Design of an Automatic Cleaning Dry-Wipe and Presentation Board

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Abstract—this paper presents the design of a prototype automatic cleaning dry-wipe and presentation board. The board cleans itself in either a clockwise or anticlockwise direction with the press of a control button in an electromechanical fashion. It is also designed to serve the purpose of a screen for short-range projector reflections during presentations in schools and office meetings. The design was carried out with the aid of a suitable CAD software (Inventor), and the design analysis and calculations were carried out to confirm its mechanical feasibility. An aesthetic, compact automatic cleaning dry-wipe and presentation board was achieved which proves to be an affordable substitute for the conventional interactive whiteboards (IWBs).

Keywords —Dry-wipe, IWBs, Prototype, Electromechanical, CAD, Inventor

I. Introduction

Dry-wipe boards popularly known as whiteboards are one of the most popular teaching aids in both educational and cooperate organisations. These boards are mostly erased manually with the aid of a small hand-held wiper by a user—usually a student or teacher. The long-term effect of constant writing and wiping poses threat to human comfort and wellbeing—sprain, backaches etc. Whilst there have been technological improvements in this area with the emergence of IWBs, its high cost of purchase and installation has been a major limiting factor to most institutions. A dry-wipe board or whiteboard is any glossy, usually white surface used for non-permanent markings. Whiteboards stem from the idea of blackboards, they ease rapid markings and erasing of the markings on their surface. The popularity of whiteboards skyrocketed in the mid1980s, ever since they have become important fixtures in classrooms, meeting rooms, offices and other strategic environments. Dry-wipe boards have emerged into enhanced technological boards such as the electronic board, interactive whiteboard (IWB) and plain whiteboards (Odiase, 2016). An Institution that adapts the appropriate technology can inspire and support teaching. (Sider, 2014). In this technological age of continually evolving computers, laptop, video displays, interactive whiteboards, and internet access, it is shocking to realize that education was first influenced by introduction of chalkboard (Zarco, 2013).

The magnetic whiteboard has gone through numerous changes over the past decade, most of which are not easily noticeable. The cost of dry-boards has gotten cheaper over time, the surface has become easier to wipe and the glare has been reduced. Howbeit, there have been modifications, new constructions and replacements of existing chalkboards, the magnetic whiteboard still remains the most popular. Whiteboards support many different learning styles and are used in different learning environments, including those with hearing impairments. Educators were the first people to recognize the whiteboard’s potential as a tool for collaboration, improving student learning outcomes and streamlining lesson plans (Souhila, 2013).

Unfortunately, whiteboards are still erased manually with the aid of hand-held wipers of different shapes—usually rectangular. Writing alone is a laborious task to board users let alone constant manual erasing. This constant action no doubt, wastes time and human energy. Furthermore, there are challenges faced by projector users to find a suitable projector screen and searching for a good angle of reflection. Hence, the motive of this paper is to present a prototype design of whiteboard which cleans itself with the push of a button and also serve as good screen for projector reflections during presentations—as a cheap substitute for IWBs.

II. EVOLUTION OF WHITEBOARDS

There are currently two different accounts of the history of whiteboards, one from the United States and the other from United Kingdom both dating back to the late 1950s and 1960s.

The first version was invented by Martin Heit, a photographer and Korean War veteran. The idea was originally developed for having next to a wall phone something to take messages down. During his work with film, he realized that notes could be recorded on film negatives using marker pen and could be easily wiped off with a damp tissue. Early whiteboards were made of film laminate, the same glossy finish found on film negatives. A prototype was made and ready to be revealed, when the showcase at the Chicago Merchandise Mart burned down the night before its unveiling. Heit chose to sell the patent out.

The second account is that Albert Stallion invented whiteboards while working at American Steel Producer Alliance in the 1960s. He was assisted by Alasdair Geddes, who was an assistant of Stallion to develop the first prototype dry-wipe board in 1972 using enamel steel as the whiteboard surface.

In classrooms, the widespread adoption whiteboards did not occur until the early 1990s when concern over allergies and other potential health risks posed by chalk dust prompted the replacement of many blackboards with whiteboards (Emily, 2011).

Over the years, the materials used for whiteboards surface include the following: Melamine, Painted Steel or Aluminium, Hard Coat Laminate, Porcelain (Enamel-on-Steel), and Polyethylene terephthalate (PET) material.

III. RELATED WORK DESIGNS

There are several works done on the incorporation of electromechanical devices to erase whiteboard markings in order to ease teaching and save time. This section appraises their works and suggests ways to make them more efficient, cheaper and compact.

