

DEVELOPMENT OF VIRTUAL CONTROL PANEL FOR SINGLE SPINDLE
CONFIGURATION 2-AXIS FILAMENT WINDING MACHINE (SSFWM)

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“I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)”

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Date : 23 OCTOBER 2008



I declare that this thesis entitled “Development of virtual control panel for single spindle configuration 2-axis filament winding machine (SSFWM)” is the result of my own research except as cited in the references. The thesis is not been accepted for any degree is not concurrently submitted in candidature of any other degree.

Signature : _____

Author : VICNESWARAN S/O KUPPUSAMY

Date : 17 November 2008

To my beloved father, mother, brother and sisters.



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In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Mr. Addie Irawan Bin Hashim, for encouragement, guidance, critics and friendship, advices and motivation. Without his continued support and interest, this thesis would not have been the same as presented here.

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ABSTRACT

This project is focused on developing the virtual control panel for single spindle configuration 2-axis filament winding machine (SSFWM) using Visual Basic 6.0. The software will interface with MMDS-RTD module Alpha version developed under the RDU070330 research project in Faculty of Electrical & Electronics Engineering, UMP. The MMDS-RTD module Alpha version which is capable of drive DC motor and Stepper motor only. In the software system, algorithms are designed to perform calculation for mathematical equation of fiber density, fiber width and product to calculate the optimal machine configuration such as number of running, velocities rotation of mandrel, velocities of carriage moment and angle of rotation. With this software system, user only need to enter the value of fiber density, diameter of mandrel, winding angle then the system will show the output their need and automatically send command to MMDS-RTD module Alpha version and control the filament winding machine. Furthermore the main idea is to transfer a fiber mould parameter equation into visual basic programming code. And from the programming code control the actuators on filament winding machine to meet with the setting given by user. This control panel capability control the movement of filament winding machine according to input parameter insert by user. Finally; the process is run continuously until the mandrel surface was fully covered by the composites.

ABSTRAK

Projek ini tertumpu kepada pembangunan panel kawalan maya untuk mesin belitan filament 2-paksi dengan menggunakan Visual Basic 6.0. Perisian ini akan berinteraksi dengan modul MMDS-RTD versi Alpha yang di bangunkan di bawah projek penyelidikan RDU070330 oleh Fakulti Kejuruteraan Elektrik dan Elektronik, UMP. Modul MMDS-RTD versi Alpha ini berupaya untuk mengawal 2 jenis motor sahaja iaitu motor stepper dan motor DC. Dalam sistem perisian, algorithms di reka untuk kiraan persamaan matematik bagi density fiber, lebar fiber dan diameter produk untuk mendapatkan konfigurasi mesin yang optima seperti bilangan kitaran, halaju putaran mandrel, halaju carriage dan sudut belitan. Dengan sistem perisian ini pengguna hanya perlu masukkan nilai formula fiber density, luas fiber, diameter mandrel serta diameter produk dan ia akan secara automatik hantar ke modul MMDS-RTD versi Alpha serta mengawal mesin belitan filament. Dalam projek ini, idea utama ialah untuk menukarkan parameter fiber persamaan dalam bentuk kod program visual basic. Dan daripada kod program mengawal pergerakan motor pada mesin belitan filamen yang serasi dengan nilai yang di set oleh pengguna. Panel kawalan ini berupaya untuk mengawal operasi mesin belitan filament winding berdasarkan parameter yang di masukkan oleh pengguna. Akhirnya, process operasi mesin yang berterusan akan menyebabkan mandrel di penuh dengan belitan filament.

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LIST OF ABBREVIATIONS

DC	-	Direct Current
AC	-	Alternating Current
MMDS	-	Multiple Motor Drive System
RTD	-	Real Time Data Acquisitions
EMF	-	Electromagnetic Force
SSFWM	-	single spindle configuration 2-axis filament winding machine
GUI	-	Graphical User Interface
COM	-	Component Object Model

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CHAPTER 1

INTRODUCTION

1.1 Background

Filament winding consists of winding continuous ravings of fiber onto a rotating mandrel in predetermined patterns. This method of manufacturing provides the greatest control over fiber placement and uniformity of structure. In the wet winding method, the fiber picks up resin either by passing through a resin bath or from a metered application system. After several layers are wound, the component is cured and removed from the mandrel (or in some cases the mandrel becomes part of the component). Filament winding is traditionally used to produce pressure vessels, pipe, rocket motor casings, tanks, ducting, golf club shafts and other symmetric parts. Filament winding technology has been expanded to include non-cylindrical, non-spherical composite parts thanks in part to advancements in computer and software technology. [1]

This project is focus on developing the virtual control panel for 2-axis configuration filament winding machine using Visual Basic 6.0. The software will interface with MMDS module card developed under the RDU070330 research project in Faculty of Electrical & Electronics Engineering, UMP. The MMDS interface module capable of controlling DC.AC & Stepper motor simultaneously which 2-3 motors at the same time. This module consist of 3 stage that is full-bridges,8 channel of converters & 3 channel for Back-EMF input reading [2].

In the system, the design the software for calculating from equation ion of fiber density, fiber width and product to calculate the optimal machine configuration such as number of running, velocities rotation of mandrel, velocities of carriage moment and angle of rotation. With this system, user only need to enter the value of fiber density, diameter of mandrel, winding angle then the system will show the output their need and automatically send command to MMDS module card and control the filament winding machine.

1.2 Objective

The objective of this project is to develop the Software Control Panel for single spindle configuration 2-axis filament winding machine (SSFWM) using Visual Basic 6.0 development program. In this project, the main idea is to transfer a fiber mould parameter equations into visual basic programming codes. And from the programming code control the actuators on filament winding machine to meet with the setting given by user.

1.3 Scopes

- i. Design the software control panel (virtual instrument) that capable of calculating and translates basic filament winding input for SSFWM motion.
- ii. Design the software control panel which is capable of interfacing with MMDS-RTD Alpha version to control carriage and holder movement of SSFWM.

1.4 Thesis Organization

This thesis is combination of 6 chapters that contains the Introduction, Literature Review, Hardware Design, Software Design, Result and Discussion, and the last chapter is a Conclusion and Further Development of the project.

Chapter 1 is an introduction of the project. In this chapter, we will explain the background and objectives of the project. The concept of the project and the overall overview of the project also will be discussed in this chapter.

Chapter 2 focuses on the literature review and the methodologies for the development of the Filament Winding Machine Process and Visual Basic 6.0 for software design.

Chapter 3 will be discussed about filament winding machine operation. This chapter is divided into two main sections that are basic wiring of controller and the basic filament winding machine design/process. In basic wiring of controller, we will discuss about the terminal block for SSFWM controller input/output. For basic filament winding machine design/process, we will discuss about the development of the SSFWM.

Chapter 4 describes the software development of the controller. In this chapter we will expose on how to design GUI and write program with Visual basic 6.0. In addition, we will discuss feature about serial communication use it for send data/command to the MMDS module cad.

Chapter 5 describes about the experimental results, expected performance and performance limits that can be achieve by the system.

Chapter 6 provides conclusions, recommendations for further work or future expectations for the system.

CHAPTER 2

LITERATURE REVIEW

2.1 Filament Winding Machine

Filament Winding is the process of winding resin-impregnated fiber or tape on a mandrel surface in a precise geometric pattern. This is accomplished by rotating the mandrel while a delivery head precisely positions fibers on the mandrel surface. By winding continuous strands of carbon fiber, fiberglass or other material in very precise patterns, structures can be built with properties stronger than steel at much lighter weights. [3]

Filament winding machines (FWM) operate on the principles of controlling machine motion through various axes of motion. The most basic motions are the spindle or mandrel rotational axis, the horizontal carriage motion axis and the cross or radial carriage motion axis. Additional axes may be added, typically a rotating eye axis or a yaw motion axis, and when the pattern calls for more precise fiber placement further additional axes may be added.

