Faculty of Mechanical Engineering

DESIGN AND ANALYSIS OF AUTOMATED WHITEBOARD CLEANER

ROSHINI D/O BASKARAN

Bachelor of Mechanical Engineering (Design & Innovation)

2020

© Universiti Teknikal Malaysia Melaka

DESIGN AND ANALYSIS OF AUTOMATED WHITEBOARD CLEANER

ROSHINI D/O BASKARAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

© Universiti Teknikal Malaysia Melaka

DESIGN AND ANALYSIS OF AUTOMATED WHITEBOARD CLEANER

ROSHINI D/O BASKARAN

A report submitted

In fulfillment of the requirement for the degree of

Bachelor of Mechanical Engineering (Design & Innovation)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2020

© Universiti Teknikal Malaysia Melaka

DECLARATION

I declare that this thesis entitled "Automated Whiteboard Cleaner" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :…….

Name : ROSHINI D/O BASKARAN

Date :…….

© Universiti Teknikal Malaysia Melaka

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (with Honours).

Signature :……

Supervisor Name : DR MOHD ASRI BIN YUSUFF

Date :……

© Universiti Teknikal Malaysia Melaka

DEDICATION

To my beloved family, friend and my lecturer

© Universiti Teknikal Malaysia Melaka

ABSTRACT

The whiteboard is the best writing medium during teaching across the world. At present, it is seen that almost everything is automated. The automation system can reduce the human effort and make any arrangement easier. Even the evolution of the writing board had made its user's life easier, yet there are still problems arise to the use of it. During the attempt of cleaning the whiteboard, educators sometimes get their hands and outfit dirty, which may disturb the lesson. Besides that, cleaning the whiteboard consumes time as the educators have to clean the same spot several times. Therefore, this project aims to design a automate whiteboard cleaner, which is objected to coming up with a simple design and effective automated whiteboard cleaner.and to reduce the time consumed to clean the whiteboard.The overall process of this project can be seen in the flow chart. The progress starts by reviewing the literature on the automated whiteboard cleaner to gain ideas for the design. Four conceptual design is made and the best is chosen from the Pugh Concept Selection with the highest final score among the four concepts that meet the customer requirement and engineering characteristic. Next, the project's components is been drawn by using Catia V5 and to ensure that the components of the Automated White Board Cleaner perform perfectly without any failure, analysis and simulation has been carried out to the components. Finally, the detail design of the project with the combination and assembly of all part and components was generated by using Catia V5.

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Papan tulis adalah media penulisan terbaik semasa mengajar di seluruh dunia. Pada masa ini, nampaknya hampir semuanya automatik. Sistem automasi mempunyai keupayaan untuk mengurangkan usaha manusia dan membuat pengaturan lebih mudah. Bahkan evolusi papan tulis menjadikan kehidupan penggunanya lebih mudah, namun masih ada masalah yang timbul kerana penggunaannya. Untuk usaha membersihkan papan putih, pendidik mesti mengatasinya dengan mengotorkan tangan mereka dan kadang-kadang pada pakaian mereka, yang mungkin mengganggu pelajaran. Selain itu, membersihkan papan putih memakan masa kerana pendidik harus membersihkan tempat yang sama beberapa kali. Oleh itu, tujuan projek ini adalah untuk merancang pembersih papan putih automatik, yang keberatan untuk hadir dengan reka bentuk ringkas dan pembersih papan tulis automatik yang berkesan dan untuk mengurangkan masa yang diperlukan untuk membersihkan papan putih. Proses keseluruhan projek ini dapat dilihat dalam carta alir. Kemajuan dimulakan dengan meninjau literatur mengenai pembersih papan putih automatik. Empat reka bentuk konseptual dibuat dan yang terbaik dipilih dari Pemilihan Konsep Pugh dengan skor akhir tertinggi di antara empat konsep yang memenuhi kehendak pelanggan dan ciri kejuruteraan. Seterusnya, komponen projek dilukis dengan menggunakan Catia V5 dan untuk memastikan bahawa komponen Automatic White Board Cleaner berfungsi dengan sempurna tanpa sebarang kegagalan, analisis dan simulasi telah dilakukan terhadap komponen tersebut. Akhirnya, reka bentuk terperinci projek dengan gabungan dan pemasangan semua bahagian dan komponen dihasilkan dengan menggunakan Catia V5.

