Design and Fabrication of a Remote Controlled Whiteboard Cleaning Mechanism

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Abstract: *The current research paper is an actual summary of an engineering project in which a mechanism was developed for cleaning of a whiteboard and its remote controlling was provided through a bluetooth module using Arduino Uno Microcontroller. A theoretical analysis was done to find the desired forces to move the cleaning duster from one end to the other end. Rack and pinion mechanism was used to provide the movement to the duster. The purpose of this project was successful as it can provide human comfort as well as hygiene for the user like a teacher.*

Keywords: *Whiteboard, cleaning mechanism, Arduino Uno, rack and pinion.*

1. Introduction and literature survey

Blackboards/white boards have been one of the most important part of teaching-learning process in any country. Teachers explain various concepts to their students through writing on these boards. When the board is filled with the written material completely, it is required to be cleaned. A manual duster is generally used for that purpose. But, it will be great if a mechanism is developed that can clean the board remotely. An attempt has been made to design a whiteboard erasing mechanism with its remote controlling.

The main part of this board cleaning mechanism is to use an additional attachment with it, which can be activated through a rack and pinion drive. This drive can be operated remotely by just by clicking a power button. This will help us to avoid manual cleaning of the boards, which may cause hygiene problem or smell issues. The mechanism an be used like any other teaching aid in colleges/schools.

Prior this project, similar works have been done by various technologists. In 2015, S.Joshibaamali and K.GeethaPriya [1] guided the development of a machine that which worked in three separate modes. Every mode had a particular operation like erasing the right side, erasing the left side, or erasing the full board. The principle of working of this machine was based on the application of two stepper motors which can make the duster move either in horizontal direction or vertical direction.

Mr. Sunil R. Kewate et. al. [2] presented a paper on “Development of New Smart Design to Erase the Classroom Blackboard of Schools/Colleges”(2014). They developed a kind of mechanism concept which could sense the locations of chalk marks on the board, and after sensing the location, it could clean that part. In this way, the text/images drawn on the board can be erased easily.

Dong Yeop Kim et al. [3] worked in a different way, and found a system known as gondola robot system in which a limit switch was used for identification. That was also a very innovative way of functioning of the mechanism.

S. Nithyananth, A. Jagatheesh, K. Madan, B. Nirmalkumar [4] described the functioning of rack and pinion mechanism. They discussed steering mechanism as its application. A steering mechanism is one of the most important controlling systems of any type of vehicle. It uses a rack which is like a straight rigid strip with teeth on it. It is moved to-and-fro along its length which causes clockwise or counter clockwise rotation of the connected pinion.

In 2005 Chirag Shah [5] on 'Automated Board Eraser' developed a mechanism in which the sensors were used for the activation of motors. The motors caused the reciprocating movement of the duster to clean the board. That was also a very effective way of cleaning the board automatically without human efforts.

Gaurav Gangurade [6] on 'Design and Development of Board Cleaning System' in 2016 said that limit switches and sensors can be used in the board erasing system for proper controlling and erasing a particular area. The area is specified by the sensors where there is a need to clean. It uses rack and pinion mechanism for longitudinal movement of the duster.

Vivek D. Ugale, et.al. [7] in 'AUTOMATIC BLACKBOARD ERASER' in 2015 make a erasing system in which they used 2 DC motors on both sides of the board for cleaning purpose. They put the eraser link in the centre so that it can clean 50% of the board in one pass and teacher can write on the remaining part of the board. They used PIC micro controller to interface the board erasing mechanism.

2. Objective

The four main points of focus in the given project work are given below-

1. The very first point is user-friendliness mechanism. The functioning is to be kept simple for use. Human effort should be as low as possible. It will be great if the functioning is done just by pressing a single button.

2. Second point is that it should work in such a way that the force required in erasing the written material should be less than the force developed by the mechanism during rubbing.

3. Third point is that the mechanism must be accurate, and reliable. Not only once or twice, but it should work as expected every time. It should not loose its functionability with time. The mechanism should work fast enough with negligible noise.

4. Fourth point of consideration is controllability of the mechanism. It should be easily controllable even from a distance. Wireless controlling using a remote or a smart phone will be preferred.