The filament winding process was originally invented to produce missile casings, nose cones and fuselage structures, but with the passage of time industries other than defense and aerospace have discovered the strength and versatility of filament winding. [3]

Entec Composite Machines is the world's oldest continually operating manufacturer of filament winding machinery, with over 40 years' experience in the field, and has built more multi-spindle filament winding machines than any other manufacturer. Entec changed the face of filament winding by producing the world's first computer-controlled filament winding machine, and has continued to lead the industry ever since. Entec engineers also created the world's most-used application software for winding pattern generation, FiberGrafiX. [3]

These contributions and countless others made over the years, along with our continued pursuit of technological innovations, have given Entec a reputation for producing the most durable and reliable winding machines on the market. [3]

Our staff consists of some of the industry's most experienced mechanical engineers, electrical engineers and software programmers. Using their skills, Entec has built the world's largest five-axis filament winding machine. The machine is used to produce large wind turbine blades with a part length of 150 ft. (45.72 m), a diameter of 27 ft. (8.23 m) and a weight in excess of 80,000 lbs. (36,287 kg). In contrast, Entec has also created some of the world's smallest machines for use in universities, research facilities and commercial companies to test sample parts before going into full-scale production. [3]

2.2 FWM Applications

The filament winding process was originally invented to produce missile casings, nose cones and fuselage structures, but with the passage of time industries other than defense and aerospace have discovered the strength and versatility of filament winding.

Entec Composite Machines is the world's oldest continually operating manufacturer of filament winding machinery, with over 40 years' experience in the field, and has built more multi-spindle filament winding machines than any other manufacturer. Entec changed the face of filament winding by producing the world's first computer-controlled filament winding machine, and has continued to lead the industry ever since. Entec engineers also created the world's most-used application software for winding pattern generation, FiberGrafIX. [4]

Filament Winding is the process of winding resin-impregnated fiber or tape on a mandrel surface in a precise geometric pattern. This is accomplished by rotating the mandrel while a delivery head precisely positions fibers on the mandrel surface. By winding continuous strands of carbon fiber, fiberglass or other material in very precise patterns, structures can be built with properties stronger than steel at much lighter weights. [4] A winding machine can be as simple as one axis of motion or as complicated as five or more axis of motion to create more precise patterns for higher performance parts. [4]

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2.3 Composite Component Design and Optimization

The designing of components made of fiber reinforced plastics requires a lot of experience and know how. Unlike other manufacturing methods such as metal processing the actual material will only appear in the production stage of the intended product. In order to exploit the full potential of the material a suitable design is the deciding factor.

The following parameters have to be adjusted to each other: component geometry, fibre and matrix material, laminate structure and wind ability. Naturally profitability of the production always has to be taken into account.

Since fiber and matrix material determine the characteristics and the price of the component, the proper choice of material is crucial. Also with production already in progress, the quality of the product can be improved and cost reduced considerably just by replacing the material. However, the selection of the most suitable material from the wide variety available world wide often poses a problem. MATERIAL uses its own up to date material database so that your new components can be designed in the best possible way or your existing product improved. [5]

Based on the performance specifications, the next step is to calculate the laminate structure (number and winding angles of the different layers). To this purpose MATERIAL uses analytical laminate calculation programs and finite element analysis software (FEA software). Once the optimal laminate structure has been found, its wind ability and cost effectiveness has to be checked. In order to do so MATERIAL links the process simulation system CADWIND to a FEA program. This guarantees a cost effective and quality product. [5]

Depending on your needs, MATERIAL not only offers you the individual stages of product development - such as selection of material, laminate calculation, FEA calculation, and wind ability check - but a total development or optimization package.

When designing a new component we guarantee that you will be able to manufacture a product of the highest technical standard at the lowest possible cost. Optimizing your components will improve their quality and reduce your production costs. [5]

The rotary assembly consists of two structural blocks; one fixed and the other linearly movable unit in which a 2-axis mechanically driven mandrel is mounted onto its holders. On the fixed end, the holder is connected to a rotating shaft, which is coupled to either a gear or a chain or belt reduction system, or directly to the motor unit. Generally, an AC or servo-motor is used because of its greater torque capabilities and accuracy when operating under conditions of heavy loading. For delivery system, rolls of continuous fibers are fed into a resin bath which is mounted onto the carriage rails that are commonly placed overhead to provide greater workroom. Generally, the shape is a surface of revolution and may or may not include end closures. When the required number of layers is applied, the wound form is cured and the mandrel removed. The material properties in each layer are constant but may vary from layer to layer. The mandrel is represented by a hollow cylinder with uniform effective wall thickness. The mandrel and the cylinder are of equal length and are ax symmetrical, so that neither the geometry nor the properties vary in the circumferential direction. Filament winding is defined as [10] a technique which “produces high-strength and lightweight products; consists basically of two ingredients; namely, a filament or tape type reinforcement and a matrix or resin”. The concept of filament winding process had been introduced in early 1940s and the first attempt was made to develop filament-winding equipment. The equipment that was designed in 1950s was very basic; performing the simplest tasks using only two axes of motion (spindle rotation and horizontal carriage). By mid-1970s, machine design once again made a dramatic shift.

This time the advancement of servo technology entered the realm of the machine design. High-speed computers allowed for rapid data processing, resulting in smoother motion and greater fiber placement accuracy. The 1980s and 1990s saw the increased use of computer technology. Computers and motion control cards became the essential pieces of hardware that were included in almost every machine. Machine speed control was greatly improved; computer control systems could track position and velocity with increased accuracy. Additional axes of motions were also incorporated into machine design; allowing for four, five and even six axes of controlled motion.

2.3.1 Fiber Winding Techniques and Patterns

The properties of a composite product are not only dependent on the properties of fiber and resin matrix, but are also dependent on the way by which they are processed. There are a variety of processing techniques for fabricating composite parts/structure; resin transfer moulding, autoclave moulding, pultrusion and filament winding. Out of these processes, filament winding involves low cost and is the fastest technique for manufacturing of fiber reinforced cylindrical components as high-pressure pipes and tanks.

In filament winding process, the winding tension can easily be controlled. Winding tension, winding angle and/or resin content in each layer of reinforcement can be varied until the desired thickness and strength of the composite are achieved. The properties of the finished composite can be varied by the type of winding pattern selected. In general, there are three basic filament winding patterns which are as follows.

It is known as the girth or circumferential winding. In hoop winding, a high-angle helical winding approaches an angle of 90° . Each full rotation of the mandrel advances the band delivery by one full bandwidth as shown in Figure 2.1

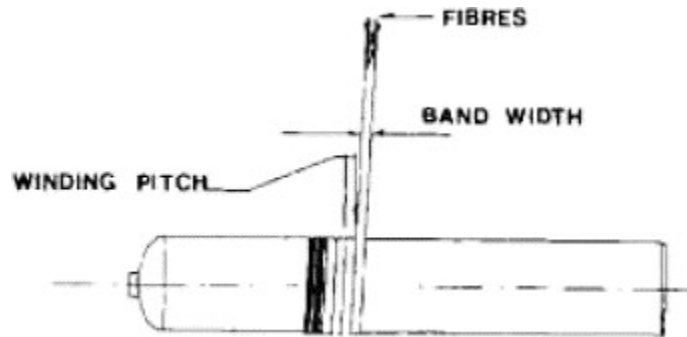


Figure 2.1: Circumferential or hoop winding

In helical winding, the mandrel rotates at a constant speed while the fiber feed carriage transverses back and forth at a speed regulated to generate the desired helical angles as shown in Figure 2.2.

