Sudan university of Science and Technology

College of Engineering

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Study of Centrifugal Sugar by Electrical Machines

دراسة نفض السكر الأبيض بواسطة الماكينات الكهربية

A project Submitted In partial Fulfillment for the Requirement of the Degree of B.Sc. (Honor) In Electrical Engineering

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الآيـــة

﴿ قَالَ الَّذِي عِندَهُ عِلْمٌ مِّنَ الْكِتَابِ أَنَا آتِيكَ بِهِ قَبْلَ أَن يَرْتَدَّ إِلَيْكَ طَرْفُكَ ۚ فَلَمَّا رَآهُ مُسْتَقِرًّا
عِندَهُ قَالَ هَٰذَا مِن فَضْلِ رَبِّي لِيَبْلُوَنِي أَأَشْكُرُ أَمْ أَكْفُرُ ۖ وَمَن شَكَرَ فَإِنَّمَا يَشْكُرُ لِنَفْسِهِ ۖ
وَمَن كَفَرَ فَإِنَّ رَبِّي غَنِيٌّ كَرِيمٌ (٤٠) قَالَ نَكِّرُوا لَهَا عَرْشَهَا نَنظُرْ أَتَهْتَدِي أَمْ تَكُونُ مِنَ الَّذِينَ
لَا يَهْتَدُونَ (٤١) فَلَمَّا جَاءَتْ قِيلَ أَهَٰكَذَا عَرْشُكِ ۖ قَالَتْ كَأَنَّهُ هُوَ ۚ وَأُوتِينَا الْعِلْمَ مِن قَبْلِهَا
وَكُنَّا مُسْلِمِينَ ﴾

صدق الله العظيم

الاية (٤٠و٤١ و٤٢) سورة النمل

DEDICATION

To our parents who always inspiring and devising us, nothing of this could be done without them, may Allah saves them always for us. To our dears, all family members who always be there when we need them .To our best friends and colleagues who are always with us step by step, supports us to go forward to everyone who is an integral part of our support group, We dedicate this work.

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Abstract

This study concern about separation of white sugar through centrifugal machines and that in kenana sugar factory where they use DC motor while in assalaya they use induction motor.

Three stages of the operation mechanism were studied , the first stages is feeding the mixture (sugar + molasses) ,it takes 40 seconds then spin level and it duration about 80 seconds which called production level and separate sugar from molasses and at last the plough discharge sugar for 60 seconds.

Programmed logic control was used to simulate one machine operation ,and at last comparison between two systems use in kenana sugar factory and assalaya was made.

مستخلص البحث

تبحث هذه الدراسة عن كيفية نفض السكر الأبيض عن طريق ماكينات الطرد المركزي وذلك بمصنع سكر كنانة الذي تعمل ماكيناته بمحرك تيار مستمر ومصنع سكر عسلاية حيث يستخدم محرك حثي في عمل ماكيناته.

درست ثلاث مراحل لعمل المنظومة حيث المرحلة الأولي هي مرحلة الإمداد بالخليط (سكر+مولاص) وذلك لمدة 40 ثانية تعرف بمرحلة التغذية تعقبها مرحلة الطرد(80 ثانية) وهي مرحلة الإنتاج (فصل السكر عن المولاص)، ثم بعدها تأتي مرحلة التفريغ(60 ثانيه).

تم استخدام المتحكمات المنطقية المبرمجة لمحاكاة سلوك ماكينة واحدة أثناء التشغيل وأجريت مقارنه بين النظام المستخدم في مصنع سكر كنانة والنظام الموجود في مصنع سكرعسلاية

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LIST OF SYMBOLS

Symbols	Meaning
C°	Celsius degree
F°	Fahrenheit degree
A	Ampere
NS	Spinning speed
NF	Feeding speed
NP	Ploughing speed
TF	Feeding time
TFT	Time of feeding timer
TS	Spinning time
TST	Time of spinning timer
TP	Ploughing time
TPT	Time of ploughing timer
TW	Washing time
TR	Repair time
TRT	Time of repair timer
TSS	Steam time
T(T003)	Time of begin washing timer
T(T004)	Time of begin steam timer

LIST OF ABBREVIATIONS

Abbreviation	Meaning
DC	Direct current
AC	Alternative current
PLC	programmable logic controller
EMC	Electromagnetic compatibility
CPU	Central processor unit
PSU	Power supply unit
LED	Light Emitting Diode
Rpm	Revolution per minute
PWM	Pulse width modulated
IGBT	Integrated gate bipolar transistor
KW	Kilo watt
LAD	Ladder diagram
FBD	Function block diagram
HMI	Human machines interface

CHAPTER ONE

INTRODUCTION

1.1 Background

Sugarcane processing is a production of sugar from sugarcane, there are by products of the processing including bagasse, molasses, and filter cake. Bagasse is the residual woody fiber of the cane, is used as fuel source for the boilers in the generation of process steam, Bagasse also is used as production of numerous papers and Paper board products and reconstituted panel board. Thus, bagasse is a renewable resource. Dried filter cake is used as an animal feed supplement, fertilizer, and source of sugarcane wax. The final byproduct is Molasses is used as edible syrup. And also used to produce ethanol, compressed yeast, citric acid, and rum. The primary goal of harvesting is to deliver to the processing mill good quality sugarcane stalks with a minimum of trash. During harvesting, the cane tops and leaves are removed because they contain little sucrose but are high in starch and reducing sugars, which reduces sugar yields [1].

1.2 Problem Statement

Study the duty cycle operation of the batch sugar centrifugal machine in sugar factories.

1.3 Objectives

The objective of this study is to know the effect of batch sugar centrifugal machines which work in production of sugar and comparison between AC centrifugal and DC.

1.4 Methodology

At the beginning of the research we started to collect data by paying field visit to kenana sugar factory and another assalaysa sugar factory, so as to see the operation of the centrifugal and the relevant equipment. In addition to data we abstracted from our observation, we also received detailed information about the operation process from the engineering teams in the factories.

Then a simulated design of operation system based on the data collected using PLC, after running the PLC simulation program the results vary with time that's put in the table.

1.5 Layout of the Project

This project consists of an abstract and five chapters. Chapter one is introduction which consists sugar industry description, problem, objectives, methodology and the last one is layout of the project. Chapter two is sugar production, batch centrifugal description ,Cycle Operation, chapter three is Batch centrifugal drives, Sequence of Centrifugal Machines, chapter four is Programmable logic controller, Centrifugal Process, Simulation, Result of simulation, Comparisons between DC Motor And Induction Motor In centrifugal system, chapter five is conclusion, recommendations.

CHAPTER TWO

BATCH CENTRIFUGAL

2.1Cane Sugar Production

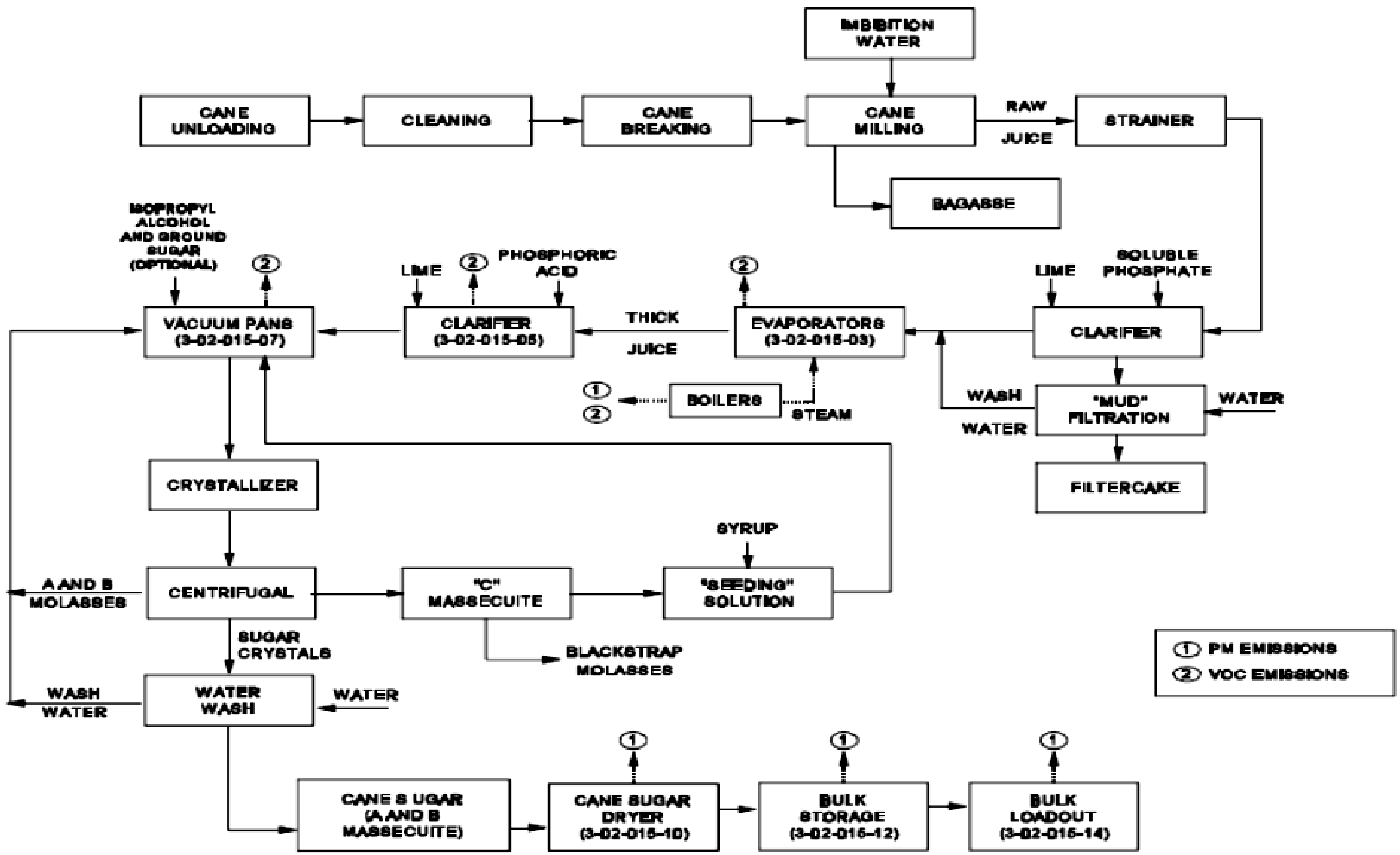
A simplified process flow diagram for a typical cane sugar production plant is shown in Figure 2-1. The cane is received at the mill and prepared for extraction of the juice. At the mill, the cane is mechanically unloaded and placed in a large pile. Prior to milling, the cane is cleaned, usually with high pressure water, the milling process occurs in two steps: first is breaking the hard structure of the cane and second is grinding the cane. Breaking the cane uses revolving knives, shredders, crushers, or a combination of these processes. For the grinding, or milling, of the crushed cane, a three-roller mill is most commonly used although some mills consist of four, five, or six rollers in a single mill. Multiple sets of mills are used with combinations of 15 to 18 rollers being predominant. Conveyors transport the crushed cane from one mill to the next. Imbibitions are the process in which water or juice is applied to the crushed cane to enhance the extraction of the juice at the next mill. The common procedure is to send the juice from the crusher and the first two mills for further processing. In imbibitions, water or juice from other processing areas is introduced into the last mill and transferred from mill to mill towards the first two mills while the crushed cane travels from the first to the last mill. The crushed cane exiting the last mill is called bagasse. The juice from the mills is strained to remove large particles and then clarified.