3. Problem statement

The intended aim of this project work is to design and fabricate an easy working board erasing mechanism which can be controlled without much human efforts from a distance. The purpose is to avoid from the probable health hazards because of the smell of xylene in the marker ink, or because of powder of the chalk. Besides this, another aim is to reduce the overall time of erasing the board as comparative to the manual efforts. Also to make a Bluetooth module for connecting it with the mobile and controlling as per user's need from a remote location.

4. Methodology

For the movement of the duster arm, rack and pinion arrangement are used in which the pinion wheel rolls over the fixed rack for the movement to the either side. Small sized DC motors are used here for the actuation of the mechanism. Two pairs of rack and pinion arrangement are used in the mechanism on upper and the bottom edges of the board, and both the pinions are connected with each other through a connecting strip. The connecting strip is also connected with the back strip which solves the three purposes:

1. It holds the motors on both sides so that proper balance of motor is made.

2. It also helps in making proper alignment of rack and pinion so that they run smoothly, and it also keeps the eraser arm in vertical position.

3. It fulfills the requirement of the proper mounting of electronic components and helps in proper handling of the electric wires.

The system uses the electronic control which is obtained by Ardinuo mechanism, motor driver and Bluetooth module so that they all together help in controlling the mechanism with a mobile interface. Ardiuno plays an important role in the assembly to stop the pinion in the end and to reverse the polarity of motors so that they may go forward and return back. And repeated motion will be provided until the board is cleaned. The back connecting strip is connected to the slider by means of C clamp.

It solves three purposes:

a) First it helps to prevent any lateral movement of spongy duster connecting strip and back connecting strip so proper alignment of rack and pinion is achieved.

b) Slider makes movement smoothly in longitudinal direction.

c) It helps in connecting to back strip to the slider.

5. Design calculations

5.1 Selection of Motor: To solve our purpose we selected Johnson DC Geared Motor. After analyzing different design steps and requirement of system and availability of sources.

Volt Rating = 12 volt

Max Current: 9 amp

$P_{max} = V * I = 108$ W

Assuming $P<P_{max}$ for the calculation considering frictional and heat dissipation losses so

Taking P= 100 Watt

Torque Rating: 10-12 kg-cm at 100rpm.

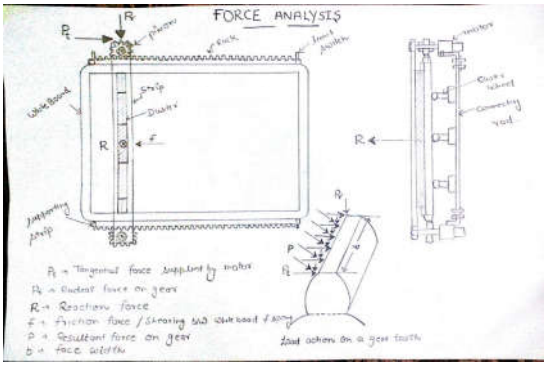

Figure 1. Schematic Diagram

5.2 Design of Gear: Based on the market survey and the analysis of actual need, plastic (Acrylonitrile butadiene styrene) rack and pinion was used instead of any metallic rack and pinion. This not only reduced the overall cost of the project, but also avoided overdesigning. Based on the availability, 20˚ full depth involute gears were used.

Plastic (Static Stress) σ_d = 58.8 MPa

1. Module: 1.5mm

2. Pitch Circle Diameter: 57mm

3. Number of Teeth: Z = 38

V = πDN/60 = 0.298 m/sec.

P = F*V implies that F = 335.57 N which is the tangential force on the gear.

5.3 Beam Strength:

$S_b = m*b*\sigma_d*\pi*y$ …(1)

Where y = tooth factor

Where 'm' is module

Where 'b' is Face width

For 20˚ FDI

y = 0.154*0.912/Z …(2)

= 0.13

And face width = 13 mm

Therefore, S_b =468.28 N from relation (1).