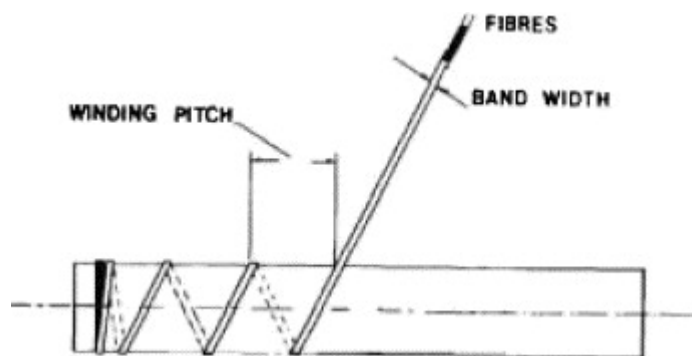


Figure 2.2: Helical winding

In polar winding, the fiber passes tangentially to the polar opening at one end of the chamber, reverses direction, and passes tangentially to the opposite side of the polar opening at the other end. In other words, fibers are wrapped from pole to pole, as the mandrel arm rotates about the longitudinal axis as shown in Figure 2.34. It is used to wind almost axial fibers on domed end type of pressure vessels. On vessels with parallel sides, a subsequent circumferential winding would be done.

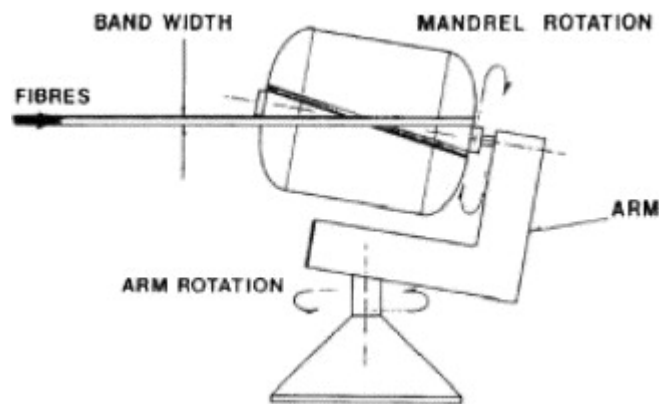


Figure 2.3: Polar winding

2.3.2 FWM Units

The rotary assembly consists of two pillar blocks which were held onto horizontal frame work and motor with a gearbox. One of the two blocks is fixed and serves as a reference, while the other one is movable and can be adjusted linearly for varying the mandrel length. Once the mandrel is seated properly into two freely rotating cup holders, the movable pillar block is then locked. At the fixed pillar end, the holder is coupled to the motor gearbox by a system of pulleys and belt. The gear ratio between the motor and the gearbox is selected as 1:60 and the reduction ratio between the pulleys was taken as 1:2, so that the velocity of the mandrel is fixed to 13.6 rpm.

The delivery unit consists of filament fibers holder, carriage and lead screw with a guide shaft. The lead screw is driven by a reversible variable speed motor. The filament fiber holder is just a table with two shafts, one used for carrying one or more of the filament fiber rolls while the other one is used as a guide for the filament fiber during the fabrication process. The carriage consists of a container and a system of polished guide pins. The container was used for carrying the resin mixture while the pins were used as a way to guide the fiber to the resin bath and to smear off excess resin from the wetted fibers after the resin bath. Also, the pins were used to generate tension in the wetted fibers before reaching the mandrel. A simple mechanism was used to bring back the smeared resin from the wetted fiber to the container and reused again in order to reduce the amount of resin used for preparing the product. An optimum tension of 10 N has been used through this work. This gave a fairly consistent volume fraction of fibers. It was found that it is important to generate tension in the later stage of the resin path when the fibers are well wetted to avoid fiber damage. Greater tension on wetted fiber produced excessive fiber damage and low tensions produced specimens with unacceptably small fiber fractions [11].

The control unit consists of relays, limit switches, timer and counter. The function of the control unit is to control the winding process in order to get the proper winding sequence, which is difficult to reach manually, and to safeguard the motor during operation. The control unit also controls the amount of end over wind which is required to prevent slippage of the roving when the traverse is reversed and the mandrel indexing to ensure that each roving slightly overlaps the previous one to produce a uniform lay-up of fibers.

2.4 Visual Basic (VB)

Visual Basic (VB) is a third-generation event driven programming language and associated development environment from Microsoft for its COM programming model.[5] Visual Basic was derived from BASIC and enables the rapid application development (RAD) of graphical user interface (GUI) applications, access to databases using DAO, RDO, or ADO, and creation of ActiveX controls and objects. Scripting languages such as VBA and VBScript are syntactically similar to Visual Basic, but perform differently [6].

Although programs can be compiled into native code executables from version 5 onwards, they still require the presence of runtime libraries of approximately 2 MB in size. This runtime is included by default in Windows 2000 and later, but for earlier versions of Windows it must be distributed together with the executable [8]. Forms are created using drag and drop techniques. A tool is used to place controls (e.g., text boxes, buttons, etc.) on the form (window). Controls have attributes and event handlers associated with them. Default values are provided when the control is created, but may be changed by the programmer. Many attribute values can be modified during run time based on user actions or changes in the environment, providing a dynamic application. For example, code can be inserted into the form resize event handler to reposition a control so that it remains centered on the form, expands to fill up the form, etc. By inserting code into the event handler for a key press in a text box, the program can automatically translate the case of the text being entered, or even prevent certain characters from being inserted [8].

Visual Basic can create executables (EXE files), ActiveX controls, DLL files, but is primarily used to develop Windows applications and to interface web database systems. Dialog boxes with less functionality (e.g., no maximize/minimize control) can be used to provide pop-up capabilities. Controls provide the basic functionality of the application, while programmers can insert additional logic within the appropriate event handlers. For example, a drop-down combination box will automatically display its list and allow the user to select any element. An event handler is called when an item is selected, which can then execute additional code created by the programmer to perform some action based on which element was selected, such as populating a related list.

Alternatively, a Visual Basic component can have no user interface, and instead provide ActiveX objects to other programs via Component Object Model (COM). This allows for server-side processing or an add-in module [8]. The language is garbage collected using reference counting, has a large library of utility objects, and has basic object oriented support. Since the more common components are included in the default project template, the programmer seldom needs to specify additional libraries. Unlike many other programming languages, Visual Basic is generally not case sensitive, although it will transform keywords into a standard case configuration and force the case of variable names to conform to the case of the entry within the symbol table entry. String comparisons are case sensitive by default, but can be made case insensitive if so desired. [8]

CHAPTER 3

FILAMENT WINDING MACHINE OPERATION

3.1 Basic Wiring on Controller and Machine

The basic wiring for the SSFWM did by me. The Filament winding machine consists of 3 type of motor. There are 1 stepper motor which can run with 24 VDC, 1 DC Motor which can operate with 24VDC and 1 AC motor 240V. The stepper motor is used to control the movement carriage of the filament winding machine. The DC Motor use for holder and the servo motor use it for movement of mandrel. For the wiring I centralize all the motor point to 1 main terminal block. The terminal block divide to two main box that is one for stepper motor point and one more for DC Motor use it holder and AC motor point use it for mandrel movement