Clarification is done almost exclusively with heat, and lime and phosphoric acid is added. The lime is added to neutralize the organic acids and the temperature of the juice is raised to about 95^{o}C (200 ^{o}F). A heavy precipitate forms which is separated from the juice in the clarifier. The phosphate acts as a flocculating agent.

The insoluble particulate mass, called "mud", is separated from the limed juice by gravity. Clarified juice goes to the evaporators without additional treatment. The mud is filtered and the filter cake is washed with water; the wash water is added to the juice recovered during filtration. The juice is screened again before going to evaporate water.

Evaporator stations consist of a series of evaporators, termed multiple-effect evaporators. This process typically uses a series of five evaporators.

Steam from large boilers is used to heat the first evaporator, and the steam from the water evaporated in the first evaporator is used to heat the second evaporator. This heat transfer process continues through the five evaporators and as the temperature decreases (due to heat loss) from evaporator to evaporator, the pressure inside each evaporator also decreases which allows the juice to boil at the lower temperatures in the subsequent evaporator. Some steam is released from the first three evaporators, and this steam is used in various process heaters in the plant. The evaporator station in raw sugar manufacture typically produces syrup with about 65 percent solids and 35 percent water. Following evaporation, the syrup is clarified by adding lime, phosphoric acid, and a polymer flocculent, aerated, and filtered in the clarifier.



Figure(2.1):Simplified process flow diagram for cane sugar Production[1].

From the clarifier, the syrup goes to the vacuum pans for crystallization. Crystallization of the sugar starts in the vacuum pans, whose function is to produce sugar crystals from the syrup. Batch pan boiling systems is used in the pan boiling process. The syrup is evaporated until it reaches the super-saturation stage. At this point, the crystallization process is initiated by "seeding" solution. When the volume of the mixture of liquor and crystals, known as mesquite, reaches the capacity of the pan, the evaporation is allowed to proceed until the final mesquite is formed. At this point, the contents of the vacuum pans (called "strike") are discharged to the crystallizer. The function of the crystallizer is to maximize the sugar crystal removal from the mesquite. From the crystallizer, the mesquite (A mesquite) is transferred to high-speed centrifugal machines (centrifugal), in which the mother liquor (termed "molasses") is centrifuged to the outer shell and the crystals remain in the inner centrifugal basket. The crystals are washed with water and the wash water centrifuged from the crystals. The liquor (A molasses) from the first centrifugal is returned to a vacuum pan and re-boiled to yield a second mesquite (B mesquite), that in turn yields a second batch of crystals. The B mesquite is transferred to the crystallizer and then to the centrifugal, and the cane sugar is separated from the molasses. This cane sugar is combined with the first crop of crystals. The molasses from the second boiling (B molasses) is of much lower purity than the first molasses. It is re-boiled to form a low grade mesquite (C mesquite) which goes to a crystallizer and then to a centrifugal. This low-grade cane sugar is mingled with syrup and used in the vacuum pans as a "seeding" solution. The final molasses from the third stage is a heavy, viscous material used primarily as a supplement in cattle feed. The cane sugar from the combined A and B mesquites is dried in fluidized bed or spouted bed driers and cooled. After cooling, the cane sugar is transferred to packing bins and then sent to bulk storage [1].

2.2 -Batch Centrifugal Description

Batch Centrifuges are filtration machines used to separate sugar mesquite into its constituent crystals and mother liquor under the action of centrifugal force. The product is processed in a cylindrical perforated basket fitted with filtering screens which is hung on the bottom end of a long spindle.

The spindle is suspended from a resilient buffer which allows the rotating assembly to swing slightly to find its own balanced axis of rotation thus reducing transmission of vibration to the support platform. The centrifuge is driven by an electric induction motor running off a variable frequency supply from a solid state inverter which allows a continuously running speed. show appendix A

All mechanisms used for feeding and discharging product are pneumatically actuated and the whole machine cycle is controlled by a programmable logic controller (PLC) [2].

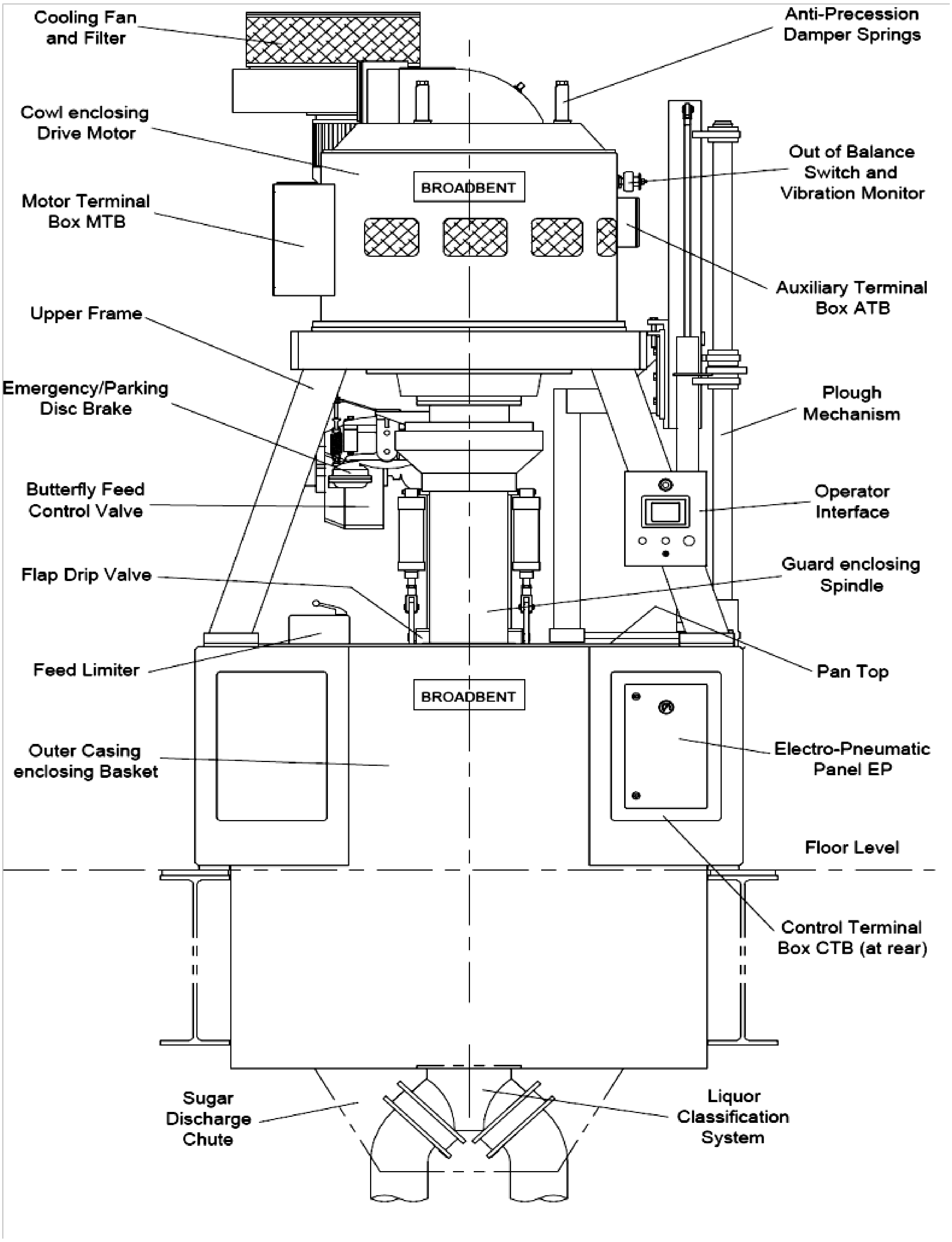


Figure (2.2): General Arrangement of Centrifuge[2].

