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DESIGN AND FABRICATION OF PORTABLE VACUUM BLACKBOARD ERASER

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Abstract - *Electronic blackboard erasers are made so as to ease the tedious job of erasing blackboards by teachers or students. Chalk dust or the marker ink may prove hazardous to health to both the teacher as well as student. So to reduce such problems vacuum blackboard erasers are one of the alternatives. Users who have their hands smeared by dust for a prolonged period of time are prone to skin problems. Users exposure to dust for a prolong period of time also could result in respiratory problems. After a thorough study of the existing conventional blackboard erasers and their design, the idea to develop a Electronic Vacuum Eraser to ease the above issues was contemplated.*

The structure of vacuum eraser for blackboard consists of major components that include a box shape eraser container, a brush, three rollers, a bracket for eraser, an eraser belt fabric, a vacuum fan, and chalk dust collector box etc.

The compartments were arranged such that the lower part of eraser container consists the space for eraser compartment and the upper part of the eraser container is divided into two sections of which one collector compartment and the other section is vacuum compartment.

***Key Words*: Vacuum Eraser, Portable, Rollers, Dust Collecting Chamber, Chalk Dust, Blackboard.**

1. INTRODUCTION

The blackboard eraser is a tool that is used to erase the blackboard and remove the chalk dust. This type of blackboard eraser is usually made of wood or plastic material for holding purpose and a polyester material to erase the blackboard. The main drawback of this type of eraser is that it spreads the erased chalk dust into the atmosphere which in turn has adverse effect on both the user and the user in vicinity.

The conventional blackboard eraser being used for education purpose (schools, colleges) which causes allergies due to chalk dust. It is important to eliminate these problems. Though writing on the board and erasing the same with a conventional eraser is easier, the challenge of containing the dust problem arises when the task of cleaning the blackboard with eraser comes into picture. However with a prolonged use the eraser becomes saturated and it does not clean the black board effectively and efficiently. Generally the user needs to clean the blackboard while teaching. Tapping the conventional eraser against the wall destroys the paint of the wall, and also produces unpleasant noise and disperses chalk dust and pollutes the class room environment. Inhalation of the chalk dust affects the user and the people in the vicinity, that can lead to problems like bronchitis i.e. asthma or if it goes into the eyes it may cause eye irritation. The chalk is made of "calcium carbonate and plaster of paris" i.e. $CaSO_4.1/2H_2O$, which is in hydrated form. In case of coloured chalk piece other than white, which are prepared by adding pigments and dies are much more harmful.

Moreover chalk dust not only harm the humans but also the machines. Equipment are exposed to this chalk dust will get easily damaged due to fine nature of the dust particles that settle on the equipment. This is one of the cause for the heat production in the equipment. When large amount of heat is produced the equipment may wear out before its actual shelf life. The vacuum blackboard eraser can be used in the class rooms to eliminate the problems associated with the conventional erasers and create a healthy atmosphere inside the class rooms.

Considering the above challenges on human respiratory system which affects the long term health of an individual. By considering the drawbacks of a conventional cleaning eraser, the concept of electronic vacuum eraser was conceived. The objective of this project is to reduce the harmful effects from chalk dust particles and provide better healthy work environment. Since majority of educational institutions are using conventional blackboard erasers, the development of a vacuum blackboard eraser becomes a boon to the teaching fraternity and the students.

2. COMPONENTS OF VACUUM BLACKBOARD ERASER

2.1 MOTOR

The Motor used for the vacuum eraser is DC type brushless motor. A brushless motor is also known as electronically commutated motors. They are synchronous motors powered by DC electricity via a switching power supply which produces a bi-directional electric current to drive each phase of the motor via a closed loop controller.

2.2 FILTER

The filter material used in the vacuum eraser is a cloth filter. These filters are used in large vacuum cleaners which are meant to clear large particles from areas such as construction sites, shops and industrial settings. They are washable, tough compared to other filter types.

Fig -2.1: Filter

2.3 CHALK DUST COLLECTING CHAMBER

The chalk dust collecting chamber is used for collecting the chalk dust particles. This chamber uses a bag like structure made of fabric material. The dust dispersed off by the strip of brush is suspended in air by the vacuum created, these dust particles flow into the chamber as the design has been channelized to serve the purpose.

Fig -2.2: Chalk dust collecting chamber

2.4 BATTERY

The battery used in the vacuum eraser is a rechargeable lead acid battery of 12Volts. In this type of battery electrical energy can be stored as chemical energy and this chemical energy is then converted to electrical energy as and when required. The conversion of electrical energy into chemical energy by applying external electrical source is known as charging of battery and the reverse is known as discharging of battery.