But,

S_b = FOS. [C*F/C_v} …(3)

Where F is tangential Force

C is Service Factor = 1 (Assuming 3 hours per day and light shock load)

And C_v = Velocity Factor= 3.05/(3.05+V)

…(4)

(From design data hand book by K.Mahadevan)

V= 0.298 m/s already found.

Therefore, C_v = 0.91 from relation (4).

Putting the values in relation (3), we get

FOS = 1.3

Also,

F_r=F*tanφ, Where F_r is the radial force on the pinion.

F=335.57 N (already found) and φ = 20˚

Hence,

F_r = 122.14 N

5.4 Design of Eraser :

Dimension of Eraser= 57cm x 6 cm

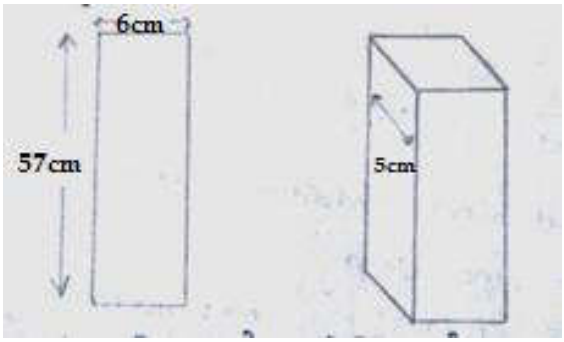

Figure 2. Eraser Dimensions

Surface Area of Eraser

(A)= 57*6 = 0.0342m^2

Average pressure due to eraser on white board perpendicular to board[2]

P_r = 1500 N/mm^2

R= Pr*A where R is reaction force.

R= 1500*0.57*0.06

= 51.3 N

Force required to pull the Eraser link (f)

f = μ* R

μ= 0.4

f = 0.4* 51.3 = 20.52 N

This Force is needed to pull the Eraser Link

f=20.52 N

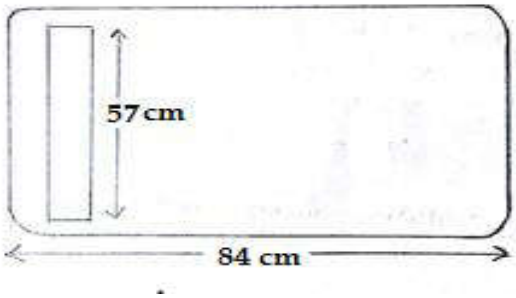

Figure 3. Board Dimensions

Work done by this force

W= f*d = f*d cos 0

W= 20.52 * 0.8 = 16.41 J

Time to clean the White Board (t)

t = d/v seconds

where d is distance travelled and v is linear velocity of eraser link.

t = 0.84/0.298

= 2.82 seconds or 3 seconds approx.

5.5 Dimension of Rack:

Pitch = 5 mm

Full depth = 3 mm

Φ = 20˚

6. Programming for Arduino Uno controlling

```
voiddrive_forward();
voiddrive_backward();
voidstopp();
#include<SoftwareSerial.h>
SoftwareSerialBTSerial(2,3);
void setup() {
pinMode(13, OUTPUT);
pinMode(12, OUTPUT);
pinMode(11, OUTPUT);
pinMode(10, OUTPUT);
Serial.begin(9600);
BTSerial.begin(9600);
```

```
}
void loop() {
if(BTSerial.available())
{
char data=BTSerial.read();
if(data=='P'||data=='p'){
drive_forward();
}
if(data=='Q'||data=='q')
{
15top();
}
if(data=='G'||data=='g'){
drive_backward();
}
}}
voiddrive_forward() {
digitalWrite(8,HIGH);
digitalWrite(9, LOW);
digitalWrite(10, LOW);
digitalWrite(11, HIGH);
}
voidstopp() {
digitalWrite(8, HIGH);
digitalWrite(9, HIGH);
digitalWrite(10, HIGH);
digitalWrite(11, HIGH);
}
voiddrive_backward() {
digitalWrite(8,LOW);
digitalWrite(9, HIGH);
digitalWrite(10, HIGH);
digitalWrite(11, LOW);
}
```

7. Fabrication process

Various components are used in automatic white board cleaner to make it a helping device to the teachers. These are listed below:

