allows for precise control of angular position. Hey are actually DC motors whose speed is slowly lowered by the gears. The servo motors usually have a revolution cut-off from 90°to180°.A few servo motors also have revolution cut-off of 360° or more. But servo motors do not rotate constantly. Their rotation is limited in between the fixed angles. So, we have used Servomotor for opening and closing of lid.

1.2.5. Rack And Pinion Gear Box

We have selected rack & pinion mechanism to compress the garbage in bin. Rack and pinion gear box will perform function of compactor in proposed system. By compressing the garbage, we can increase the storage capacity of traditional waste Bin. We designed the gear box according to gear design procedure and found out dimensions of rack and pinion.

2. NUMERICAL STATEMENT:

To design a Rack & Pinion gearbox having No. of teeth on pinion as 18. Input power is 0.12 KW, Motor shaft has 1500 RPM output speed. No. of teeth on rack are 37. Face width as 10m

2.1. Solution:

Dimensions of Pinion:

No. of Teeth = 18

Module = 4mm

PCD = 72mm

Face width = 40mm

Pitch = 12.566 mm

Dimensions of Rack:

No. of Teeth = 37

Module = 4 mm

Rack Length = 464.95 mm

Face width = 40 mm

3. Program to rotate the motor shaft in both directions:

/*

The voltage variation on the output pins is carried out by the

Digital to Analog converter on the arduino, the output voltage

of the Analog pins is a 10-bit factor(a factor of 1024) so it

might be a bit inaccurate, increase or decrease the below

values to get proper desired voltage.

*/

#define VOLTAGE30 (int)1024*0.3

#define VOLTAGE60 (int)1024*0.6

#define VOLTAGE80 (int)1024*0.8

#define VOLTAGE100 1024

/*

If you are using a motor driver with a PWM based control then

you will have to change the above values as a factor of 255 and

change output pins to any pins that have PWM support (you can

choose any input pins on the whole board).

*/

```
/*INPUT PINS     I1                      I2
                 I3 */

int inputPins = { 6,                     7,
                 8};

/*OUTPUT PINS                  O1
        O2                   O3
        O4              O5   O6*/

int outputPins = {12,                    A3,
                 A4,                     A5,  A6,  10};


int i,val[3], outVals[6];


void setup(){
        i = 3;
        pinMode(output[i],OUTPUT);
        pinMode(output[4],OUTPUT);
        pinMode(output[5],OUTPUT);
        while(i--){
                pinMode(inputPins[i],INPUT);
                pinMode(outputPins[i],OUTPUT);
        }
}
```

/*

Here the hirarchy of the inputs was not specified so input 3 is given

the top level followed by input 2 and input 1 at last, what it means isthat if input 3 is high input 2 is ignored and if input 2 is high input

1 is ignored.

*/

```
unsigned long tn, tp;
bool first1 = false, first2 = false;
void loop{
        tn = millis();
        i = 3;
        while(i--)
                val[i] = digitalRead(inputPins[i]);


        if(val[2]){ //if input 3 goes high
                first1 = false;
                first2 = false;
                i = 6;
                while(i--)
                        outVals[i] = 0;
                tp = tn;

        }else if(val[1]){ //if input 2 goes high(reverse loop)
```

```
            if(!first2){
                first1 = false;
                first2 = true;
                tp = tn;
            }
            outVals[0] = HIGH;
            outVals[5] = LOW;
            outVals[4] = 0;
            outVals[3] = VOLTAGE80;
            if(tn-tp > 2000){
                outVals[3] = 0;
                outVals[2] = VOLTAGE60;
            }
            if(tn-tp > 4000){
                outVals[2] = 0;
                outVals[1] = VOLTAGE30;
            }
            if(tn-tp > 6000){
                outVals[1] = 0;
                outVals[0] = LOW;
            }
        }else if(val[0]){ //if input 1 goes high
            if(!first1){
                first2 = false;
                first1 = true;
                tp = tn;
            }
            outVals[0] = HIGH;
            outVals[1] = VOLTAGE30;
            if(tn - tn > 2000){
                outVals[2] = VOLTAGE60;
                outVals[1] = 0;
            }
            if(tn-tp > 4000){
                outVals[2] = 0;
                outVals[3] = VOLTAGE80;
            }
            if(tn-tp > 6000){
                outVals[3] = 0;
                outVals[4] = VOLTAGE100;
                outVals[5] = HIGH;
            }
        }
        i = 6;
        while(i--){
            analogWrite(outputPins[i],outVals[i]);
        }
```