2.5 BRUSH STRIP

Brush is a strip of a brush line up which is situated just above the rollers. When the vacuum eraser erases the blackboard, the chalk dust is made to pass through the sideways just above the rollers by means of brusher which tries to disperse the chalk dust and help the chalk dust to separate from the fabric belt. A certain number of brushers are installed due to which there is an efficient way to separate the chalk dust from the respective fabric belt.

Fig -2.3: Brush

2.6 ROLLERS

Rollers play an important role in vacuum eraser. Rollers rotate gradually on their respective axis in such a way that the fabric belt which is covered upon it, tries to move back and forth depending on user, which in turn helps to erase the blackboard and take up all the chalk dust onto the fabric belt. All this action happens with the help of the rollers which assist the belt. Rollers which are used are made of nylon. When the diameter is taken into consideration, eccentricity projects the rollers outwards due to which the contact between the roller, fabric belt and the surface of the blackboard comes into picture. With the help of the contact between the surface of the blackboard and the rollers, the chalk dust is taken over.

Fig -2.4: Nylon Rollers

2.7 ERASER FABRIC BELT

The elastic belt material used is spandex. Spandex, Lycra or elastane is a synthetic fiber known for its exceptional elasticity. It is stronger and more durable. Because of its elasticity and strength (stretching up to five times its length). A benefit of spandex is its significant strength and elasticity and its ability to return to the original shape after stretching and faster drying than ordinary fabrics. The purpose of the elastic fabric belt is to collect the chalk dust as the user erases the board and convey the same chalk dust to the upper side. By doing this the elastic fabric material on to which the chalk dust is adhered is dispersed into the dust collecting bag as brush strips suspends the dust particles below the vacuum chamber.

Fig -2.5: Eraser fabric belt

3. DESIGN, ANALYSIS AND FABRICATION

3.1 DESIGN

3.1.1 GEOMETRY

The 3D Geometry model of Solid Part Programming is shown in the figure. It consists of dual fans, batteries, filter material, vacuum chamber, brush strip, rollers and roller material. The geometry model is symmetry. Inlet is provided at the bottom of the model and exhaust fan is provided at the top position.

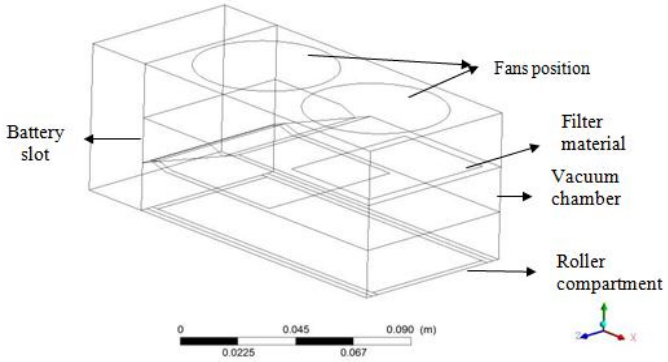

Fig -3.1: 3-D frame model

3.1.2 MESHING

Model is created with mapped hexagonal mesh. The model is meshed keeping minimum with minimum of 73551 faces and 25557 nodes. The isometric view model is as shown in figure.

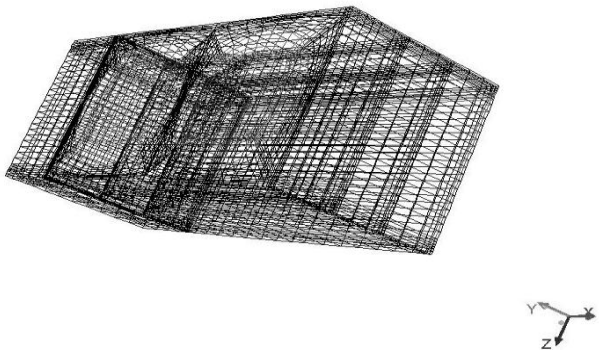

Fig -3.2: Meshed 3-D model

3.2 ANALYSIS

The simulation of the flow of chalk dust particles within the vacuum blackboard eraser was carried out using commercial computational package – Ansys Fluent. The domain consists of inlet, outlet, symmetric plane, battery bank, controller and dual fans. The outlet is with exhaust fans and boundary conditions with 16.43 CFM the mid plane is provided with symmetry wall. Wall is stationary with no slip boundary condition. The flow of air in the model is steady. The residual value for governing equation is maintained for 1e-6 except energy is maintained at 1e-7. The solution is initialized by standard initialization.