* Principles of Operation

The centrifuge processes batches of product in a cyclic manner as follows; the centrifuge accelerates to a low speed. The butterfly feed control valve and a flap valve open allowing product to flow down a feeding chute onto a flinger disc attached to the spindle. This throws the product onto the inside of the basket where it flows under centrifugal force to form a uniform wall. Liquor starts to flow out through the filtering screens and basket perforations and is collected in the outer casing and discharged down pipe-work under the machine. The product thickness builds up inside the basket until the feed detector trips causing the feed control valve to close. The inside of the feed chute is sprayed with water and after a short delay the flap valve closes to prevent any remaining dark colored product dripping onto the product inside the basket. The feeding rate depends on how far the feed valve opens and this can be manually or automatically controlled. On completion of feeding, the centrifuge accelerates to a medium speed hold point to await operator or sequence permission to proceed. The centrifuge then accelerates to its maximum spin speed. During this time, purging of liquor from the product cake continues and water and steam can be sprayed on to remove the final traces of mother-liquor from the crystals. The purity of the run off liquor rises and a classification valve system can be used to direct this liquor down a different discharge pipe. The centrifuge pauses at spin speed for a preset time to dry the crystal cake to the desired level. On completion of spinning, the centrifuge decelerates to a very low speed. A discharge valve plate under the bottom of the basket opens. A plough blade cuts into the top of the cake and moves slowly down the basket screens discharging dried crystals through the basket bottom and down a chute onto a conveyor running beneath the casing. The plough blade moves back to its parked position, the discharge valve shuts, and the machine accelerates to feed speed to begin another cycle.

During acceleration, the filtering screens can sprayed with a small amount of water to remove any remaining crystals and thus prevent clogging [2].

*** Basket**

The basket is a high integrity fabrication made from materials appropriate to the product being processed. The shell is rolled from plate, seam welded, and perforated. Depending on the operating speed and density of the product, the shell may be reinforced by shrink fitted, high tensile, seamless rolled hoops. The basket bottom includes a hub for attachment to the spindle and a spoked opening for product discharge. The basket top is an annular disc that’s inside diameter or 'lip' determines the maximum possible product cake thickness which can be accommodated. The perforated shell of the basket is lined with 3 screens. The innermost 'working' screen is made from thin metal plate which has many fine perforations and acts as the filter medium. The 'intermediate' screen is fine woven mesh, and the 'backing' screen is coarse woven mesh. The system is designed to optimize support of the working screen whilst allowing easy dispersion of the liquor filtrate [2].

* Main Drive Induction Motor

The cyclic duty induction motor is an induction motor specially designed for high torque variable speed duty. It operates from a variable frequency supply and has much lower headroom requirements than an equivalent conventional motor .The stator is a 3 phase winding in a laminated core with skewed slots to minimize harmonics. The stator frame is of fabricated construction and bolts directly to the spindle bearing housing. The rotor has a low resistance cage in a laminated core and is fitted on a fabricated spoked hub which is attached directly to the spindle. The motor is enclosed by a cowl which provides EMC and noise shielding and includes mesh covered air ducts to allow cooling air to escape. The motor cowl also includes the main motor terminal box. The motor is force ventilated from above by a separate electric motor driven centrifugal fan unit. The air delivered by the cooling fan is drawn through an oil wetted filter to prevent any dust or debris being fed into the internal motor assembly. A rotating baffle on the top of the rotor splits this cooling air flow so that some passes directly across the upper end-windings whilst the remainder passes down the inside of the rotor and a cross the lower end-windings [2].

* Main Drive Direct current Motor

D.C motor separate specially designed for high torque variable speed duty. It is operate from a variable voltage supply .This motor cool by another induction motor to prevent any dusty [2].show name plate at appendix A

* Spindle and Bearing Housing

The spindle is a long tubular shaft with the basket attached at the bottom and the motor at the top. The spindle is suspended in a bearing housing just below the motor. The spindle is located radially by two cylindrical roller bearings and vertically by a 4 point angular contact ball thrust bearing which are all retained in a cast bearing housing. All bearings are grease lubricated and rated for long life. Just beneath the bearing housing is a disc brake for parking and emergency duties (In normal operation, the centrifuge is decelerated by regeneration in the inverter). The disc is attached to the spindle by a split taper collar. The caliper is mounted on a bracket attached to the lower bearing cap. The disc and brake shoes are surrounded by a substantial guard. Lower down the spindle is a conical flinger disc to aid distribution of product in the basket. This is also attached to the spindle by a split taper hub [2].

* Casing and Support Frame

The spindle bearing housing is flexibly supported in a conical elastomer bush or 'buffer' which allows the whole rotating assembly to swing slightly. The buffer rests in a conical seating in the top of a rigid support frame which has splayed legs fabricated from square hollow tube. The frame is in turn supported from the casing with intermediate packing plates whose thickness can be changed to adjust the vertical position of the basket. The casing is a fabricated assembly comprising a central cylinder with boxed sides. The cylindrical section surrounds the basket to catch the spun off liquor and incorporates a bottom gutter and bump ring to restrict the lateral motion of the basket. The side frames transfer loads from the upper support frame direct to the supporting foundations [2].

* Cooling and anti-precession system

The motor cowl supports an auxiliary motor driven fan and filter unit which directs cooling air via a duct into the top of the main drive motor.

An anti-precession system is fitted to control gyration of the rotating assembly during feeding and to prevent gyroscopic precession at high speed. This comprises a damper plate with a friction lining which is pressed down onto the motor top by 3 springs mounted on the motor cowl. The damper plate is held centrally by a rubber ring which is a tight fit on the cooling air duct. When the rotating assembly swings, the motor top is forced to slide against the damper plate giving rise to frictional damping [2].

* Braking System

In normal operation, the centrifuge is decelerated only by regeneration by the Drive Panel and mechanical brake [1].

* Feeding System

Product is fed into the centrifuge via a flow control valve, streamlined feed spout and secondary anti-drip valve. The product falls onto a conical distributor disc or 'flinger' attached to the spindle by a split taper hub. This throws the product onto the basket inner wall approximately halfway up from, where it flows to form a product wall under centrifugal action.

The flow control valve is a butterfly valve with a double acting actuator controlled from an integral electro-pneumatic positioner which responds to a 4-20 mA signal from the PLC. The flow control valve is mounted as close as possible to the mixer tank to avoid plugging. To avoid unsightly drips of colored feedstock onto spun product, a secondary valve is mounted directly onto the casing top. The secondary valve is a flap pulled up onto a soft seating under the spout outlet by a pair of double acting pneumatic cylinders. Mounted locally is an air reservoir with sufficient capacity to allow emergency closing of both valves in the event that the main pneumatic supply fails [1].

* Feed Limiter

A mechanical feed limiter unit initiates closing of the feed valve when the build-up of product cake inside the basket reaches the desired thickness. This comprises a slipper arm inside the basket connected via a rod to a control box on the casing top. The control box contains a pneumatic cylinder and spring loaded linkages. Just before feeding, the cylinder pushes the slipper close to the basket wall. As the product cake thickens, the slipper rides on the cake surface under spring pressure until the lever arms in the control box move sufficiently to trip a proximity switch. This sends a signal to close the feed valve and releases the cylinder in the control box so that the slipper arm moves well away from the product for the remainder of the cycle. The rod from the slipper arm extends through to a handle on the top of the control box which can be used as a manual override to terminate feeding. The desired product cake thickness is adjusted by rotating the whole assembly on the casing top [2].

* Plough Discharger

Product is ploughed from the basket by a blade which remains within the basket at all times. Its parked position is near the spindle near the top of the basket. For discharging, the blade lifts slightly, moves horizontally to cut into the top of the cake, pauses, and moves slowly vertically down the basket screens, pauses, moves vertically up, moves horizontally back to the spindle and finally drops slightly into the parked position. All plough motions take place with the basket rotating at very slow speeds. The actuating mechanism is mounted to the right of the main support frame and is connected to the blade by an 'L' shaped arm which passes through a curved slot with a sliding cover in the casing top. The heart of the mechanism is a vertical circular shaft on which the carriage supporting the plough arm slides vertically under the action of double acting pneumatic cylinder mounted in parallel with an oil filled dashpot unit. The dashpot allows a slow, adjustable speed downwards during plough. And a fast upwards motion when returning to the parked position. The horizontal motion is obtained by a second double acting pneumatic cylinder pushing on a lever arm attached to the bottom of the plough shaft which rotates the shaft and carriage in bushes at the casing top and at the top of the upper frame. Rollers in the end of the lever arm move the plough arm. The geometry in plain view is such that under cutting action, the blade naturally 'castors' to about half the maximum cake thickness. When first pushing the blade into the cake, the horizontal cylinder operates at full pressure but once on the screens, the pressure is reduced to gently hold the blade lightly against the basket to ensure that all traces of product are removed from the filtering screens. A spring loaded pin engages in cutouts in a locking plate rigidly attached to the plough shaft to hold the mechanism either out towards the screens so that the blade cannot touch the flinger during ploughing or in the parked position close to the spindle during the rest of the cycle. At appropriate points in the sequence, this pin is lifted out of engagement by a lifting ridge on the carriage. When parked, a lug on the carriage rests on a lug on the bracket supporting the upper plough shaft bush. This bracket also supports the proximity switches which sense the position of the mechanism. The solenoid valves controlling the actuators are spring return units and are connected in such a way that if the electrical power fails during ploughing, the plough will naturally tend to return up and in to the spindle towards the parked position [2].