A. Preliminary Design of an Automated Whiteboard Cleaner (Simolowo, 2014)

In this work, an electromechanical system is created with the use of sprockets, an electric motor and a chain. The board was powered by a single phase 0.6 HP electric motor. The chain drive parameters were determined based on estimations of the centre distance between the sprockets, the required cleaning time, number of sweeps, total number of chain links and the expected performance. One of the major limitations of this method is that the chains used would need frequent lubrication. Also, the cost of a chain drive is higher as compared to belt

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drive. Maintenance cost of the chain drives are also higher and more complex than the belt drive.

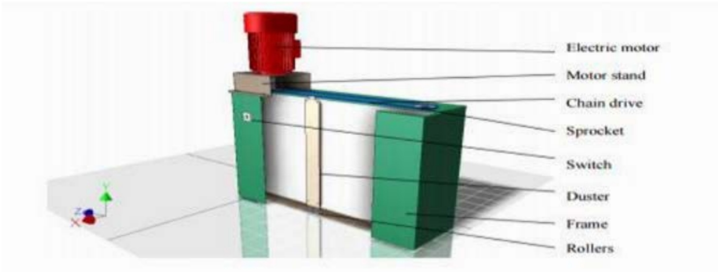

Fig 1: Shows the Isometric View of the Automated Whiteboard Cleaner (Simolowo, 2014)

B. System for Automatic Whiteboard Erasure (Chirag Shah, 2005)

This patent is for a system for automatic erasure of a board embodied by a motor plus a pair of rods capable of being rotatable driven by the motor. Pulleys attached to each of the rods with an eraser member affixed to two belts provide horizontal erasing action.

C. Electromechanical Based Automated Whiteboard Wiper (Odiase and Okoli, 2016)

In this work, an automatic whiteboard erasing system which consistently cleans boards with the push of a button was made. It is an electromechanical system that applies the use of combinational circuits and DC motor to automatically control the wiping of a board. However, this design does not make provision function in case of electric power outage. Also, this work cannot serve the purpose of a projector screen due to its nature of design of electrical attachments.

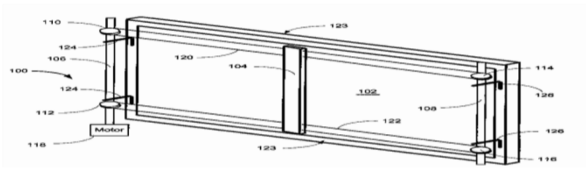

Fig 2: Whiteboard Wiper (Odiase and Okoli, 2016)

IV. DESIGN DESCRIPTION

The prototype automatic cleaning dry-wipe and presentation board is a compact system of different functionalities. It is an improvement of the existing designs. In this design, the markings on a whiteboard is erased with the press of a button which triggers the rotation of the whiteboard material (PET) around two shafts located at both ends of the board caused by the rotation of the motor. At the left-end of the board is a woolly soft cleaner which does the cleaning as the PET material rotates clockwise or anti-clockwise about the shafts situated at both ends of the board.

Another unique feature of this design is that unlike other designs, it can serve the function of a projector screen with the overhanging protrusion at the top- centre of the board which holds the projector in place at a reasonable angle of reflection just like the interactive whiteboards (IWBs). With this, the board can be used for presentation at schools and office meetings. The DC battery aesthetically situated behind the board allows for its usage in places where there are no power supply or at instances where there is constant power disruption—especially in the developing countries.

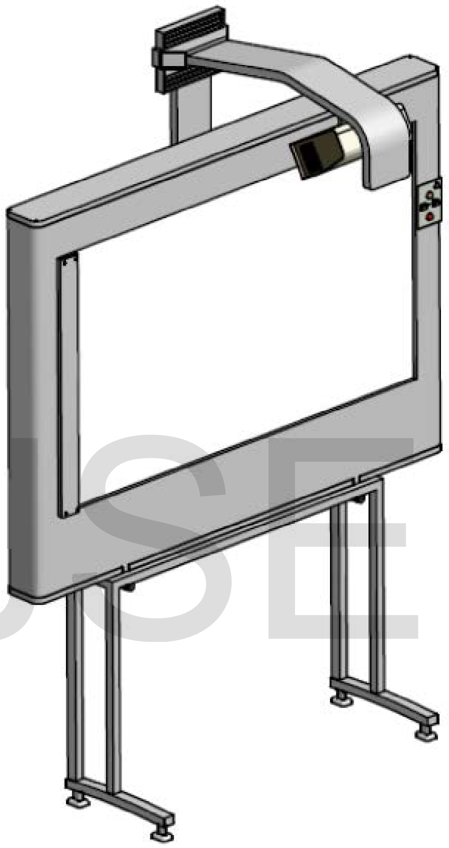

Fig 3: Isometric view of the Prototype Automatic Cleaning Dry-wipe and Presentation Board

The basic parts and their functionalities are described below.