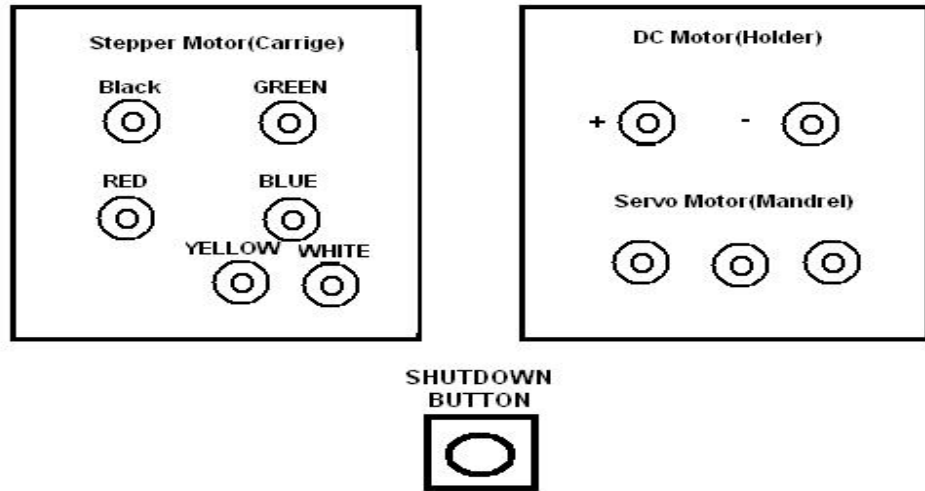


Figure 3.1: Terminal Point for Motors

3.2 SSFWM Design and Operation

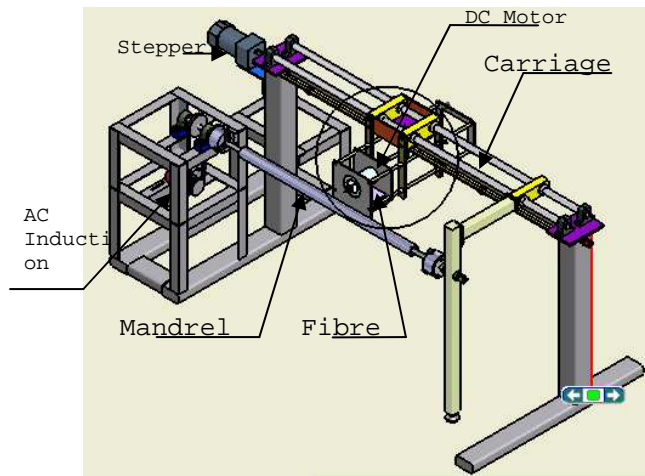


Figure 3.2: SSFWM Features

In general, the composite pipes are fabricated using glass fiber and polyester resin matrix by hand lay-up and also by SSFWM. For MMDS-RTD application SSFWM is designed and developed for the pipes and round shape specimens moulding. A lathe-type machine and a wet winding method are used in the machine structure design. This design provides a capability for producing pipe specimens with an internal diameter up to 100 mm and lengths up to 1000 mm.

The range of the winding angle, or the fiber orientation angle, starts from 20° to 90° depending on the mandrel diameter used. Mandrel speed is kept constant as 13.6 revolutions per minute (rpm) while the speed of screw of delivery unit varies from 0 rpm to a maximum of 250 rpm. Basically in wet filament winding process, a single glass roving is drawn through a bath of pre-catalyzed resin which is mounted on the lead screw by the rotating mandrel.

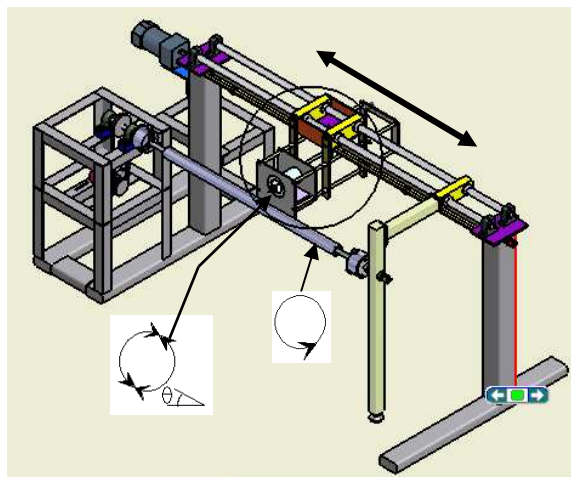


Figure 3.3: The movement of SSFWM

In SSFWM operation, the holder will be driven first. For this design DC motor to control the holder angle which is to patent fiber strip on mandrel. For example 45 degree movement, the DC motor will rotate 45 degree at first and 90 degree for the next step clock wise and counter clock wise respectively. After second step of fiber holder the carriage will start move from initial point of track. Thus mandrel started roll after carriage

start to drive. These three important steps are important for SSFWM type in order to make sure the fibre is wounded properly on the configured mandrel.

There are two different winding methods: (I) wet winding, in which the fibres are passed through a resin bath and wound onto a rotating mandrel (II) pre preg winding, in which the pre-impregnated fibre tows are placed on the rotating mandrel. Wet winding is more common and widely used for manufacturing fibre reinforced thermosetting matrix composite cylinders. Compared with pre preg winding, wet winding has several advantages such low material cost; short winding time; and the resin equation which can be easily varied to meet specific requirements (Figure 3.4).

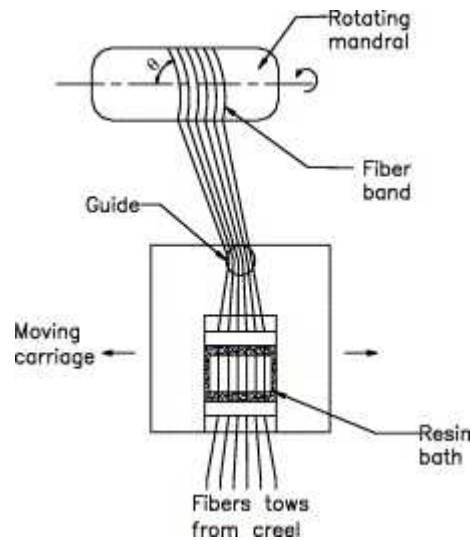


Figure 3.4: Schematic of the wet filament winding process

3.3 MMDS-RTD Configuration for SSFWM

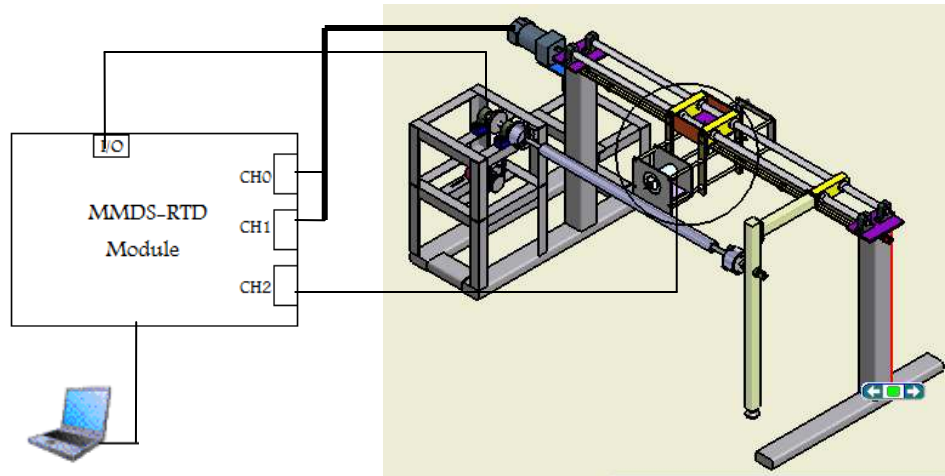


Figure 3.5: MMDS-RTD connection on SSFWM

MMDS-RTD version 1.0 is designed to support only on DC motor drive and Stepper motor drive. Therefore with the feature as discussed in Chapter 4, MMDS-RTD version 1.0 has extended I/O available. Therefore this I/O is used to ON/OFF the AC induction motor for mandrel drive. Speed of mandrel is manually set by attached AC induction speed controller.

In this configuration, MMDS-RTD module is applied with SM. SM allows SSFWM being control with proper manner as discussed in section 5.1.1. The software control panel that has been set needs to follow the protocol as shown in Figure 3.6.