* Discharge Valve

The discharge valve is a cone which is normally pulled up hard against the underside of the spoked opening in the basket bottom. This cone is lowered away from the basket during ploughing. The discharge valve actuating mechanism is housed entirely within the hollow spindle. It comprises a central pushrod surrounded by a long coil spring which is housed within a tubular hanger attached to the spindle. Spring pressure normally pulls up the pushrod to hold the discharge valve against the basket bottom. However, the top of the hanger houses a single acting cylinder which can compress the spring to depress the pushrod and open the discharge valve. The cylinder air supply is via a rotary union and a flexible hose to the cooling fan duct. To aid assembly the pushrod can be split into two pieces at a joint just below the spring hanger. A sealing plate assembly attached beneath the basket bottom incorporates a bush to guide the pushrod and a lip seal to protect the mechanism against ingress of product [1].

* Process Fitments

A static hot water spray pipe protruding into the basket from the casing top allows the screens to be rinsed after ploughing and the product to be washed during spinning. The pipe is short to prevent 'dragging' in the product during ploughing. The spray nozzles sizes, positions and angles have been carefully selected to provide an even wash distribution. The wash is controlled by a pneumatically actuated ball valve attached to the end of the wash pipe. An optional short steam injection pipe protruding into the basket from the casing top allows steam to be added to help dry the product cake. The steam injection is controlled by a pneumatically actuated ball valve attached to the end of the steam pipe. An optional liquor classification unit is attached to the rectangular liquor outlet under the casing. This allows separation of the initial low purity mother liquor spun off immediately after feeding from the wash water containing dissolved product spun off later. It comprises a ‘Y’ splitter box with a pair of pneumatically actuated butterfly valves on the two outlets. The controls are organized such that both valves are never shut simultaneously [2].

* Control Panel (PLC)

The whole production cycle of the machine, including operation of the inverter, feed valves, plough, and the discharge valve and process fitments is controlled by an electronic Programmable Logic Controller (PLC). The PLC together with its interface devices and auxiliaries is housed in a remote Control Panel cabinet. An isolator, 'Power On' indicator and 'Machine Running' indicator are mounted on the outside of the door. Components inside include the following:

** Central Processor Unit (CPU)

The CPU is a solid state device consisting of a microprocessor and its support system. It contains the operating program for the machine within its EPROM memory. The program cannot normally be corrupted but changes can be made when required by a suitably qualified and experienced person using a special programming unit. The CPU scans the inputs to the PLC from the various sensors on the centrifuge, acts upon these inputs as determined by the program, and then turns on the appropriate outputs to the inverter and centrifuge actuators in a cyclic manner. A series of indicating LEDs are incorporated on the front of the unit to show the operating status of the unit.

** Power Supply Unit (PSU)

This separate unit supplies 24V D.C. to the input/output module mounted on the rack. A light on the PSU indicates when the power supply is active.

** Input Modules

The input modules are all 16 way, low voltage DC. Optically isolated positive logic units. Each input has an associated Light Emitting Diode (LED) on the front of the unit to indicate its status (ON or OFF).

** Output Modules

The output modules are all 16 ways, low voltage DC optically isolated positive logic units. Each output has an associated LED on the front of the unit to indicate its status (ON or OFF) [2].

* Speed Monitoring System

The speed of the machine is measured by impulses from two proximity sensors mounted above a series of holes through the brake disc. To guard against faulty speed control, two entirely independent speed monitoring systems are fitted. In the main system, the impulses from one of the sensors are changed to a 4-20 mA analogue signal by a frequency to current converter and this analogue signal is fed to the main PLC. In the secondary system, the impulses from the second sensor are fed directly to a secondary programmable logic controller (PLC2) which is of a different type and manufacture to the main PLC. PLC2 is basically a pulse counting unit and is configured to operate 6 sets of contacts corresponding to different speeds. The main PLC continuously scans the status of these contacts and compares these for consistency with its own measurement of speed. If a discrepancy is detected, a fault condition occurs. As a further protection against faults in the main PLC and/or the inverter causing random uncontrolled actions, some of the contacts in PLC2 are hard wired via relays to inhibit dangerous conditions. One set of contacts isolates the plough actuators to prevent the plough deploying above low speed. Another set of contacts isolates the feed valve actuators to prevent feeding above medium speed. A particularly dangerous situation is over speeding the centrifuge. The main PLC is set with a software limit on maximum speed and the inverter is preset with a software limit to the output frequency. In the unlikely event of faults in both these systems occurring simultaneously, two sets of contacts in PLC2 are used as a final protection against over-speeding. The first set removes the inverter enable signal and the second, higher speed, set trips the inverter input contactor and disconnects power [1].

* Machine Electrical Equipment

The following control equipment is mounted on the centrifuge.

♦ Operator Interface

The operator Interface is mounted on the front of the centrifuge frame. This incorporates a touch sensitive panel with pushbuttons and indicators. It allows operators to monitor and control the machine via the PLC in the Control Panel. The interface allows displays machine status, interaction with the production cycle, and modification of process parameters [2].

2.3 Cycle Operation

The sequence of events during a normal operating cycle of the centrifuge is as follows, the centrifuge accelerates to a low speed. The butterfly feed control valve and a flap valve open allowing product to flow down a feeding chute onto a flinger disc attached to the spindle. This throws the product onto the inside of the basket where it flows under centrifugal force to form a uniform wall. Liquor starts to flow out through the filtering screens and basket perforations and is collected in the outer casing and discharged down pipe-work under the machine. The product thickness builds up inside the basket until the feed detector trips causing the feed control valve to close. The inside of the feed chute is sprayed with water and after a short delay the flap valve closes to prevent any remaining dark color product dripping onto the product inside the basket. The feeding rate depends on how far the feed valve opens and this can be manually or automatically controlled. On completion of feeding, the centrifuge accelerates to a medium speed hold point, this is to wait operator or sequence permission to proceed. The centrifuge then accelerates to its maximum spin speed. During this time, purging of liquor from the product cake continues and water and steam can be sprayed on to remove the final traces of mother liquor from the crystals. The purity of the run off liquor rises and a classification valve system can be used to direct this liquor down a different discharge pipe.

The centrifuge pauses at spin speed for a preset time to dry the crystal cake to the desired level. On completion of spinning, the centrifuge decelerates to a very low speed. The discharge valve plate under the bottom of the basket opens. The plough blade cuts into the top of the cake and moves slowly down the basket screens discharging dried crystals through the basket bottom and down a chute onto a conveyor running beneath the casing. The plough blade moves back to its parked position, the discharge valve shuts, and the machine accelerates to feed speed to begin another cycle. During acceleration, the filtering screens can sprayed with a small amount of water to remove any remaining crystals and thus prevent clogging.

A number of different operating modes can be selected by the operator, the cycle Modes are:

2.3.1 Automatic Cycle Mode

The centrifuge cycles automatically, with the operator able to change feed, spin, wash, and plough parameters without affecting the centrifuge sequence. The centrifuge continues in this mode unless the Stop or Emergency Stop buttons are pressed or a fault occurs. Faults will switch the centrifuge into Manual Cycle Mode and, depending on the type and severity of the fault, may also stop the centrifuge or shift it to another part of the cycle.

2.3.2 Manual Cycle Mode

The centrifuge cycles in the same way as in Automatic Cycle Mode except that the centrifuge pauses awaiting operator intervention at certain parts of the cycle and also comes to rest at the end of each cycle. The operator is required to press the Start button at the following points:

(a) To allow feeding to commence

(b) To allow acceleration from holding speed to spin speed

(c) To allow continuation to another cycle

Manual Cycle Mode is useful when commissioning the centrifuge to find the optimum operating parameters and also during fault finding[2].

CHAPTER THREE

CENTRIFUGAL CYCLE

3.1 Batch centrifugal drives

There are two basic types of induction motor drives - fixed frequency mains supplied and variable frequency inverter supplied.

The developments in motors and controls have provided a variety of induction motor drive systems for batch sugar centrifugal. These include motors with 2 or 3 windings each providing a different speed when supplied by a standard three phase supply. A limited regenerative electrical braking is provided by drives of this type.

Power electronic devices over 20 years ago the growth of inverter technology has formed the basis of an entirely new drive concept. This provides the induction motor with a ‘variable’ supply giving control of both motor torque and speed over a wide range with a reduction in net power usage[1].

3.1.1 Centrifugal Drive Requirements

The drive for a batch centrifugal, presents an intriguing problem. The cyclic duty of the centrifugal process requires acceleration from low (discharge) speed through feeding of the massecuite to spin for separation, followed by deceleration to low speed for discharge – typical cycle times.

A large amount of energy is needed to accelerate the centrifugal and most of it is stored in the rotating loaded basket. The energies involved are large - a medium sized centrifugal spinning at 1200 rpm has the same stored energy as a 1.5 ton. If a proportion of this stored energy can be returned to the supply during deceleration then the net energy demand is reduced pro rata.

As the centrifugal commences and ends the cycle at the same discharge speed, the energy input has either been recovered by regeneration or dissipated in the losses in the system (controls + motor + windage & friction + energy lost to spun off syrup). Thus the net energy input, that is the energy input minus the energy recovered, equals the system losses. This applies equally to multi-speed and inverter drives [3].