A. Roller Shafts

The function of the shaft in the design is to transmit power or motion from the motor to the other shaft. When the 0.6hp motor rotates, the shaft transmit motion from it to the other shaft. In that process, the linking material which is the whiteboard material is caused to rotate, an action of which causes it to be cleaned by the cleaner at the end-side of the board.

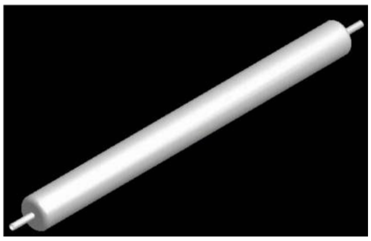

Fig 3: Roller Shaft

B. *Whiteboard Material*

The whiteboard material which is made of polyethylene terephthalate material (PET) is the material upon which the user writes. PET is unreinforced, semi-crystalline thermo-plastic polyester derived from polyethylene terephthalate. Its excellent wear resistance, low coefficient of friction, high flexural modulus, and superior dimensional stability make it a versatile material for designing mechanical and electro-mechanical parts. Because PET has no centre line porosity, the possibility of fluid absorption and leakage is virtually eliminated.

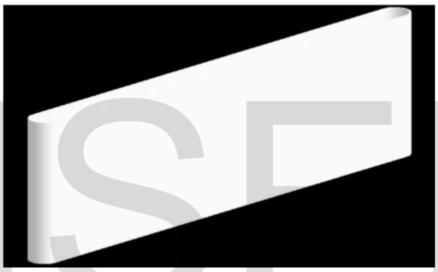

Fig 4: Whiteboard Material (PET)

C. *Board Rest*

This is the solid body within the PET which provides support for the whiteboard material and produces a sense of rigidity as the user writes on the board.

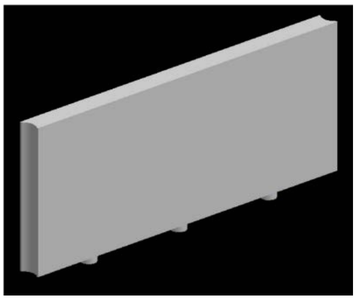

Fig 5: Board Rest

D. *Control System*

This is where the board is being controlled. It consists of five buttons which transmits signals to various parts of the board. The function of the control buttons are to: turn on/off the power, turn on the attached projector, clockwise rotation of whiteboard material, anticlockwise rotation of the whiteboard material

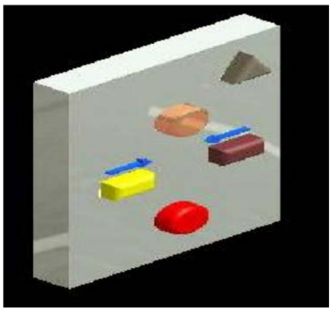

Fig 6: Control System

E. The Gear System and Motor

The major component of the wiper is the motor, gear teeth, pulley and moving belt. A pulley is a wheel which is driven by a power source (Slocum, 2008). The 0.6hp motor converts electrical energy into mechanical energy—rotation of the whiteboard material. Whereas, the gear has a total number of 60 teeth and it helps to reduce the speed of the motor to avoid high speed, temperature and quick damage of the whiteboard material.

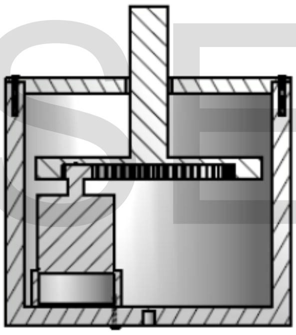

Fig 7: Section View of the Gear System

V. DESIGN CALCULATIONS

The design calculations and analysis are given in details below.