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENTS

Firstly, I would like to take this opportunity to express my special thanks to my supervisor, Dr Mohd Asri Yusuff from the Faculty of Mechanical Engineering University Teknikal Malaysia Melaka (UTeM) for his unconditional guidance, support and continuous encouragement toward completing the thesis.

Furthermore, I would like to appreciate the Faculty of Mechanical Engineering (FKM) of University Teknikal Malaysia Melaka (UTeM) for providing the opportunity to conduct my project although the prototype was not been able to be complete due to the Covid-19 crisis and somehow it helps in completing this thesis.

Apart from that, a special thanks to my family and friends for their moral support in completing this degree and not forgetting, those who have directly or indirectly contributed to the realization of this thesis.

© Universiti Teknikal Malaysia Melaka

TABLE OF CONTENT

DECLARATION **i**

APPROVAL **ii**

DEDICATION **iii**

ABSTRACT **iv**

ABSTRAK **v**

ACKNOWLEDGEMENTS **vi**

LIST OF TABLES **ix**

LIST OF FIGURES **x**

LIST OF ABBREVIATIONS **xii**

LIST OF APPENDICES **xiii**

CHAPTER 1

INTRODUCTION **1**

1.1 Background 1

1.2 Problem Statement 2

1.3 Objective 2

1.4 Scope of Project 2

1.5 General Methodology 3

CHAPTER 2

LITERATURE REVIEW **4**

2.1 Introduction 4

2.2 Design Type 1 4

2.3 Design Type 2 6

2.4 Design Type 3 7

2.5 Design Type 4 8

2.6 Design Type 5 10

CHAPTER 3

METHODOLOGY **12**

3.1 Introduction 12

3.2 Business Opportunity 14

3.3 Specifications And Needs Identification 14

3.3.1 Questionnaire 15

3.3.2 Customer Requirement 23

© Universiti Teknikal Malaysia Melaka

3.3.3 Engineering Characteristic 24
3.3.4 Quality Function Development (QFD) 25
3.3.5 Product Design Specification 28
3.4 Competitors 29
3.5 Concept Generation 29
3.5.1 Morphological Chart 30
3.5.2 Conceptual Design 32
3.6 Concept Evaluation 36
3.6.1 Pugh Concept Selection 36
3.6.2 Best Concept 37
3.7 Material Selection 38
3.7.1 6061 Aluminium Alloy 38
3.7.2 Stainless Steel – Grade 316 39
3.7.3 Rubber 40
3.7.4 Acrylic Board 41
CHAPTER 4
RESULT AND DISCUSSION 42
4.1 Parametric Design 42
4.1.1 Product Architecture 42
4.2 Analysis And Stimulation 43
4.2.1 Analysis On Housing 43
4.2.2 Analysis On Bearing 46
4.2.3 Analysis On Additional Block 48
4.2.4 Motor Torque 50
4.3 Detail Design 52
4.3.1 Product Structure 52
4.3.2 List Of Components 55
4.4 Manufacturing Process And Cost 56
CHAPTER 5
CONCLUSION AND RECOMMENDATION 58
5.1 Conclusion 58
5.2 Recommendation 59
REFERENCE 60
APPENDIX 62

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

Table 3. 1:Customer Requirements Rating 24
Table 3. 2:Engineering Characteristic with Units 24
Table 3. 3:Design Specification of Automated Whiteboard Cleaner 28
Table 3. 4:Comparisons between three products 29
Table 3. 5:Features of Automated Whiteboard Cleaner 30
Table 3. 6:Number of options chosen for 1st Concept Design 33
Table 3. 7:Number of options chosen for 2nd Concept Design 34
Table 3. 8:Number of options chosen for 3rd Concept Design 35
Table 3. 9:Number of options chosen for 4th Concept Design 36
Table 3.10: Concept Evaluation of Automated Whiteboard Cleaner 46
Table 4. 1:Properties of Stainless Steel 55
Table 4, 2:Manufacturing Process of Automated Whiteboard Cleaner's Components 68
Table 4. 3:Manufacturing Cost of Automated Whiteboard Cleaner's Components 69