1. Duster
2. Plastic rack and pinion
3. Sliders
4. Spider couplings
5. Arduino uno
6. Johnson DC geared motor
7. HC06 Bluetooth module
8. 5mm LEDs
9. Breadboard
10. Jump wires
11. Motor Driver

8. Fabrication steps

Following were the steps taken for fabrication of the project:

1. Design analysis for the mechanism
2. Installation of Rack on both sides.

Figure 4. Rack and Pinion Arrangement Location

3. Fabrication of back link, duster assembly and mounting of motors, gears and couplings.
4. Installation of sliders on the back sides.
5. Mounting of duster mechanism on the board.
6. Installation of arduino and electrical switches.

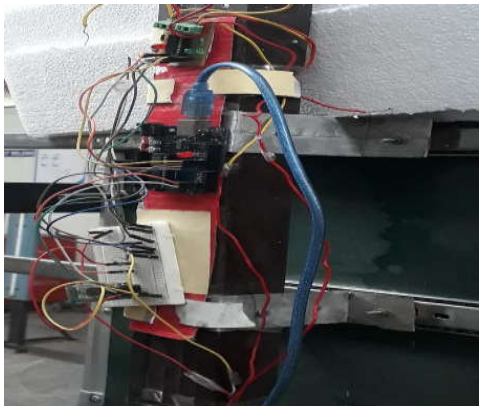

Figure 5. Electrical Wiring

7. Connecting all the electrical devices to the duster assembly and operate through mobile application.

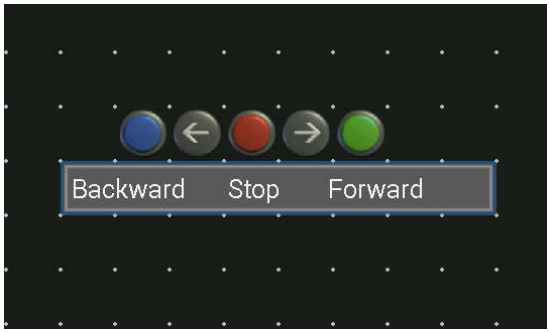

Figure 6. Mobile Control Interface

8. Inspection and Testing of the final assembly.

Figure 7. Final Assembly

9. Machines and equipments used

The following machines and tools were used in the fabrication process:

1. Bench Grinding Machine
2. Hand Grinder
3. Arc Welding Machine
4. Bench Drill Machine
5. Sheet Metal Cutter
6. Pliers
7. Screwdriver
8. Hacksaw
9. Multimeter
10. Bench vice

10. Results and conclusion

The testing of the project was successful, and the whole assembly worked as per the expectations. Very light marks were remaining on the board after cleaning which can be ignored. For perfect cleaning, the duster arm can be easily moved to-and-fro for 2-3 times. Even remote controlling through Bluetooth connectivity also worked fine. The eraser finely moved both the sides, i.e. front and the back sides, by just pressing the touch buttons in our smart phone. In this way, if such mechanism is used by any faculty member during lectures, he/she will need not to apply any efforts in erasing the written material, and just by controlling a few buttons, the board will be cleaned within a few seconds.

In the present time there are many operations which are performed manually, but seeing towards the progress of present technologies, In future everything will be operated automatically or through various mechanisms and machines. So this project may serve as one of the advanced technology in future and may be installed in different colleges, schools, etc.

11. Future scope for further improvements

There can be further possible modifications/improvements to the project which can make the system even better and more efficient. Some of the future improvements which can be done are:

1. System can be made in such a way that will erase the board in lesser time.
2. System can be made smarter, where it can recognize the dirty place on the board and it will erase that part only.
3. Controlling can be even more improved.

4. Rubbing action can be improved so that after cleaning, the remaining marks could be reduced to zero. Then only a single stroke of the eraser-arm from one side to the other side will ensure 100% clean board.

5. It can be made with water sprinkle unit for using it in blackboard/green board erasing.

6. A small vacuum-cleaner can be attached for collecting chalk dust if used in blackboard/green board erasing mechanism.

Although these points can be included for considerations as improvement, but it will definitely increase the total cost of the mechanism, for sure.

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