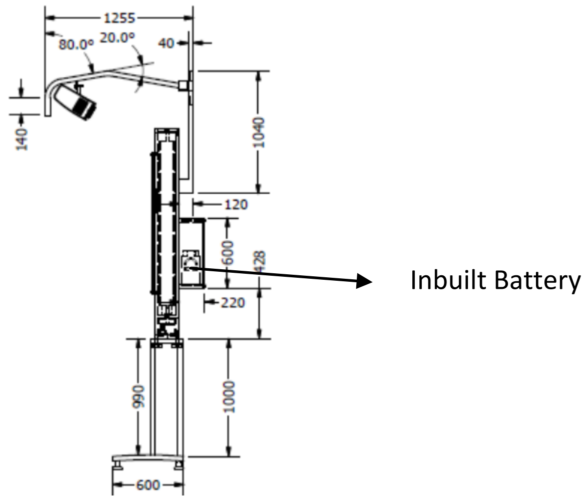

Fig 8: Side View of the Dry-Wipe Board with Dimensions in mm

A. Determination of the Length of the Whiteboard Material

The centre distance between the two shafts would be assumed to be 2220mm using the formula

$$L = \left[\frac{\pi}{2}(D_1 + D_2) + 2x + \frac{(D_1 + D_2)^2}{4x}\right]$$

(Khurmi and Gupta, 2015)

Where $D_1 = D_2$

$$L = \left[\frac{\pi}{2}(3.1 + 3.1) + 2(2220) + \frac{(0)^2}{4(2220)}\right] = 4449.73$$

B. Determination of Weight of the Gear and Pinion with Number of Teeth

Since auger shaft rotating at 100rpm has to transmit 0.746kw to another shaft at the same speed taking the $14\frac{1}{2}$ degree involutes teeth (Khurmi and Gupta, 2005) if both pinion and gear are made of steel. Pinion teeth of 60

$$V_R = \frac{N_G}{N_P} = \frac{T_G}{T_P} = 1$$

$T_P = 1T_P = 1 \times 60 = 60teeth$

Take modulus for pinion and gear 3.34mm
Pitch circle diameter of pinion

$D_P = MT_P$

3.34 X 60 = 200mm

Pitch Circle Diameter of Gear

$D_G = MT_G$

3.34 X 60 = 200mm

Pitch time velocity V=$\pi \frac{D_P N_P}{60} = \pi \times \frac{0.2 \times 100}{60} = 1.047 m/s$

Assuming steady load condition and 8 – 10 hours of service per day, the service factor (C_S) from table is given as C_S= 1 (Khurmi and Gupta, 2005)

Tangential tooth load $W_T = \frac{P_1}{V} \times C_S = \frac{746}{1.047}$ = 712.5N

Since velocity is not more than 12.5m/s

Then velocity factor $C_V = \frac{3}{3+V} = \frac{3}{3+1.407} = 0.88$

$$y_P = 0.124 - \frac{0.684}{T_P} = 0.124 - \frac{0.684}{60} = 0.1126$$

And $W_T = (\sigma_{WP})\, bm\pi y_p$

$= (\sigma_{op} \times C_V)\, b \times m \times \pi \times y_P$ (Khurmi and Gupta)

$712.5 = (56 \times 0.385^3)\, b \times \pi \times 3.34 \times 0.1126$

712.5 = 3.78b

b = 188.49mm

$W_P = 0.00118 T_P b m^2$ (Khurmi and Gupta, 2015)

$$W_P = 0.00118 \times 60 \times 188.49 \times 3.34^2$$

$$W_P = 148.87N$$

$$W_R = \sqrt{\left[\left({W_N}^2\right) + \left({W_P}^2\right) + 2W_N + W_P \, cos \, \emptyset\right]}$$

$$W_N = \frac{W_T}{\cos \emptyset} = \frac{155.42}{\cos 14\frac{1}{2}} = \frac{712.5}{0.96815}$$

$$W_N = 735.93N$$

$$W_{PR} = \sqrt{\left[\left({W_N}^2\right) + \left({W_P}^2\right) + 2W_N + W_P \cos \emptyset\right]}$$

$$W_{PR} = \sqrt{\left[(735.93^2) + (148.87^2) + (2 \times 735.93 \times 148.87 \times \cos 14\frac{1}{2}\emptyset\right]}$$

$$W_{PR} = 880.85N$$

This is same for the gear since they are transmitting the same velocity and power

$$W_{GR} = 880.85N$$

C. *Shaft Key Design*

The shaft key is designed in order to determine the size of the key that will be used and its allowable shear stress. The key calculation is done below.