3.1.2 Inverter Drives.

With the advent of electronic power inverters, particularly the pulse width modulated (PWM) type; the induction motor entered a new area. With given a variable frequency/voltage output of the inverter the induction motor could operate at any speed above a few rpm to a top speed fixed by either the inverter maximum frequency or the motor rotor stresses, The centrifuge main drive motor is an induction motor and runs just below the synchronous speed which is determined by the number of poles in the winding and by the frequency of the electrical supply. The motor speed can therefore be changed by varying the frequency of the electrical supply to it. This function is performed by the Drive Panel which is a solid state electronic frequency converter (inverter), Converter is converting electric energy from one form to another, converting between AC and DC, or just changing the voltage or frequency, or some combination of these The fixed frequency alternating current supply to the Drive Panel is first rectified to a direct current which is then electronically switched on and off to construct an output alternating current at the desired frequency. The inverter is housed in a remote cabinet with a door mounted keypad and display for use during setup and fault finding. The inverter driven motor still operates in the cyclic mode described above and therefore both motor and inverter need to be rated to suit this cyclic duty. When applied to a centrifugal, acceleration is controlled by frequency/voltage change or torque/flux control within the allowed power to give the compromise between energy demand and centrifugal product processed. With an inverter capable of regeneration deceleration is controlled in a similar way to the discharge speed and mechanical braking is only needed for emergencies. Inverters are complex and expensive typically 3.5 to 4 times the cost of the three speed induction motor controls and can create substantial harmonic distortion in the electric supply system when using diode/thyristor input power electronics. In the last few years this distortion has been substantially reduced using newer power electronic devices (IGBTs) increasing the cost to 4.5 to 5 times that of the three speed motor controls. Many modern centrifugal, particularly the larger units, are PWM inverter/induction motor driven by the inverter, then the centrifugal motor with 100 electrical units input returns 85 electrical units to the supply,Speed and motor current against time for an inverter drive is shown below for one cycle of 180 seconds on a 440 volts 60 HZ supply and the centrifugal capacity of 1.3 tones mesquite [3].

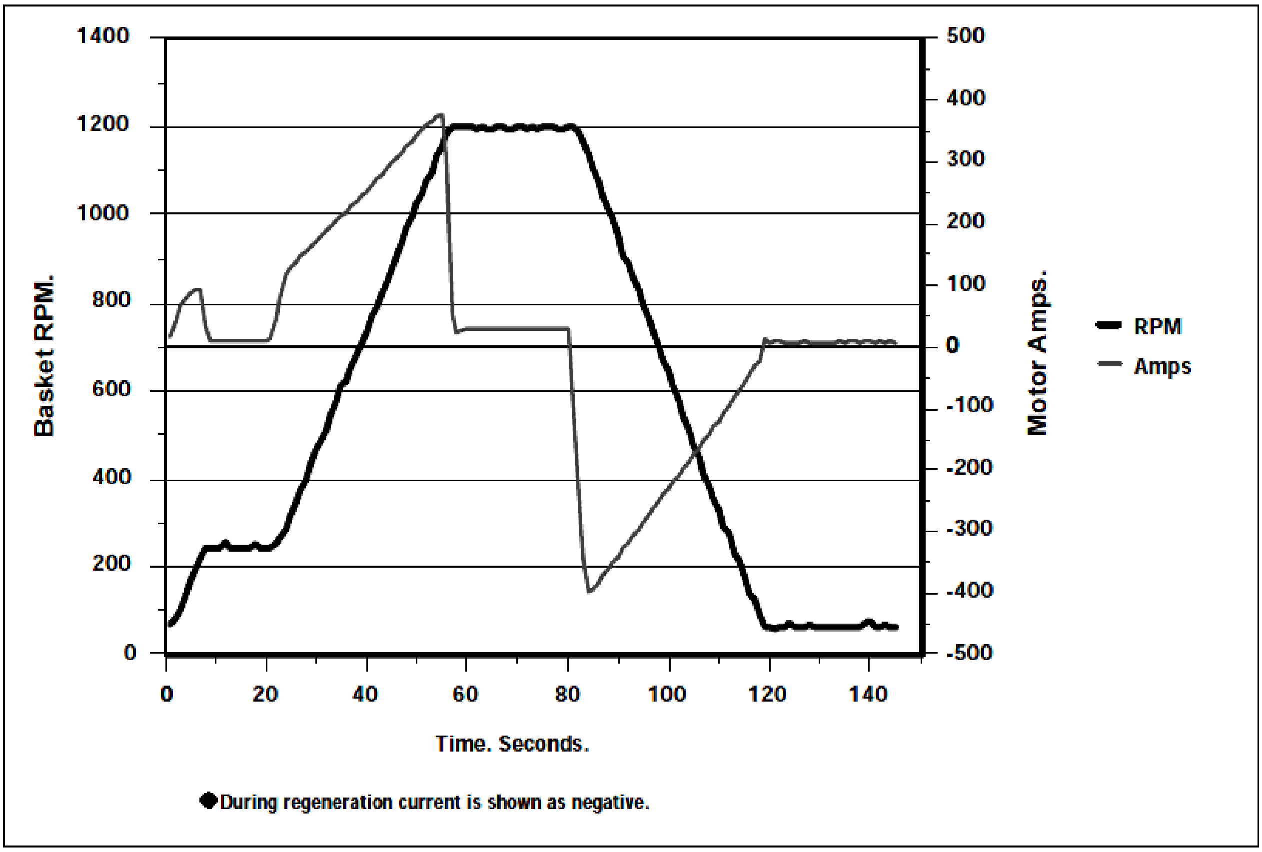


Figure (3.1): Speed and motor current against time for an inverter drive [3].

3.1.3 Converter Drives

The D.C motor entered a new area with given a variable voltage output of converter; motor could operate at any speed above a few rpm to a top speed. Speed can change by varying voltage, armature current and field current. Here we use varying voltage source controlled by gate of convertor, which convert electrical energy from AC to DC.

DC motor runs one cycle at 180 second with 400Volt, 215KW and field voltage 290 Volt take 7.6Amp [3].show appendix B

3.2 Sequence of Centrifugal Machines

Sequence control refers to user actions and computer logic that initiate, interrupt, or terminate transactions, Sequence control governs the transition from one transaction to the next (Sidney 1986), sequence control is used to coordinate the various actions of the production system (e.g., transfer of parts, changing of the tool, feeding of the metal cutting tool, etc.).

Typically the control problem is to cause/ prevent occurrence of

- ♦ Particular values of outputs process variables
- ♦ Particular values of outputs obeying timing restrictions
- ♦ given sequences of discrete outputs
- ♦ given orders between various discrete outputs (IIT Kharagpur 2008) .

The basic idea of the sequence control is used here to organize the work of the centrifugal machines ,was based on a constant delay time , every machines is wait to take permission either before spinning to cure sugar at high speed, or before discharge to drop the product (plough).

Broadbent is British Company specialist on sugar centrifugal machines manufacturing, applied three types of sequence control in Assalaya Sugar Factory, all these controls based on the method of delay time, the early one use moving contacts (cams) rotate with constant speed, which is adjust by the operator to control the time delay between machines, the user have a chance to select the request signal of the specific machine to be send when the machine start accelerate to high (spin) speed i.e. sequence at acceleration, or when the machine begin discharge sugar (sequence at plough), if sequence at acceleration is selected the request signal is send to the controller after machine complete feeding, it wait rotating at speed of 500 rpm until the desired contact is closed this let the machine accelerate to 1000 rpm (spin speed) and continue the remaining operations , if sequence at plough is chosen the controller check if the sugar conveyor running or not, in case of conveyor stoppages the machine rotate at 50 rpm (plough speed) and sugar will not be drop until the conveyor running signal come back to the sequence controller, after checking the conveyor signal the machine stay at plough speed until the permission signal send from the sequence controller, beside all these the sequence control can be override by switch inside the machine itself.

The second type of sequence control has the same function of the early one but it used electromechanical relays and on/off-delay timers, the wiring connection of these devices made the desired control, timers is used for the purpose of adjusting the interval times between machines

The last application is used Microcontroller, functionally has the same previous method and behavior, more over the machines can be sequentially operate In ascending or arbitrary order. The sequence control is connected with the programmable logic controller (PLC) of the machine control, and the feature of this application which is cold 5/10 is shown and explained below [3].