4. ANALYTICAL RESULTS

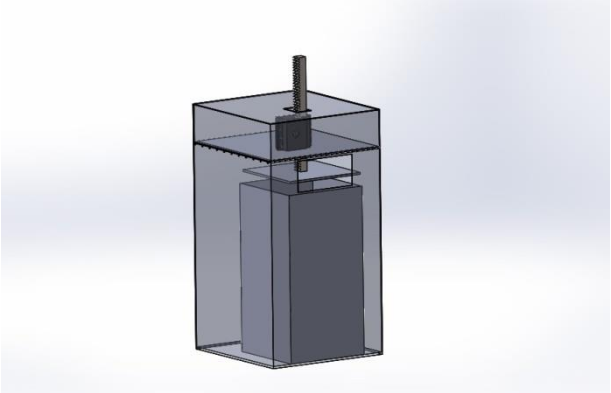

Fig 1. CAD Model

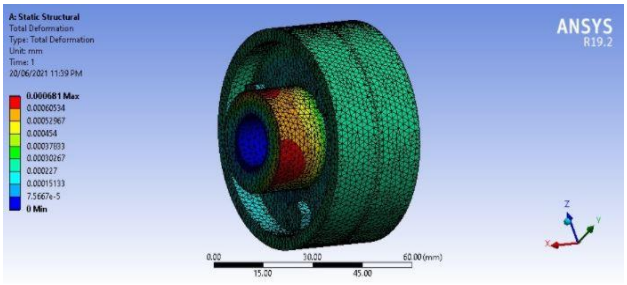

Fig 2. Total Deformation of Coupling

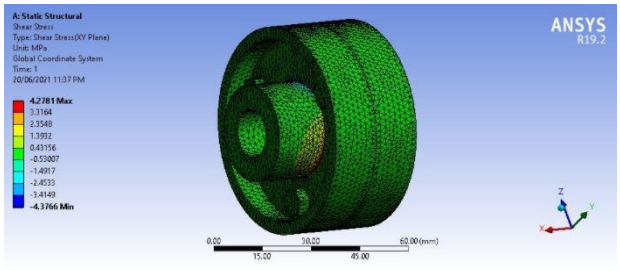

Fig 3. Shear Stress on Coupling

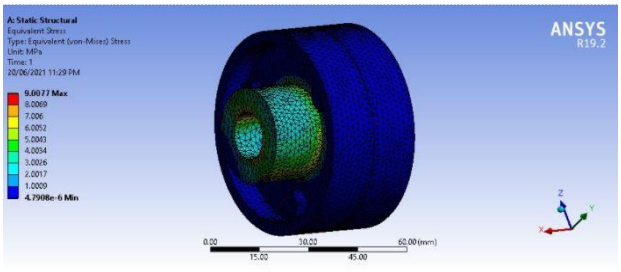

Fig 4. Equivalent Stress on Coupling

Table 1. Analytical Results of Static Structural Analysis on Coupling

Sr. No.	Parameter	Maximum	Minimum
1	Equivalent Stress	9.0077 N/mm	4.7908 e^{-6}
2	Shear Stress	4.2781 N/mm	-4.3766 N/mm
3	Deformation	0.000681 mm	7.5667 e^{-5} mm