Width of key, $w = {}^{d}/_{4}$

Thickness of key, ${}^{2w}/_{3}$

Where,

d = inner diameter of the shaft to be selected, 28mm

w = 7.75mm; t = 5.2mm

Thus, for a shaft of 31mm diameter, the dimensions for the key to be used are: width = 10mm, thickness = 8mm

(Khurmi and Gupta, 2005)

VI. WORKING OF THE BOARD CLEANING SYSTEM

The entire cleaning system works on the principle of electromechanical relation. The direct current (DC) converts electrical power from the power source into mechanical energy through the interaction of two magnetic fields. One field is produced by a permanent magnet assembly; the other field is produced by an electrical current flowing in the motor windings. These two fields result in a torque which tends to rotate the rotor. As the rotor turns, the current in the windings is commutated to produce a continuous torque output. The stationary electromagnetic field of the motor can also be wire-wound like the armature (called a wound-field motor) or can be made up of permanent magnets (called a permanent magnetmotor).

Fig 8: Process Flow Diagram for Board Cleaning System

In either style (wound-field or permanent magnet) the commutator acts as half of a mechanical switch and rotates with the armature as it turns. The commutator is composed of conductive segments (called bars), usually made of copper, which represent the termination of individual coils of wire distributed around the armature. The second half of the mechanical switch is completed by the brushes. These brushes typically remain stationary with the motor's housing but ride (or brush) on the rotating commutator. As electrical energy is passed through the brushes and consequently through the armature a torsional force is generated as a reaction between the motor's field and the armature causing the motor's armature to turn. As the armature turns, the brushes switch to adjacent bars on the commutator. This switching action transfers the electrical energy to an adjacent winding on the armature which in turn perpetuates the torsional motion of the armature. The direction of rotation, clockwise or anticlockwise depends on the polarity supply to the motor.

The motor is connected to the gear—this has 60teeth—to control the high speed of the motor. These two components are fused together to form the gear system as shown in Fig. 7 ditto.

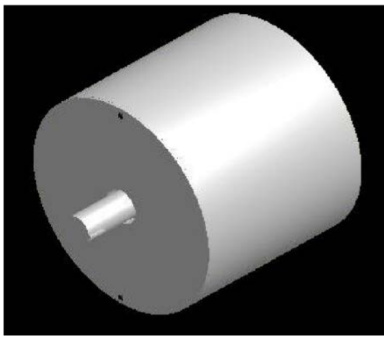

Fig 9: Isometric view of the gear system with a keyway

One of the roller shaft with a keyway is connected to the gear system via a key. Hence, the rotary motion of the motor causes the rotation of the shaft which is in turn transmitted to the other shaft through the whiteboard material. This transmission of motion from one shaft to the other is what brings about the cleaning of the dry-wipe board.

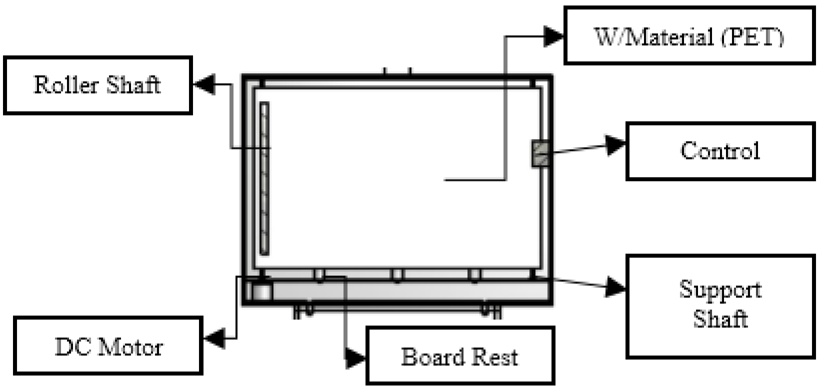

Fig. 10: Section View of the Board Cleaning System

VII. CONCLUSION

This paper has succeeded in presenting a viable alternative to amelioratethe challenge—laborious constant board wiping—faced in financially constrained formal learning institutions and organisations in developing countries. With this design massive adoption and implementation, teachers, lecturers, and other whiteboard users can save their energy, time and money to achieve a hitch-free information and knowledge dissemination to their pupils, students and co-workers irrespective of whether there is electric power supply or not. Also, PowerPoint presentations can be carried out easily without being disturbed about projector screen or angle of projector reflection because all these are being catered for in the compact design. However, this paper does not dispute the existence of IWBs which are products of high technological learning-aid prodigy in this present time, especially in the developed countries. Its high cost of procurement and installation is what turns off many institutions in these parts—developing nations—of the world. This work has succeeded in providing an affordable near substitute for IWBs.

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