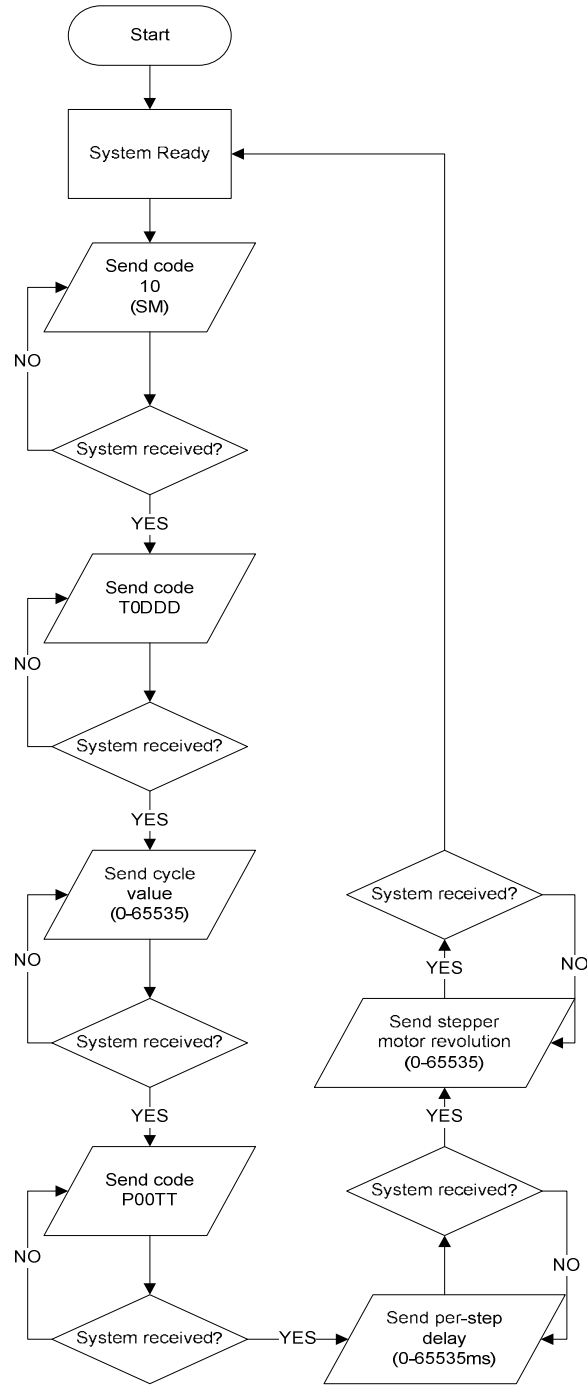


Figure 3.6: MMDS-RTD command for SSFWM application

CHAPTER 4

SOFTWARE CONTROL PANEL DESIGN

4.1 Overview on SSFWM Software Control Panel Design

On designing software control panel for single spindle configuration 2-axis filament winding machine (SSFWM) divided into two parts which are fiber mould parameters calculation program (user input) and mould parameter conversion program (machine operation command). For the first part several equations of fiber mould were programmed to calculate the optimal configurations for filament winding process. The overall system for SSFWM software control panel system design is shown as Figure 4.1.

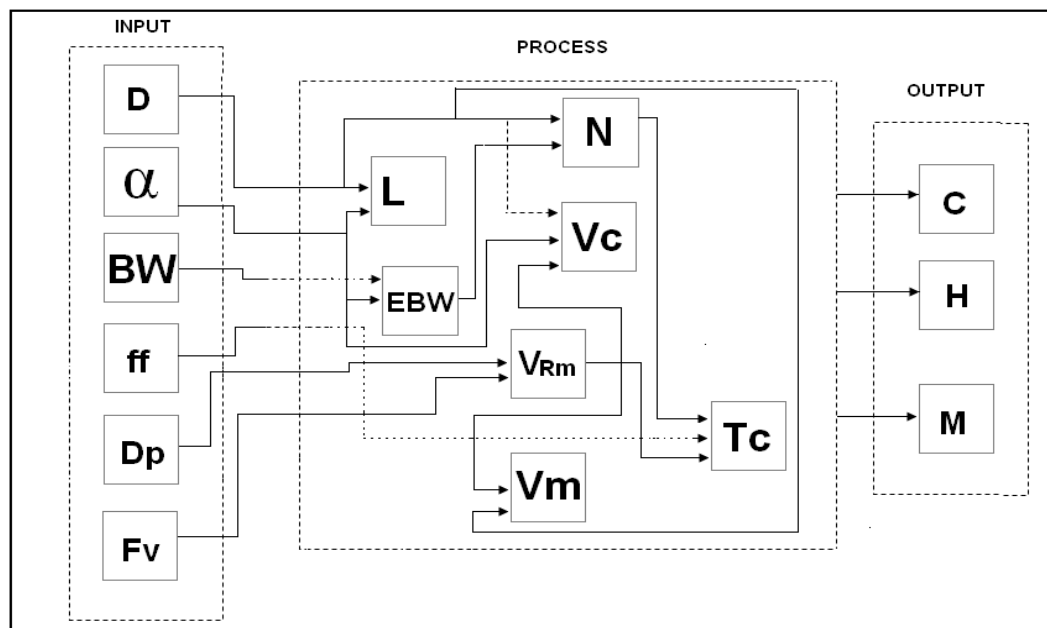


Figure 4.1: System structure for software control panel for SSFWM

4.2 Input Parameters for User Interfaces

For the winding helical, several rotations are needed to close the surface of the mandrel for one fiber mould. In order to complete a full winding for a rotation of mandrel (line of winding from start to end), length (L) need to be calculated using equation 1.

$$\text{Length of circumference (L)} = \frac{\pi D}{\tan \alpha} \quad (1)$$

References:

L = α = Winding Angle (°)

D =Diameter Mandrel (m)

At least two places where the angle of the winding is 90 degree that is at the end of both winding when the winding is returned. Equation 2 is used to calculate the effective bandwidth (EBW) of the closed surface of mandrel for bandwidth (BW):

$$\text{Effective bandwidth (EBW)} = \frac{BW}{\cos \alpha} \quad (2)$$

References:

BW=Bandwidth (m)

α = Winding Angle (°)

In order to get a complete resin fiber, several circumferences at surface of mandrel are needed. An effective bandwidth closed one segment of mandrel is assumed. Then, eight EBW are needed to close complete surface of mandrel. From the situation, the equation to calculate number of rotation to produce one resin fiber can be derived as equation 3.

$$\text{Number of running } (N) = \frac{\pi D}{EBW} \quad (3)$$

References:

EBW=Effective Bandwidth

D =Diameter Mandrel (m)

 Π = pie

Several value of diameter mandrel, angle of winding and bandwidth (BW) will produced the number of running/rotation (integer value). On the other hand, in circumference process, velocity of fiber depends on pull of rotation mandrel. The speed of pulling motion fiber from mandrel is directly proportional to speed of rotation mandrel. But the limitation of fiber's wounding speed for wet technique is from 0.6096m/s-0.9144m/s. Therefore the range for the technique pre-preg is from 1.524 m/s-1.8288m/s.

$$\text{Velocity mandrel rotation (rpm) } VRm = (Fv / \Pi Dp) 60 \quad (4)$$

References:Fv=Velocity of fibre in angle of rotation of
Mandrel (m/s)

Dp=Diameter product (m)

 Π = pie

At the first stage, velocity of mandrel (Vm) needs a suitable speed of carriage (Vc) in order to get proper velocity rotation without exit the limit of speed of fiber. In order to stabilize the setting different angle is needed depends on minimum to maximum angle (nearly to 90 degree).

$$\text{Velocity of carriage moment } (Vc) = (\pi VRmD) / (60 \tan \alpha) \quad (5)$$

References:

VRm=Velocity rotation of mandrel (rpm)

D = Diameter Mandrel (m)

 α = winding angle(°)

The velocity of tangent to mandrel is calculated based on velocity rotation of mandrel and diameter mandrel as shown in equation 6. In addition to calculate the total time to fabricate of the fiber equation 7 is used.

$$\text{Velocity of tangen Mandrel } (Vm) = [2\pi VRm] \frac{D}{2} \quad (6)$$

References:

VRm=Velocity rotation of mandrel (rpm)