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

Figure 2.1: Front View and Circuit Diagram 5
Figure 2.2: Front View of the Black Board 6
Figure 2.3:3D View of Blackboard Cleaning System 8
Figure 2.4: Isometric View of Automated Whiteboard Cleaner 9
Figure 2.5: Front and Back View of The System 11
Figure 3.1: Flowchart of Project 13
Figure 3.2: Pie Chart Analysis for Question 1 15
Figure 3.3: Pie Chart Analysis for Question 2 16
Figure 3.4: Pie Chart Analysis for Question 3 17
Figure 3.5: Pie Chart Analysis for Question 4 17
Figure 3.6: Pie Chart Analysis for Question 5 18
Figure 3.7: Pie Chart Analysis for Question 6 19
Figure 3.8: Pie Chart Analysis for Question 7 19
Figure 3.9: Pie Chart Analysis for Aspect 1 20
Figure 3.10: Pie Chart Analysis for Aspect 2 20
Figure 3.11: Pie Chart Analysis for Aspect 3 21
Figure 3.12: Pie Chart Analysis for Aspect 4 21
Figure 3.13: Pie Chart Analysis for Aspect 5 22
Figure 3.14: Pie Chart Analysis for Aspect 6 22
Figure 3.15: Pie Chart Analysis for Aspect 7 23
Figure 3.16: House of Quality of Automated Whiteboard Cleaner 27
Figure 3.17: Morphological Chart of Automated Whiteboard Cleaner 31
Figure 3.18: Concept Design 1 32
Figure 3.19: Concept Design 2 33
Figure 3.20: Concept Design 4 34
Figure 3.21: Concept Design 5 35
Figure 3.22: The Best Concept 37
Figure 3.23: AL6061 Guide Rail 38
Figure 3.24: Pulley 39
Figure 3.25: Stainless Steel Materials 39
Figure 3.26: Additional Block 39
Figure 3.27: Housing 40
Figure 3.28: Rubber Timing Belt 40
Figure 3.29: Acrylic Board 41

© Universiti Teknikal Malaysia Melaka

Figure 4.1: Drawing of Automated White Board Cleaner 42
Figure 4.3:Right Housing 44
Figure 4.2:Left Housing 44
Figure 4.4: Deformation on the Left Housing 44
Figure 4.5: Deformation on the Right Housing 44
Figure 4.6: Von Mises Stress of Left Housing 45
Figure 4.7: Von Mises Stress of Right Housing 45
Figure 4.8: Bearing 47
Figure 4.9: Deformation on Bearing 47
Figure 4.10: Von Mises Stress on Bearing 48
Figure 4.11:Additional Block 48
Figure4.12:Deformation Of Additional Block 49
Figure 4.13:Von Mises Stress on Additional Bock 49
Figure 4.14: Isometric View 3D Drawing 52
Figure 4.15: The Body Of Automated White Board Cleaner 53
Figure 4.16: Duster Holder of Automated White Board Cleaner 54
Figure 4.17: Orthographic View of Automated Whiteboard Cleaner 55
Figure 4.18: Bill of Material of Automated Whiteboard Cleaner 56

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATIONS

CAD	Computer Aided Design
ABS	Acrylonitrile Butadiene Styrene
HOQ	House Of Quality
PM	Pugh Matrix
CATIA	Computer Aided Three Dimensional Interactive Application
RM	Ringgit Malaysia
BOM	Bill Of Material
CRs	Customer Requirements
ECs	Engineering Characteristics
QDF	Quality Function Development
PDS	Product Design Specification

© Universiti Teknikal Malaysia Melaka

LIST OF APPENDICES

A1	Gantt Chart For Psm 1
A2	Gantt Chart Psm 2
B	Survey Form
C1	Isomatric View
C2	Orthographic View
C3	Exploded View
C4	Part 1 Guide Rail
C5	Part 2 Guide Rail Bearing
C6	Part 3 Left Housing
C7	Part 3b Right Housing
C8	Part 4 Additional Block
C9	Part 5 100mm Shaft
C10	Part 6 Shaft Holder
C11	Part 7 Motor
C12	Part 8 Pully
C13	Part 10 Timing Belt
C14	Part 11 Duster Board
C15	Part 12 Duster Holder
C16	Part 13 Duster Holder Back Screw
C17	Part 14 Duster Holder Side Screw
C18	Part 17 Project Holder

© Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 Background

A man living in the cave early in the civilization used the wall of the cave as the writing medium. They used the wall to capture various memories or the story of their own culture and daily activities. Over the long haul and an acculturated society was being framed the situation started to change. Individuals started to utilize a major cut of the wood piece as the board and coal as the pen medium in the middle age. But it was not so comfortable, and it became nasty.

