

**DESIGN AND DEVELOPMENT OF AUTOMATED
DIFFERENT VISCOSITY CHEMICAL MIXING
MACHINE FOR GLOVE INDUSTRY**

AmilaPrasangaPahalavithana

139527V

Degree of Master of Science

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

May 2018

**DESIGN AND DEVELOPMENT OF AUTOMATED
DIFFERENT VISCOSITY CHEMICAL MIXING
MACHINE FOR GLOVE INDUSTRY**

AmilaPrasangaPahalavithana

139527V

Dissertation submitted in partial fulfillment of the requirements for the Degree Master of
Science in Industrial Automation

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

May 2018

DECLARATION

“I declare that this is my own work and this thesis/dissertationi does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

Date:

The above candidate has carried out research for the Masters Dissertation under my supervision.

Signature of the supervisor:

Date:

ABSTRACT

Compound preparation is one of the most important processes in glove manufacturing industry. It is highly concerned to achieve required physical and mechanical properties of a specific glove. This is almost depending on quality compounding. Therefore compound preparation should be done according to correct formulation. Since this is a manual process, long term practice is very important and hence high skilled labor is required.

In this manual process weighing of each chemical precisely and mixing them in a specific time is essential. Also in this process human interference is very high and this is a monotonous work too. Furthermore there are specific compound formulation among competitive companies which are to be kept securely without revealing to others. Therefore there's a necessity of minimizing human intervention in compounding. Automating the compounding process is a good solution for this and also it is a challenging task, since there are so many factors to be considered in designing.

This research oriented towards design and development of an automated compounding machine by eliminating all drawbacks in manual process. Here measuring of chemicals precisely, feeding chemicals in to the mixing chamber with a required flow rate, maintaining the mixing sequence of chemicals, easy operation of the machine and maintaining the secrecy of compound formulation are highly concerned. Basically in this machine an authorized personal can enter the mass, time and impeller speed data according to the process and formulation. These data are stored in the PLC memory until they are edited by the authorized personals as they required. The operator simply can select the compound type and the batch size and then start the machine by means of the HMI unit. The filling and measuring of the required amount of chemicals in to the intermediate compartment are done by means of a system comprises of a servo pump, load cell with a load cell amplifier and a PLC unit. According to the load cell feedback signal the PLC controls the servo pump by varying the output pulse rate and hence measure the correct amount of

chemicals. Also feeding of the measured chemical into the mixing chamber is done by a servo pump attached to the intermediate compartment and the flow rate is maintained by varying the output pulse to the above servo pump according to the load cell signal. Chemical feeding sequence, Chemical filling, maintaining required flow rate, controlling impeller speeds and all other operations are controlled by the PLC unit. The PLC algorithm is developed for fulfill the above operations and can be further developed. The operator machine interface is done via the HMI unit. The outcome of this machine is successful. That is when checking the properties of the compounds prepared from this machine, it can be confirmed that they were up to the standard.

DEDICATION

Dedicated to

my beloved

Parents, Wife and Two Children

ACKNOWLEDGEMENT

First I would like to express my gratitude to my supervisor Dr. BuddhikaJayasekara for giving me his fullest support and guidance for this research project. Also I am grateful to all of the academic staff who serve their valuable knowledge during the Industrial Automation Course.

Also I owe special thanks to my work place and subordinate staff for giving me support to successfully complete this project.

Finally my sincere thanks goes to my family members for giving their continuous support during the Industrial Automation Course.

AmilaPrasangaPahalavithana

139527V

TABLE OF CONTENTS

Declaration of the candidate & Supervisor	i
Abstract	ii
Dedication	iv
Acknowledgements	v
Table of content	vi
List of Figures	viii
List of Tables	xi
1 INTRODUCTION	1
1.1 Background	1
1.2 Characteristics of the Existing System	1
1.3 Literature Review	2
1.3.1 Design and Development of an Automated Paint Mixing Machine	2
1.3.2 Automated Microcontroller-based Cocktail Mixer and Dispenser	4
1.3.3 Automatic Paint Mixing Process Using Lab view software	5
1.3.4 Comparison of Researches.	6
1.3.5. Reviewing of some more researches	7
1.4 Problem Statement	12
1.5 Objectives of the Study	13
1.6 Methodology	13
1.6.1 Measuring Technique	13
1.6.2 Mixing Technique	17

1.6.3	Operator Machine Interface	17
1.6.4	Automation and Minimizing Human Intervention	18
2	DESIGN	18
2.1	System Identification	18
2.1.1	Chemical Filling System.	19
2.1.2	Chemical Weighing and Feeding System	19
2.1.3	Chemical Mixing System	19
2.2	Electrical and Control System	24
2.2.1	Selection of Controller	24
2.2.2	Selection of Pumps	27
2.2.3	Selection of Drive Motors	28
2.2.4	Selection of Other Components	31
2.2.5	Selection of Load Cell	36
2.2.6	Interfacing of Load Cell	38
2.3	Mechanical System Design	41
2.3.1	Pumps Drive Shaft Designing	41
2.3.2	Design of Keys	51
2.3.3	Selection of coupling for shafts	52
3	DEVELOPMENT OF THE MACHINE	53
3.1	Mechanical Drawings	53
3.2	Electrical Drawings	55
3.3	Fabrication Work	59
3.4	Programming	62