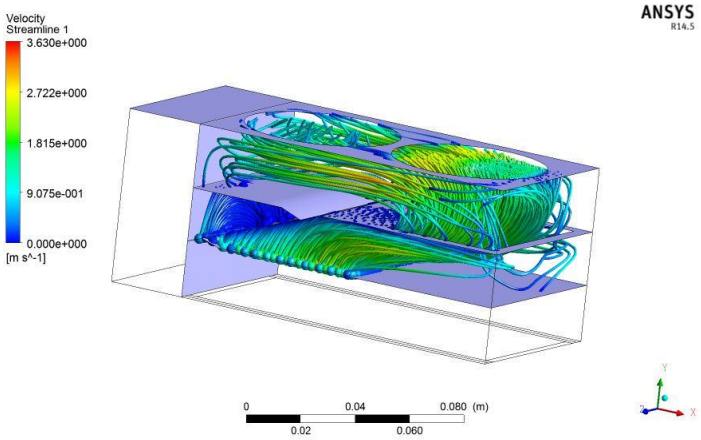

Fig -3.3: Streamline of Air in the Vacuum Blackboard Eraser

From the simulation various parameters such as inlet velocity of air, outlet velocity of air, inlet pressure of air, outlet pressure of air and velocity and pressure at mid-plane were studied.

3.3 FABRICATION

The initial stage of fabrication a model was made using a single fan and plastic hollow rollers. In this trial we have encountered irregular air flow due to which the suction of chalk dust was less with use of a single fan.

Fig -3.4: Trial model with single fan

The second trial model was developed using dual fans and aluminum rollers. In the second trial we encountered the aluminium rollers generating noise while erasing the

blackboard and the placement of the battery was affecting the user to handle the eraser.

Fig -3.5: Trial model with dual fans

In the final trial, we optimized to a certain level such that vacuum eraser enables the corresponding suction capacity, mass flow rate, velocity and pressure required. Moreover, the placement of the battery is in such a way that the user does not encounter any problem with respect to handling the vacuum eraser, and the rollers are been upgraded to nylon rollers which reduces the noise when rolled on the blackboard when compared to the aluminium rollers.

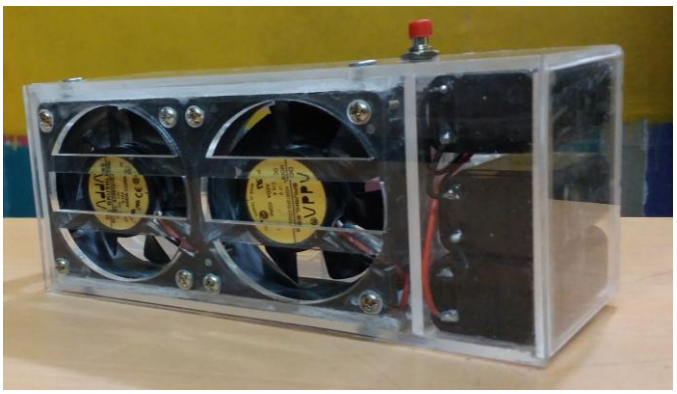

Fig -3.6: Final fabricated model

4. RESULTS

The results were calculated theoretically and compared with the results obtained from the analysis using Ansys Fluent. From the results it can be inferred that the analytical results are close to the results obtained theoretically.

Table 4.1: Comparison of Results

PARAMETERS	THEORETICAL	ANALYTICAL	
	Without Loss	Without Loss	With Loss
Inlet Velocity, V_1	5.45m/s	5 m/s	2.54 m/s
Outlet Velocity, V_2	2.93 m/s	2.4 m/s	1.45m/s
Inlet mass flow rate, $\dot{m}$	8.97×10^{-3} kg/s	8.45×10^{-3} kg/s	4.7×10^{-3} kg/s
Outlet mass flow rate, $\dot{m}$	8.97×10^{-3} kg/s	8.45×10^{-3} kg/s	-4.7×10^{-3} kg/s

However there is a variation in the results obtained with and without loss. To validate the same we use an anemometer which is a device used to measure the air flow. The final result with loss i.e., considering the obstructions to the air flow was measured using an anemometer and was found to be close to the value obtained analytically.

Fig -4.1: Actual outlet velocity (with loss) measured by Anemometer

5. CONCLUSIONS

The design and development of electronic vacuum blackboard eraser has resulted in providing a better solution for a clean and healthy environment which otherwise would have caused health hazards both to the teaching fraternity and students. The damage to the electric components in the class rooms is also minimized. The electronic vacuum eraser is easy to operate, highly reliable and with minimum maintenance. If produced in large quantities it can be cost effective. The product is suitable for large, medium and small institutions.

The outstanding contribution of this tool lies in its ability to provide a clean healthy and a less polluted learning environment.

6. FUTURE WORK

There is a great scope to modify this device in different ways by increasing the suction power using high speed fans of same size. The overall air loss of the product can be minimized by reducing the number of parts and joints. The efficiency of the product can be further increased by using Injection Moulding which results in complete sealing of the body. By the usage of high grade and low weight plastic material for the body the overall weight of the product can be reduced. Also there is scope to change the material used for rollers in order to reduce the effort applied by the user.

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