From that point forward, the writing board had been presented. It's only a dark canvas where chalk is utilized as the pen medium. Chalk is a composite of calcium carbonate and it would appear like a stick. It was agreeable however it makes dust during cleaning the board utilizing the duster. A duster is a gadget which is utilized to wipe the works from the board. Despite that, the board has not lost its ubiquity as in present time and it's being utilized broadly over the world. But it is a whiteboard which is the modified version of the blackboard. Here, man uses a marker pen for writing, and they use a piece of cloth or foam as a duster. Now, the whiteboard is the best writing medium during teaching across the world. At present, it is seen that almost everything is automated. The automation system has the capacity to reduce the human effort and to make any arrangement easier.

© Universiti Teknikal Malaysia Melaka

1.2 Problem Statement

Information is passing by writing on the whiteboard used by educators around the world. Even the evolution of the writing board had made its user's life easier, yet there are still problems arise to the use of it. To the attempt of cleaning the whiteboard, educators must handle it by getting their hands dirty and sometimes to their clothes. This causes the flow of teaching being disturbed as they must continuously keep their hands clean.

Besides that, cleaning the whiteboard consumes time as the educators have to clean the same spot several times. This is due to the uneven force applied by them. Furthermore, cleaning the whiteboard needs proper material because the wrong one will not give a proper finishing, thus contributing to time-consuming. Therefore, this project aims to design a automate whiteboard cleaner.

1.3 Objective

The objectives of the project are as follow:

I. To design a simple and effective automated whiteboard cleaner.

II. To reduce the time required to clean the whiteboard.

1.4 Scope of Project

This project will be served as one of the advanced technologies in future and will be implemented in every college, school etc.

I. Clean whiteboard automatically

II. Reduce time taken to clean the whiteboard and to achieve a clean finishing

© Universiti Teknikal Malaysia Melaka

1.5 General Methodology

The action that needs to be carried out to accomplish the objectives in this project are listed below:

I. Literature review

Journals, articles or any material concerning the task will be checked on.

II. Conceptual design

Draw a suitable sketch that is selected as the final product.

III. Design using Catia V5 software

Outline the task utilizing any plan miscreant in 2D and 3D drawing model.

IV. Report writing

A report on this study will be written at the end of the project.

© Universiti Teknikal Malaysia Melaka

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In order to design an Automatic White Board Cleaner, research and studies on components and mechanisms of existing projects on whiteboard cleaning method are carried out. Besides that, the early invention of manual whiteboard cleaning is disused in this chapter. Mechanisms applied in existing projects on automatic whiteboard cleaner are used to generate ideas on designing a better version of an automatic whiteboard cleaner.

2.2 Design Type 1

The International Research Journal of Engineering and Technology (IRJET) had come up with a title of **Design and Fabrication of SmartBoard Cleaner**. This concept uses ATMEGA-328P Microcontroller, Rack & Pinion and L298N motor driver to come up with a partial cleaning mechanism. The electronic kit used is portable, light in weight, compact in size and Lead Screw is used for accuracy.

Working Principle

This device functions automatically where the duster is fixed vertically which slides over the two horizontal rods and forward, the backward motion of duster is provided by rack and pinion mechanism. In this device, the cleaning action of the

© Universiti Teknikal Malaysia Melaka

duster is controlled by the mobile application used. It is controlled by a microcontroller (Arduino Uno) which can be controlled up to a 10m range by using mobile. (Mohan Umbarkar et al., year 2019).