D = Diameter Mandrel (m)

Π = pie

$$Tc = (N / VRm) ff \quad (7)$$

References:

Tc =Time to fabricate

Fibre fraction (ff)

VRm=Velocity rotation of mandrel (rpm)

4.3 Output Parameters for Machine Operations

As shown in Figure 4.3, the software control panel that has been designed playing a main role on converting all the input parameters from user which has been discussed in section 4.1. Therefore the result of conversion is used to program the MMDS-RTD alpha version by following the protocol discussed in section 3.3 of Chapter 3. Equation 9 shows the calculation of determine the output parameter value (rotation) for DC Motor which used as a drive for Fiber holder.

$$\text{Rotation DC Motor} = \alpha (N_{\text{cycle}}/360^\circ) \quad (9)$$

References:

N_{cycle} =Number of Cycle
 α = winding angle ($^\circ$)

Furthermore, for carriage movement the speed information is needed by MMDS-RTD to run the Two-phase stepper motor which is attached with ration of 5:1 to the carriage of SSFWM. The equation that needed to be programmed in software control panel for SSFWM is shown as equation 10.

$$\text{Speed of carriage rail } (V_c) = (\pi VRmD) / (60 \tan \alpha) \quad (10)$$

On the other hand for mandrel movement which is driven by single phase AC induction motor, the speed is determine by following the protocol that has been set in manual for the controller attached (see Appendix A).

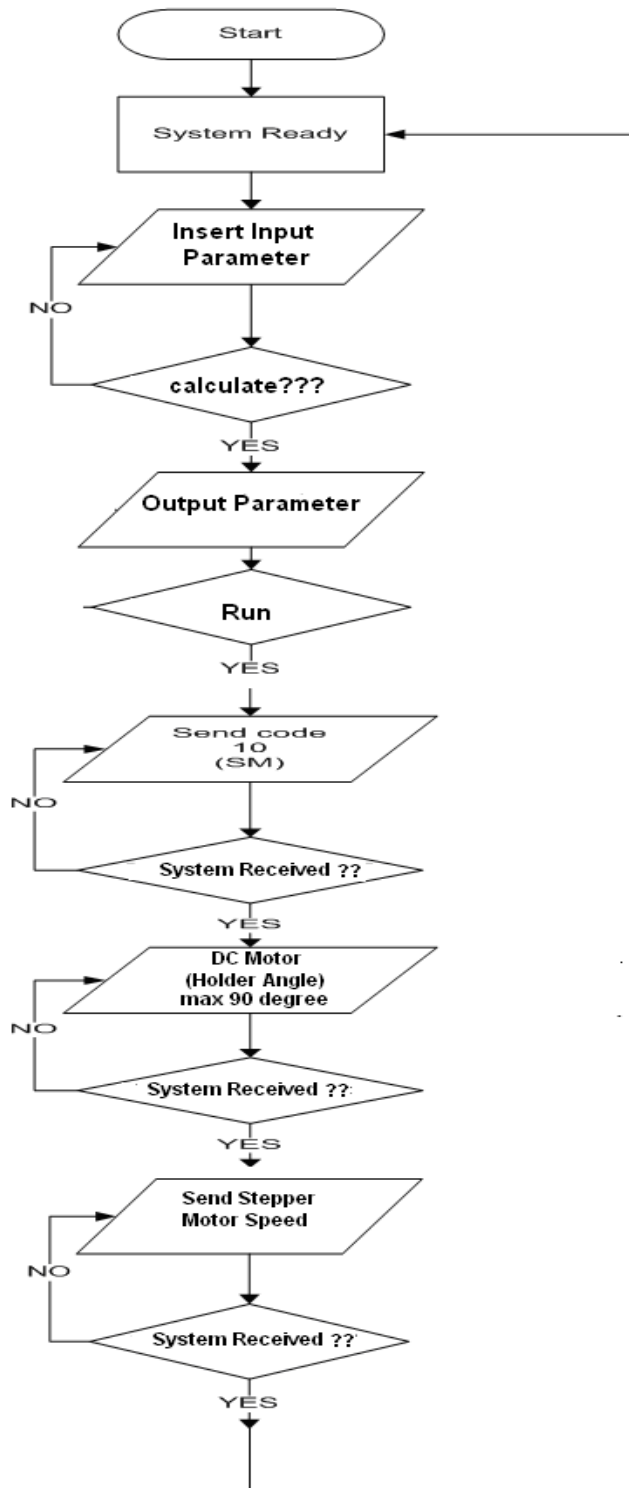


Figure 4.2: Software Control Panel of SSFWM user procedures

4.4 Graphical User Interface (GUI)

The main reason the GUI is used is to provide which are inputs from fibre winding parameters to give actuators setting (MMDS-RTD Alpha version). The control panel of the GUI should look like below.

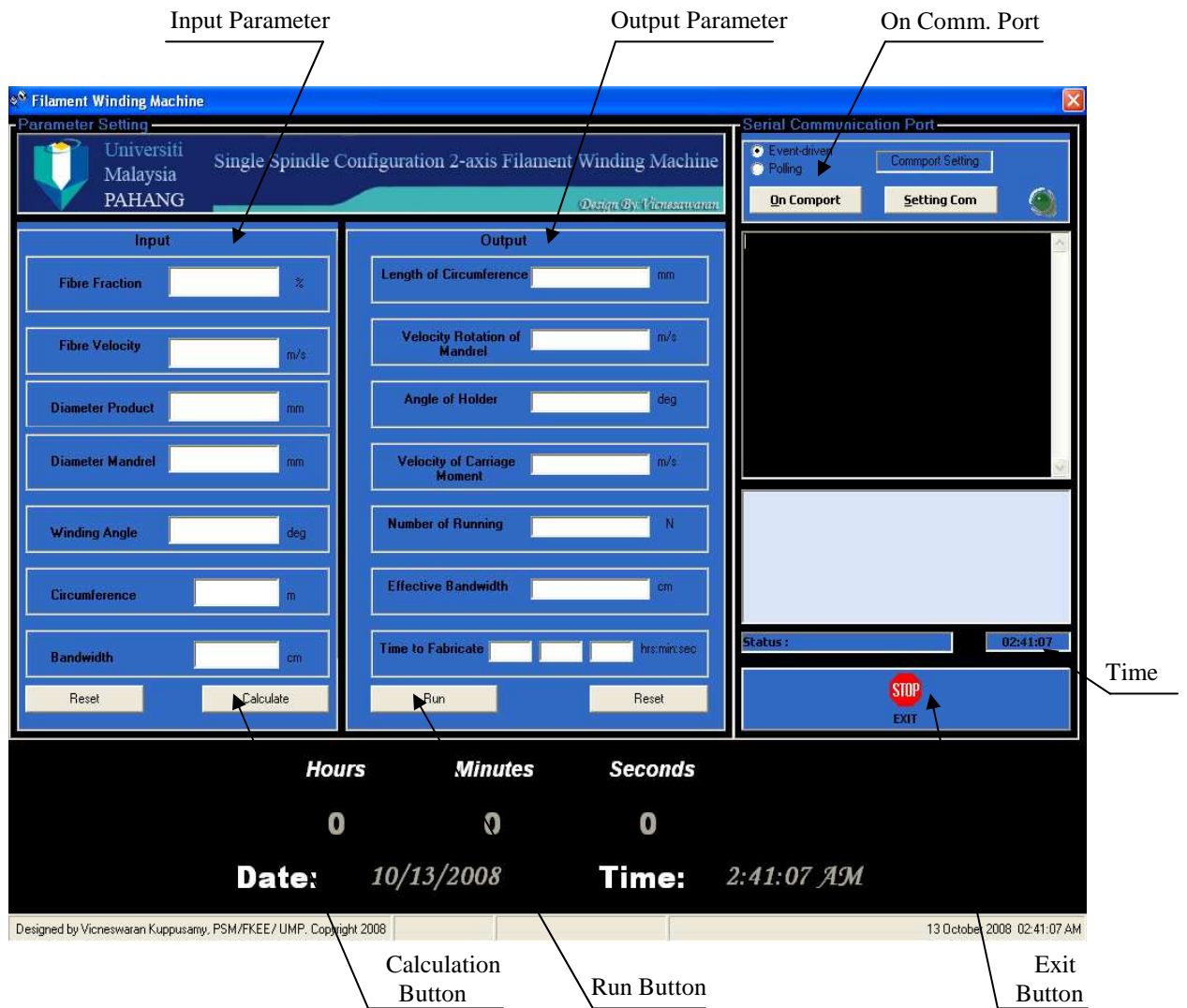


Figure 4.3: GUI form of Software Control Panel for SSFWM

The main point of design of this setting is for easy to troubleshoot if any corrupted occurred on virtual control panel of SSFWM. This default system can be used by inserting the type user need then set DC Motor clock wise or counter clock wise with cycle and duty. After that insert the stepper motor setting for the movement of carriage. The step for configuration of system default shown in figure 4.5.