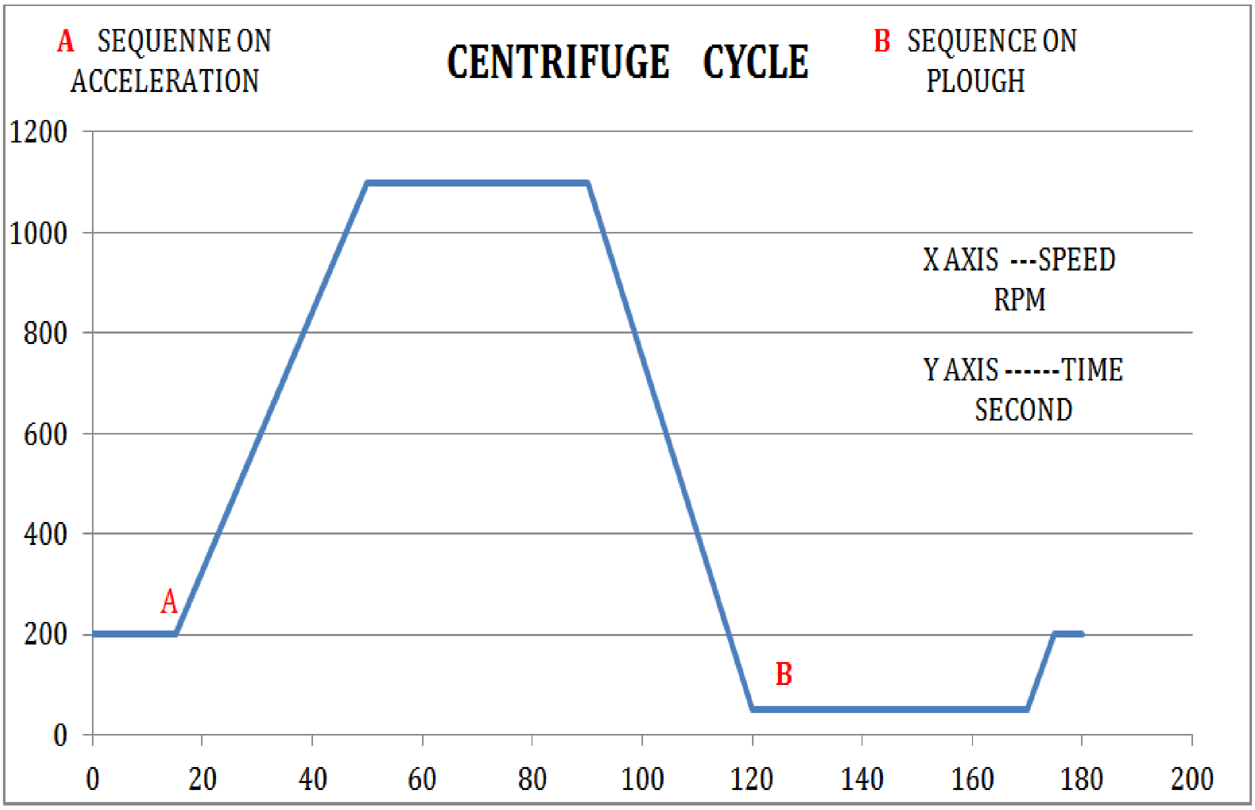


Figure (3.2): centrifuge cycle time [3].

3.2.1Connection required for sequence Panel.

Referring to figure (3.3) a five core cable is required to connect each centrifuge to (M1 to M5), when a centrifuge reaches the selected sequence point (either acceleration or plough) then a PLC output is turned on the sequence relay (SEQ) is energized in the centrifuge control panel this send a signal to the sequence panel (on terminals M4 and M5) that the centrifuge is at the sequence holding point. If no other centrifuge is being sequenced then the sequence panel sends a signal back to the centrifuge (on terminals M1 and M2) allowing the centrifuge past the sequence holding point. The sequence panel also has the function of telling the centrifuge if the discharge conveyor is running (if the conveyor is running a signal is sent to each centrifuge on terminals M1and M3).

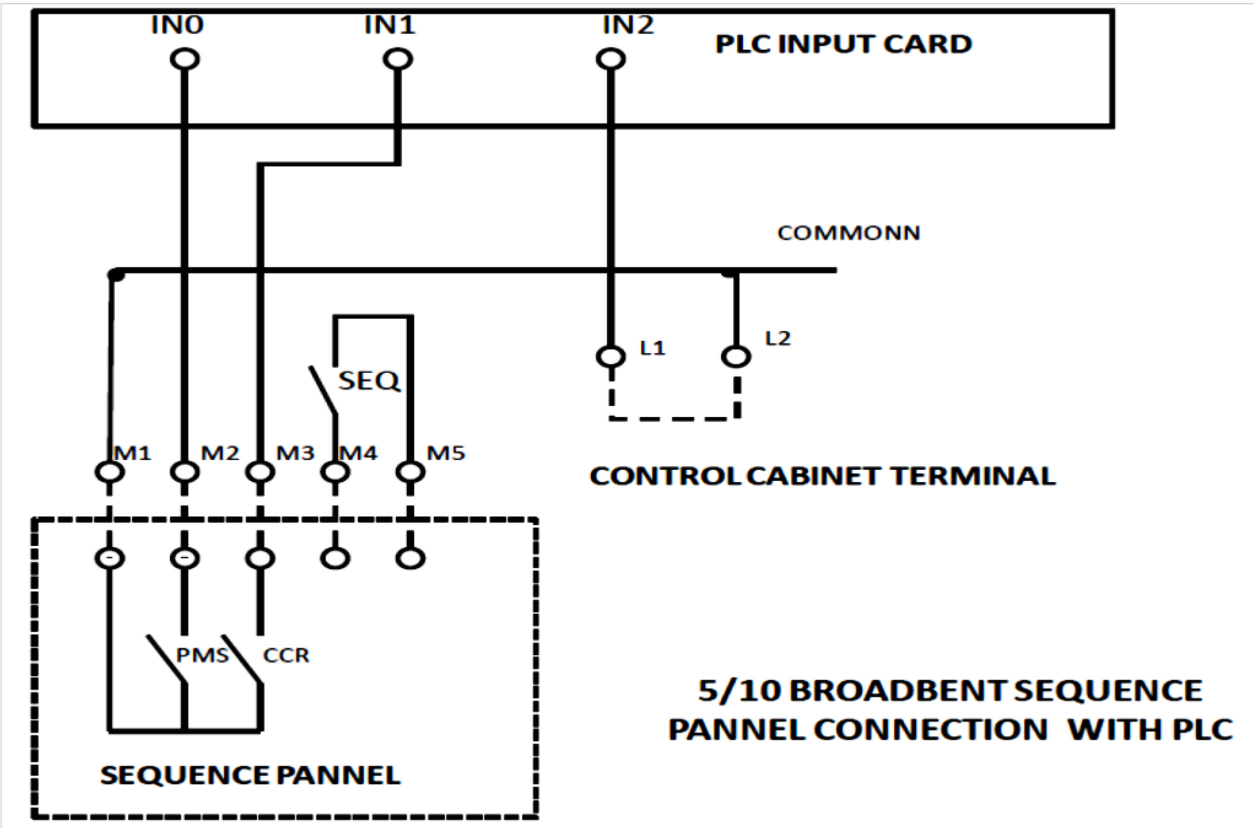


Figure (3.3): 5/10 Broadbent sequence connection with PLC [2].

3.2.2 Required Centrifuge HMI Settings with Sequence Panel

The first thing required that when the operator decides to use sequence is to ensure sequencing is selected (not overridden).

Sequence selection for each centrifuge can be accessed as follows:

I- From the centrifuges touch screen main screen figure (3.4) select menu screen.

II- from menu screen figure (3.5) selects spin screen

After selection the following screen appeared figure (3.4).

It can be useful to override the sequence interlock if the sequence panel is turned off or faulty.

The next consideration is to sequence on acceleration or to sequence at plough, below is brief explanation as to the relative merits of sequencing at each of these points [2].

MAIN SCREEN

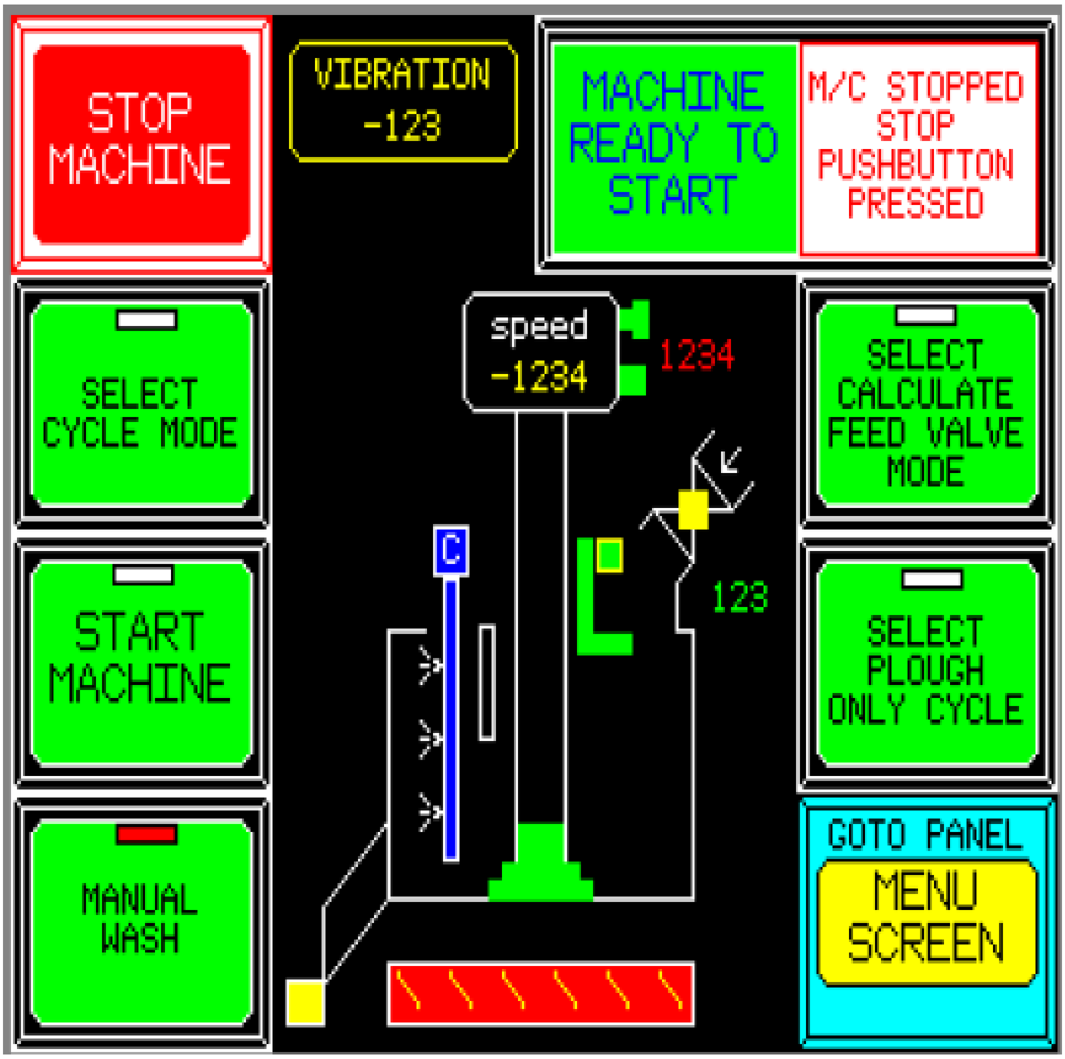


Figure (3.4): Main Screen [2].