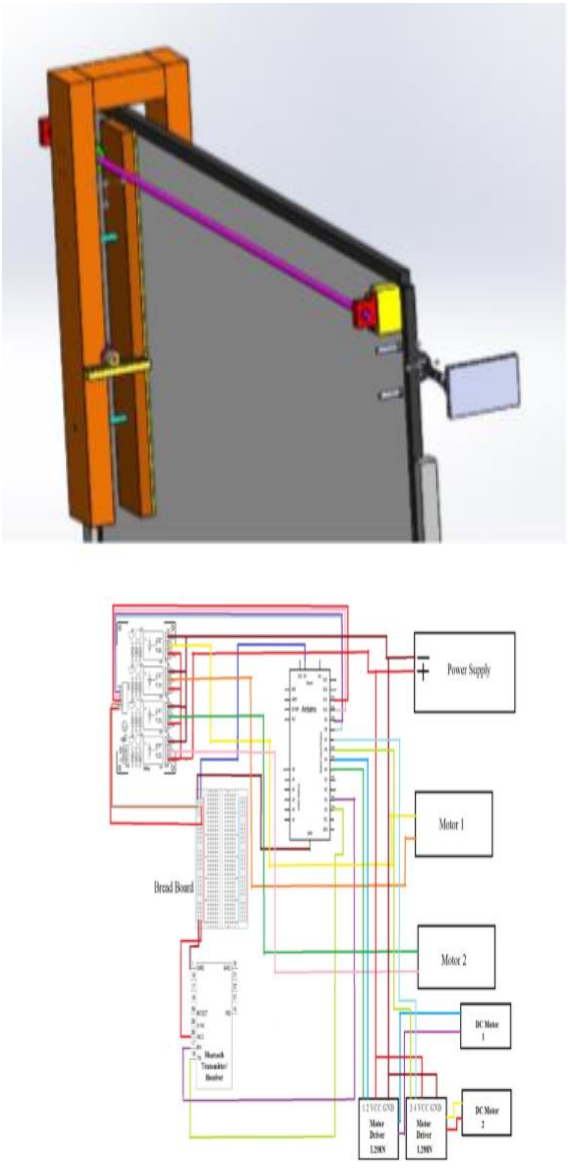

Figure 2.1: Front View and Circuit Diagram

. (Mohan Umbarkar et al., year 2019)

© Universiti Teknikal Malaysia Melaka

2.3 Design Type 2

(Mr Tumpala Uma Santhosh, et al, year 2016) **Design and Fabrication of an Automatic Black Board Cleaner**. A mechanism that can automatically detect the blackboard chalk stains, and erase the font, keep the blackboard clean. The duster includes a track structure to permit reciprocation of the duster laterally of an elongate blackboard frame. The chain which is connected to duster includes a drive motor to effect rotation of a drive duster positioned above the blackboard frame. The principal object of the present automatic blackboard duster is to provide an attachment for blackboards in the form of a power-driven erasing apparatus which can be set in operation by the throw of a switch, thus eliminating the drudgery of manually cleaning blackboards.

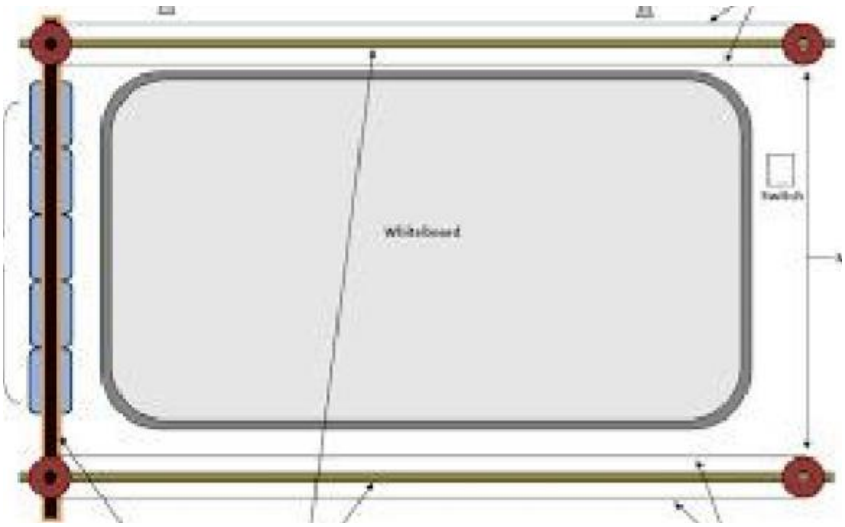

Figure 2.2: Front View of the Black Board
(Mr. Tumpala Uma Santhosh, et al, year 2016)