	3.4.1 State Based Ladder Logic Programing	64
4	RESULTS	76
5	CONCLUTION	78
6	REFERENCES	79

LIST OF FIGURES

Fig 1.1	Automated Paint Mixing Machine	2
Fig 1.2	Automated Cocktail Mixer and Dispenser	4
Fig 1.3	Automatic Paint Mixing Machine in Lab View Environment	5
Fig 1.4	Block diagram of the weight based liquid filling System	8
Fig 1.5	Flow chart of the weight based liquid filling process	9
Fig 1.6	Control operation block diagram	10
Fig 1.7	Pump and servo motor arrangement used in trial	14
Fig 1.8	Non drip valve	14
Fig 1.9	Chemical weighing arrangement used in the trial	15
Fig 1.10	Solenoid valves used in test	16
Fig 1.11	Non drip pinch valve	16
Fig 1.12	Xinje XC3-60RT-E PLC and Xinje TH765-N HMI unit	17
Fig 2.1	Overall System	18
Fig 2.2	System flow chart	20
Fig 2.3	Control System Diagram	22
Fig 2.4	XINJE PLC, XC3-60RT-E	25
Fig 2.5	XINJE PLC Expansion Unit, XC 16X16YR-E	26
Fig 2.6	XINJE PLC Analog Expansion Unit, XC-E2AD2PT2DA	26
Fig 2.7	Fluid head at pump	28
Fig 2.8	Pulley arrangement of filling pump operation	33
Fig 2.9	Pulley arrangement of feeding pump operation	34
Fig 2.10	Tianji TJ-A1 Clutch	35
Fig 2.11	Intermediate Collecting tank and structure	36
Fig 2.12	LCB04 Load cell specifications	37
Fig 2.13	Strain gauge type beam load cell structure	38
Fig 2.14	Four strain gauges arranged in a Wheatstone bridge	38

Fig 2.15	Selected Load cell Amplifier	40
Fig 2.16	Load cell connection and output signals of the amplifier	40
Fig 2.17	Pump and Clutch Assembly	41
Fig 2.18	Pumps and drive shaft arrangement	42
Fig 2.19	Motor and drive shaft arrangement	42
Fig 2.20	Forces on Timing belt at drive shaft pump pulley	42
Fig 2.21	Portions of Drive shaft	43
Fig 2.22	Shear Force and Bending Moment Diagrams Of Shaft “A”	44
Fig 2.23	Shear Force and Bending Moment Diagrams of Shaft “B”	45
Fig 2.24	Shear Force and Bending Moment Diagrams of Shaft “C”	46
Fig 2.25	Shear Force and Bending Moment Diagrams of Shaft “D”	47
Fig 2.26	Torque Speed Characteristics of 0.75kW and 400W servo motors	49
Fig 2.27	Forces on Shaft Key	51
Fig 3.1	3D View of Overall Machine	53
Fig 3.2	Close-up View of Mixing Head, Collecting Tank, and Pumps	53
Fig 3.3	End Elevation of the Machine	54
Fig 3.4	Plan of the Machine	54
Fig 3.5	Front Elevation of the Machine	55
Fig 3.6	Circuit Diagram of Mixing Head	55
Fig 3.7	Circuit Diagram of Impeller and Drive Shaft	56
Fig 3.8	Circuit Diagram of Chemical Feeding Unit	56
Fig 3.9	Circuit Diagram of Filling Pumps	57
Fig 3.10	Circuit Diagram of Filling Pump Clutches	57
Fig 3.11	Circuit Diagram of Filling Pump Solenoid Valves	58
Fig 3.12	Circuit Diagram of Load Cell Amplifier	58
Fig 3.13	Close View of Collecting Tank, Pumps and Pipe Work	59
Fig 3.14	Pumps, Clutches and Drive Shaft-View from Front	59
Fig 3.15	Close View of Collecting Tanks, Feeding Pumps and Solenoid Valves	60

Fig 3.16	Control Panels	60
Fig 3.17	Control Panels-Outside View	61
Fig 3.18	View of Complete Machine	61
Fig 3.19	Programming Structure	62
Fig 3.20	PLC Inputs and Outputs	70
Fig 3.21	State Transition Diagram-From starting to fill pump 3 operation	71
Fig 3.22	State Transition Diagram-Final steps of machine operation	72
Fig 3.23	Part of the Output Table	73
Fig 3.24	Part of the PLC program	74
Fig 3.25	One of the Pages of Touch Panel Program	75
Fig 4.1	Weighing System (Left Side)	76

LIST OF TABLES

Table 1.1	Comparison of significant points of three researches	6
Table 1.2	Relevant significant points in Table-1 compared with the compounding process to be automated	7
Table 1.3	Advantages and disadvantages of liquid level measuring techniques	11
Table 2.1	Controller inputs	24
Table 2.2	Controller Outputs	24
Table 2.3	ROTOFLUID gear pump specification chart	27
Table 2.4	ASDA AC Servo motor specifications	30
Table 2.5	Selected Motors and Motor Drives	31
Table 2.6	Synchroflex Timing belt specifications	32
Table 2.7	Selected timing pulleys for filling pumps	32
Table 2.8	Selected timing pulleys for feeding pumps	33
Table 2.9	Tianji Electromagnetic clutch specifications	35
Table 2.10	Yield and Tensile Strength of Stainless Steel	49
Table 2.11	Values of Shock and Fatigue factors	49
Table 2.12	Jaw Coupling Specifications	52
Table 4.1	Test Results	77