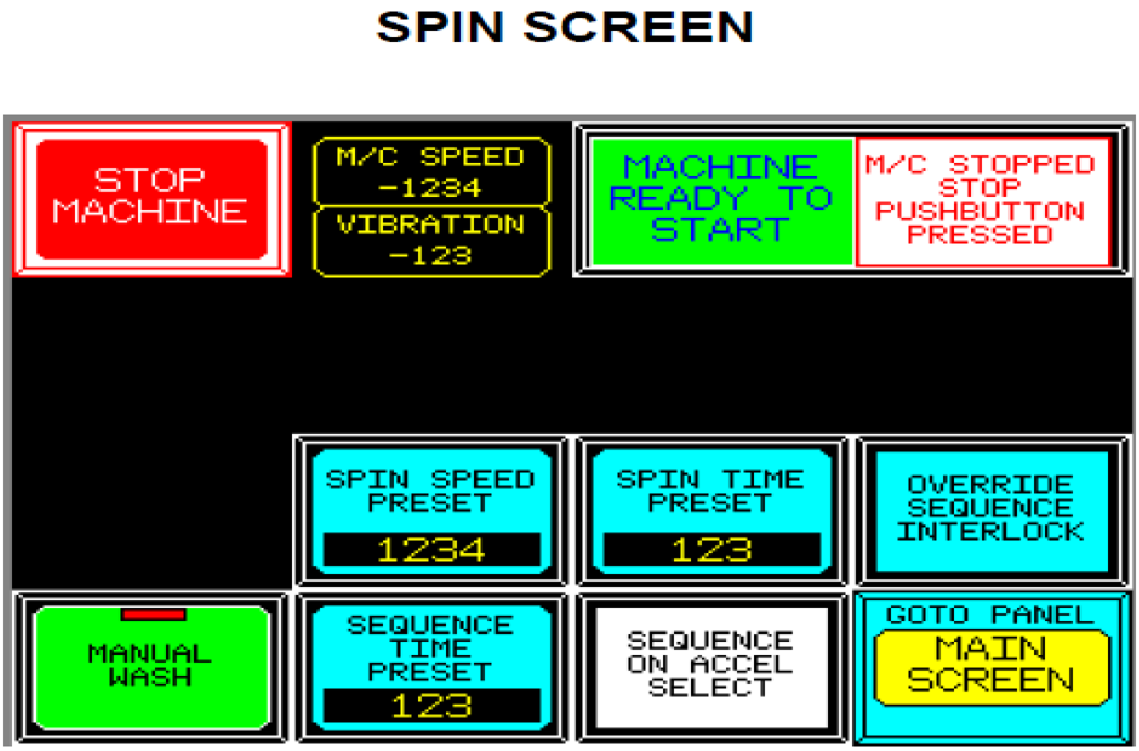


Figure (3.5): Spin Screen [2].

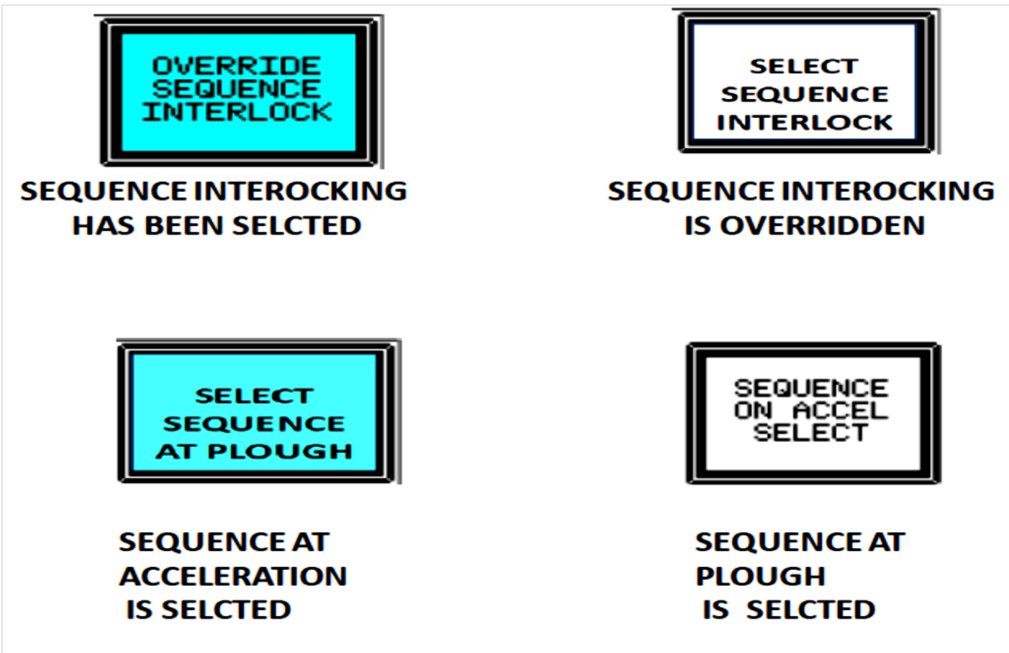


Figure (3.6): Sequence Selecting Icons [2].

3.2.3 Sequence on Acceleration

If there is a need to minimize the peak electrical supply demand then the sequence on acceleration should be selected, this will inhibit more than one centrifuge from acceleration at the same time.

3.2.4 Sequence on Plough

If there is limitation for the amount of sugar to be discharge in the conveyor, then sequence on plough should this will not allow more than one machine to discharge at the same time [2].

CHAPTER FOUR

SIMULATION AND COMPARISONS

4.1 Programmable logic controller

Every aspect of industry from power generation to automobile painting to food packaging uses programmable controllers to expand and enhance. Production Programmable logic controllers, also called programmable controllers or PLCs are solid state members of the computer family, using integrates Circuits instead of electromechanical devices to implement control functions. they are capable of storing instructions, such as sequencing, timing counting, arithmetic, data manipulation, and communication, to control industrial machines and processes controllers have many definitions. However, PLCs can be thought of in simple terms as industrial computers with specially designed architecture in Programmable both their central units (the PLC itself) and their interfacing circuitry to field devices (input/output connections to the real world [4] .

4.1.1 Historical Background

The Hydromantic Division of the General Motors Corporation specified the design criteria for the first programmable controller in 1968. Their primary goal was to eliminate the high costs associated with inflexible, relay controlled systems. The specifications required a solid-state system with computer flexibility able to: Survive in an industrial environment be easily programmed and maintained by plant engineers and technicians and be reusable. Such a control system would reduce machine downtime and provide expandability for the future. Some of the initial specifications included the following:

* The new control system had to be price competitive with the use of Relay systems.

* The system had to be capable of sustaining an industrial environment.

* The input and output interfaces had to be easily replaceable.

* The controller had to be designed in modular form, so that subassemblies could be removed easily for replacement or repair.

* The control system needed the capability to pass data collection to a Central system the system had to be reusable.

* The method used to program the controller had to be simple, so that It could be easily understood by plant personnel [4].

4.1.2 Advantage of using PLC

In general, PLC architecture is modular and flexible, allowing hardware and software elements to expand as the application requirements change. In the event that an application outgrows the limitations of the programmable controller, the unit can be easily replaced with a unit having greater memory and I/O capacity, and the old hardware can be reused for a smaller application a PLC system provides many benefits to control solutions, from reliability and repeatability to programmability. The benefits achieved with programmable controllers will grow with the individual using them the more you learn about PLCs, the more you will be able to solve other control problems .The Components of a PLC is: In puts, Out puts and CPU. [4]

4.2 Centrifugal Process

A simplified process flow chart diagram for a typically centrifugal plant is show in figure (4.1).