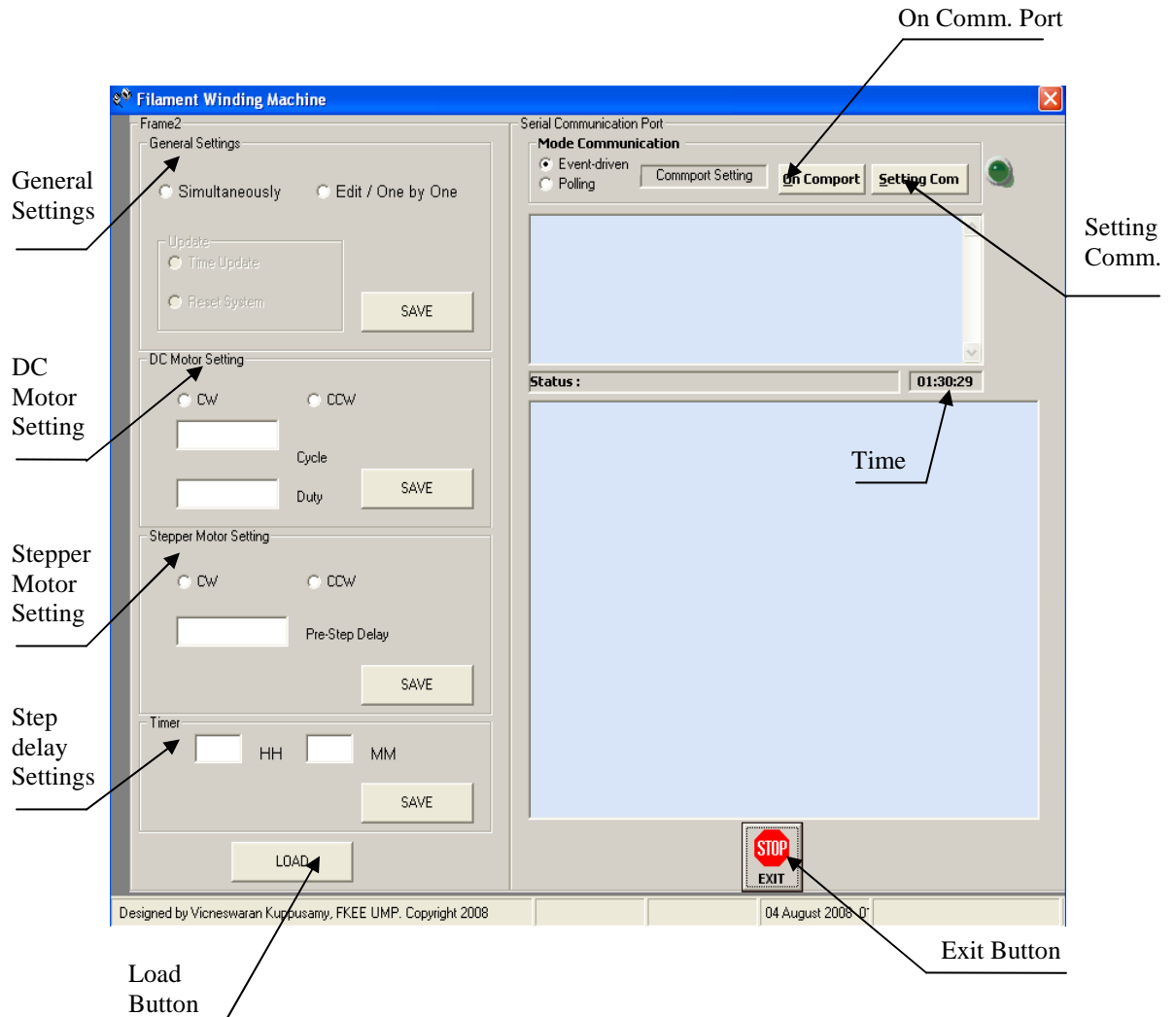


Figure 4.4: SSFWM default setting form

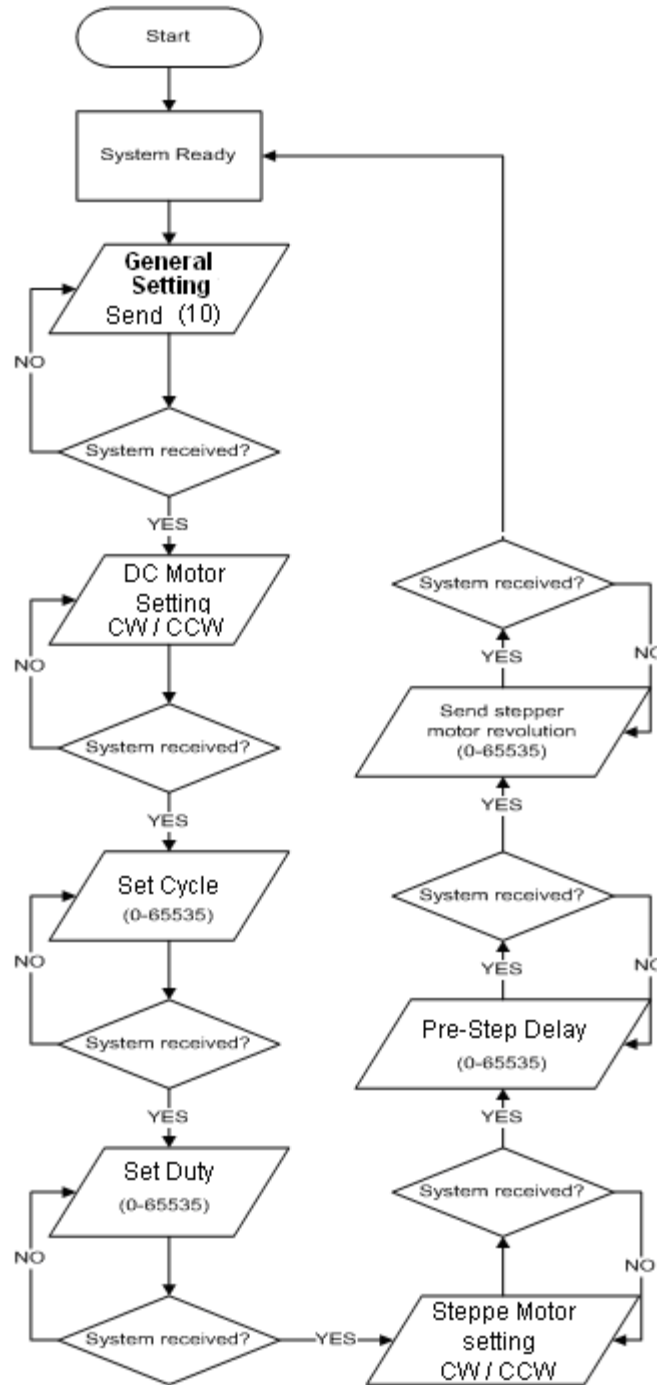


Figure 4.5: SSFWM default setting procedures

CHAPTER 5

RESULT AND DISCUSSION

5.1 Introduction

This chapter will review about testing results of the project, system performance, system limits and discussion about the results of the system. The results are made through the research.