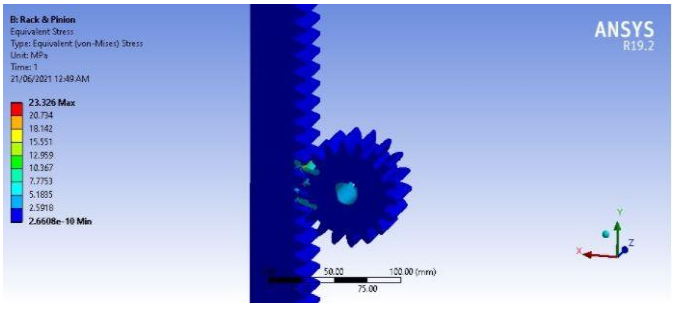

Fig 5. Equivalent Stress on Rack & Pinion

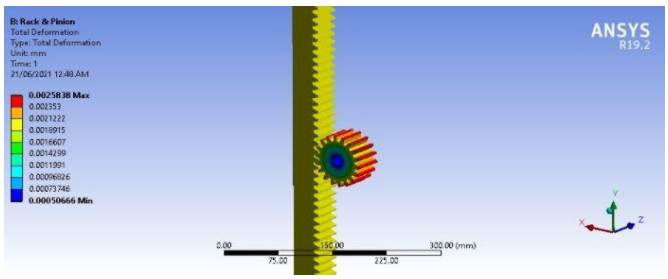

Fig 6. Total Deformation of Rack & Pinion

Sr. No.	Parameter	Maximum	Minimum
1	Equivalent Stress	23.326 N/mm	2.6608e-10N/mm
2	Deformation	0.00258 mm	0.000506 mm

Table no. 2 Analytical Results of Static Structural Analysis on Rack & Pinion

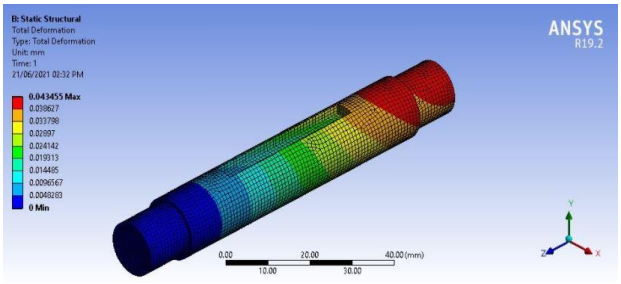

Fig.7 Total Deformation of Shaft

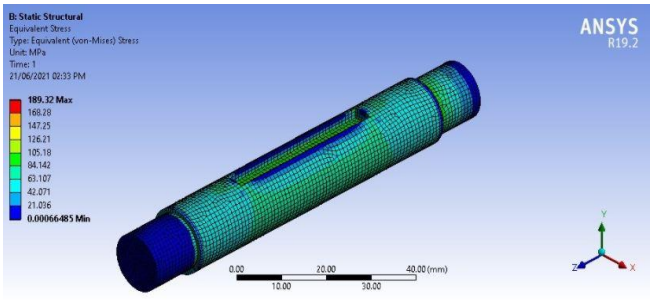

Fig.8 Equivalent Stress on Shaft

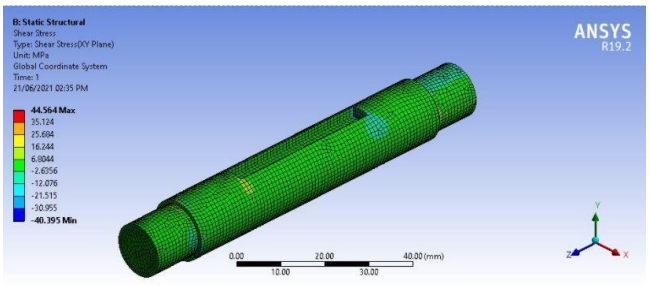

Fig.9 Shear Stress on Shaft

Table no. 3 Analytical Results of Static Structural Analysis on Shaft

Sr. No.	Parameter	Maximum	Minimum
1	Deformation	0.043455 mm	0 mm
2	Equivalent Stress	189.32 N/mm	0.00066485 N/mm

3	Shear Stress	44.564 N/mm	-40.395 N/mm

5. CONCLUSION

Various features such as durability, affordability, prevention against damage and maintenance issues are considered when these smart dustbins are designed. This Smart Dustbin can contribute a lot towards clean and hygienic environment in a city. The compression mechanism was designed and used to reduce the volumes of waste generated from the house holds ending up at the collection or disposal sites and simultaneously act as a storage facility. As a result, there are going to be a lot of benefits as it will increase savings in transportation costs, branches of fuel cost, labour cost, and the cost of maintenance. All these savings give an indication that the trash compactor has reached its goals. Not only does the trash compactor achieve savings in transportation costs but also it helps in keeping the streets clean as it prevents overfilling of garbage bins, which will hope fully make the country look much more attractive and help improve the overall image of the nation.

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