© Universiti Teknikal Malaysia Melaka

Working Principle

In the working of automatic blackboard duster, as the power is supplied to the motor, the shaft stars rotating. A gearbox is connected to the motor shaft is connected by another gear. Thus, movement of these gears rotates the wheel axil by which both the upper and lower wheels start rotating. By the rotation of these shafts, the wheels which are mounted on these guideways in horizontal direction start to rotate as well. A duster which is mounted on this wheel starts reciprocating left and right, thus clean the board. A switch is provided for the left and right motion. (Mr Tumpala Uma Santhosh, et al, year 2016)

2.4 Design Type 3

Design and Development of Board Cleaning System. This project works on combined principles of mechanical and electronics where rack and pinion mechanism are used for cleaning the blackboard and whiteboard with the help of the DC geared motors for rotation and limit switch to stop the motion.

Working Principle

The motors will drive the pinions which will convert the rotary motion of pinions into linear motion on the rack carrying the connecting strip with duster attached to it by bearing arrangement. DPDT switch and limit switch are also going to play a minor role in this system for stopping the pinion and rotating one gear clockwise and another anti-clockwise. A small water sprinkler is used to spray the water on the blackboard. With the help of wiper motor, the pressure will be created for sprinkling the water on the blackboard. This will save energy, time and eliminate

© Universiti Teknikal Malaysia Melaka

the load on the motor. Toggle mechanism is used in the back connecting strip to adjust the clearance between pinion and rack. (Gaurav Gangurde, year 2016).

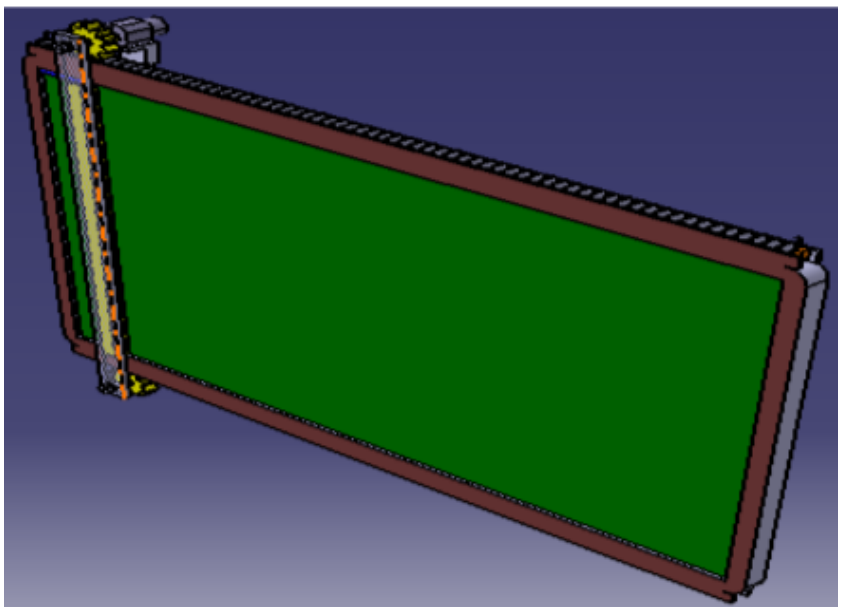

Figure 2.3:3D View of Blackboard Cleaning System
(Gaurav Gangurde, year 2016).

2.5 Design Type 4

Preliminary Design of an Automated White Board Cleaner. The automated whiteboard cleaner is a movable device; which is mostly made up of wood (plywood to be precise). The equipment is made up of a whiteboard frame, whiteboard duster, electric motor, sprocket, chain, duster and top cover. The motor to be used is a servo–motor which is to run at a relatively low speed.

Working Principle

By turning on the switch, the current is transmitted to a variable voltage supply which will decrease the amount of voltage going into the motor hence slowing

© Universiti Teknikal Malaysia Melaka