5.2 Testing results

Testing result for the system can divide into 2 section or parts. The sections are:

- i. Operation on Virtual Control Panel single spindle configuration 2-axis filament winding machine (SSFWM)
- ii. Operation of single spindle configuration 2-axis filament winding machine (SSFWM).

5.2.1 Operation on Virtual Control Panel single spindle configuration 2-axis filament winding machine (SSFWM)

The result for this section is showed by the fiber mould parameter which insert by user will convert into output parameter. The fiber mould parameter insert by user based on user parameter settings .The output that showed on the VB 6.0 form is which is the input that need transmit to MMDS-RTD Alpha version module card.

Input		Output	
Fibre Fraction	60 %	Length of Circumference	66 mm
Fibre Velocity	0.9144 m/s	Velocity Rotation of Mandrel	2 m/s
Diameter Product	14 mm	Angle of Holder	45 deg
Diameter Mandrel	34 mm	Velocity of Carriage Moment	20 m/s
Winding Angle	45 deg	Number of Running	54 N
Bandwidth	2 cm	Effective Bandwidth	4 cm
Circumference	107 mm	Time to Fabricate	3 hrs, 36 min, 0 sec
Reset	Calculate	Run	Reset

Figure 5.1 showed the result on the Control Panel for SSFWM.

Table 5.1 User Parameter Settings Parameter

Parameter	Desired Value
Fiber Fraction	3% - 10%
Fiber Velocity	0.6096 m/s- 0.9144 m/s
Diameter Product	10 m – 20 m
Diameter Mandrel	34 m(depends on Machine)
Winding Angle	45 °(Degree)
Bandwidth	2 cm – 5 cm

5.2.2 Discussion on the Performances of SSFWM.

This section showed about the operation of single spindle configuration 2-axis filament winding machine (SSFWM) which the output parameter use to control 2 motors which are DC motor used for angle holder, Stepper Motor used carriage rail. At this section also will showed about the process is run continuously until the mandrel surface was fully covered by the dry fiber. Figure 5.2 showed the moving of DC Motor to 45 degree clock wise which is control of angle of holder.

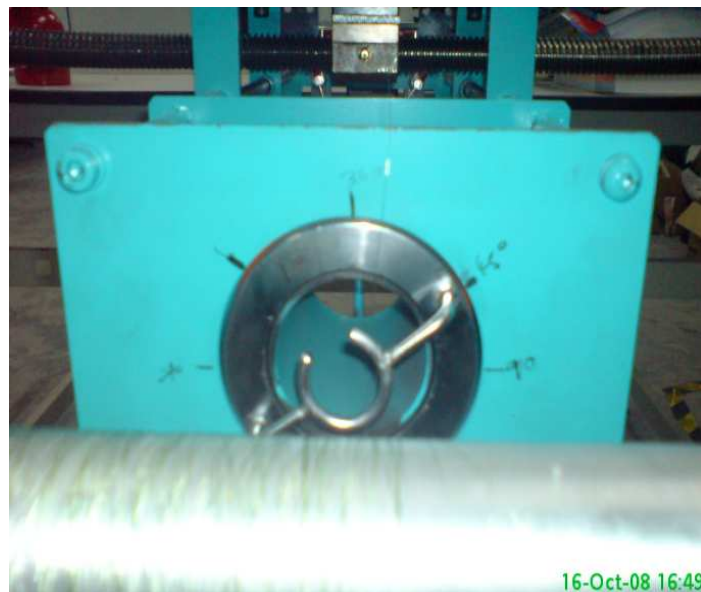


Figure 5.2 Angle Of holder (45 Degree Clock Wise)

Figure 5.3 and figure 5.4 showed that the moving of carriage rail based on output parameter which is velocity carriage.



Figure 5.3 Moving of Carriage Rail from left to right



Figure 5.4 Moving of Carriage Rail from right to left right

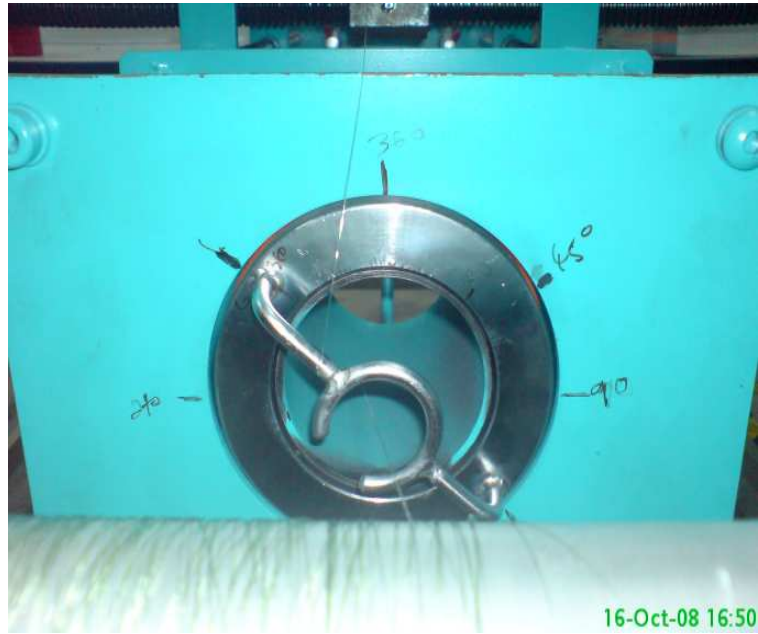


Figure 5.5 Angle Of holder (90 Degree Counter Clock Wise)



Figure 5.6 the dry fiber covered the mandrel



Figure 5.7 the fiber half covered the mandrel

Based on the research that has been done, there are a few discussions that can be sum up. Below is the list of related discussion:

- i. The output parameter that been calculate by the control panel can control the actuators of single spindle configuration 2-axis filament winding machine (SSFWM) more accurately based on input parameter which insert by the user based on the user parameter settings.
- ii. The serial communication in Visual Basic 6.0 is the most sensitive component that required data buffering programming code when transmit data to MDS-RTD Alpha version to stable in the transmitting.
- iii. The motor for carriage rail should me changed from stepper motor to DC motor because the movement of carriage rail is too slow.

CHAPTER 6

CONCLUSION & RECOMMENDATION

6.1 Conclusion

This project is an alternative way for to control the single spindle configuration 2-axis filament winding machine (SSFWM) using simple virtual control panel. This control panel capability control the movement of filament winding machine according to input parameter insert by user. This system will make the user easily interface the control panel with the machine.However, the system still need to upgrade little bit to more stable to control the machine.

6.2 Recommendation

There are few recommendations to improve this project:

- i. The system can be modified to control 4-axis or 6 axis configuration filament winding machine.
- ii. The limit switch can add on machine when the fabrication over or done it will send signal to control panel and stop the operation automatically.

6.3 Costing & Commercialization

The overall cost of the whole project is zero because it just a software development. As discussed in previous chapter, the software development consists of two parts. Therefore the whole project cost is based on energy and time is used to develop the design.

In addition, the system offers various forms of I/O parameter settings and provides the IDE environments which normally are not provided by the current market. Furthermore, the system can be redesigned to suit and meet the requirement of the user. Needless to say, the product has highly potential to be commercialized.

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APPENDIX A

SINGLE SPINDLE CONFIGURATION 2-AXIS FILAMENT WINDING MACHINE (SSFWM)



APPENDIX B

MMDS-RTD MODULE ALPHA VERSION