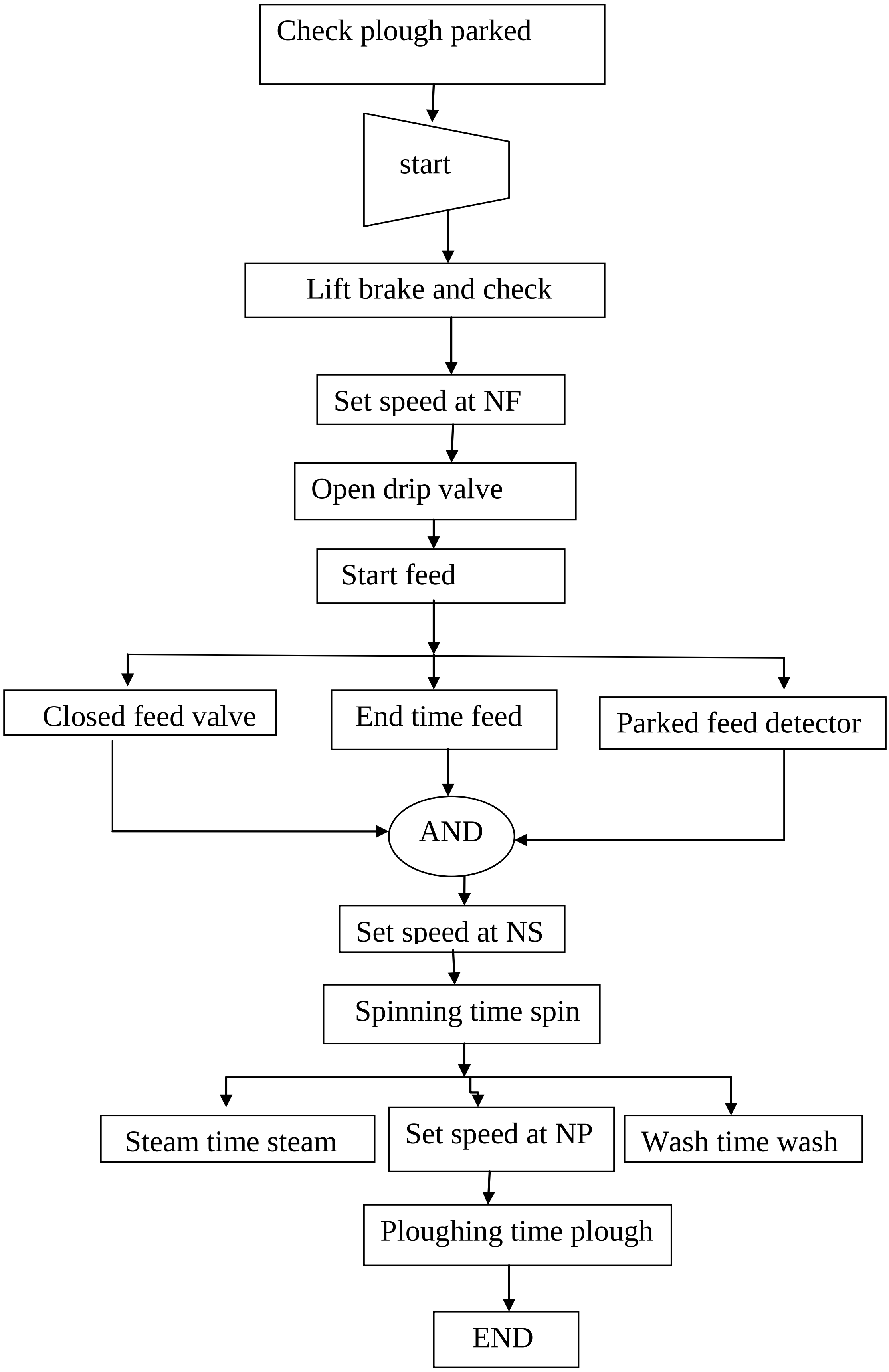


Figure (4.1): Simplified process flow chart diagram for centrifugal.

The machine repair itself and begin feeding at (NF=200rpm), the feed end while time feed end, parked feed detector (by energize I6) and close feed valve to start spinning at (NS=1200rpm /1000rpm). The sugar washing and drying by steam during the spinning, after that centrifugal plough the sugar at (NP=60rpm).show Appendix C

4.3 Simulation

We can use three methods to program any system by PLC: ladder diagram (LAD), function block diagram (FBD) and statement list, In this research used (LAD) Figure (4.6).

Equation bellow used to estimate time of any stage

$$TF \geq TFT \quad (4.1$$

$$TS = TST \quad (4.2)$$

$$TP = TPT \quad (4.3)$$

$$TR = TRT \quad (4.4)$$

$$TW = T(T004) - T(T003) \quad (4.5)$$

$$TSS = TST - T(T004) \quad (4.6)$$

Circuit Diagram2.lld

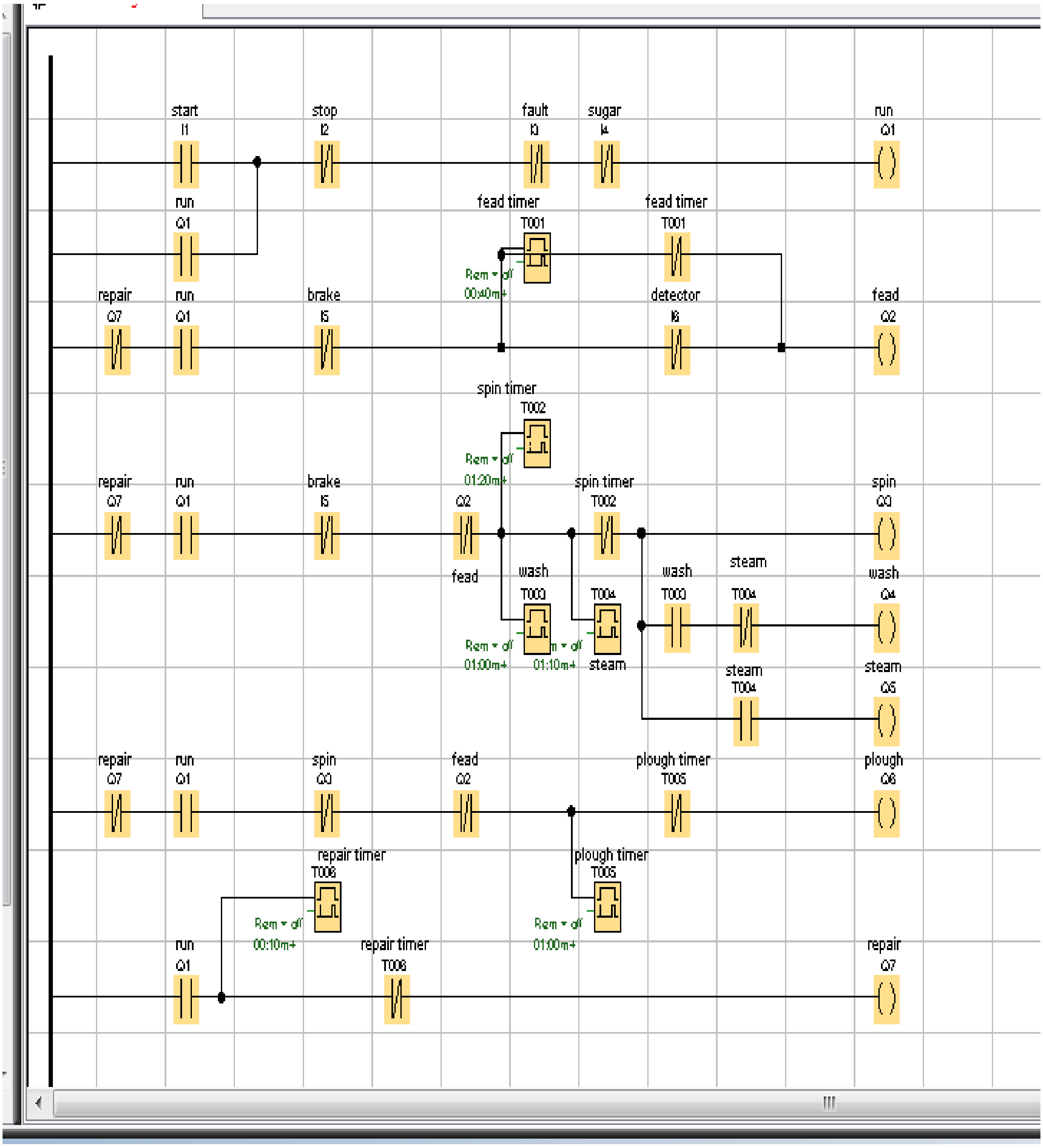


Figure (4.6): Simulation program

4.4 Result of simulation

The results vary with time that's put in the table.

Table (4.1): result of simulation

				Spin			
		Repair	Feed		Wash	steam	Plough
Q7	Repair	On	Off	Off	Off	Off	Off
Q6	Plough	Off	Off	Off	Off	Off	On
Q5	Steam	Off	Off	Off	Off	On	Off
Q4	Wash	Off	Off	Off	On	Off	Off
Q3	Spin	Off	Off	On	On	On	Off
Q2	Feed	Off	On	Off	Off	Off	Off
Q1	Run	On	On	On	On	On	On
		10sec	40sec	60sec	10sec	10sec	60sec

4.5 Comparisons between DC Motor and Induction Motor In centrifugal system

Table (4.2) Comparisons between DC Motor and Induction Motor

In centrifugal system

Functional Classification	DC Motor (Kenana sugar factory)	Induction Motor (assalaya sugar factory)
Drive	Convertor	Inverter
Speed control	Variable voltage supply	Variable frequency supply
Cool	Forced	Forced
Maintenance	High cost	Low cost
Generating of motor	Motor can not to be Generator	Motor can to be Generator
Speed spin	1000rpm	1200rpm
Power loss	Low	High
Quantity of sugar	Depend on perforations of basket	Depend on perforations of basket
Operation period	All period of harvest (six month)	All period of harvest (six month)
Quality of sugar	Depend on perforations of basket And sugar Juice	Depend on perforations of basket And sugar juice

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The different concepts of batch sugar centrifugal machines have been studied, by the view the duty cycle of AC batch centrifugal in asalaya sugar factory and DC one in kenana sugar factory.

The duty cycle of four stages of two batch sugar centrifugal have been programmed by PLC program , and the effects of the batch sugar centrifugal AC and DC in production of sugar have been known, and the performance of the duty cycle in all the two factory has been analysed to support the comparison operation.

5.2 Recommendations

1- Study the effect of convert of AC motor to generator in the stability of power house, power factor and solve this problem.

2-used the AC motor system in batch sugar centrifugal machine because it's the best as shown in comparison table.

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3-Variable frequency centrifugal drives - a convergence on converters,

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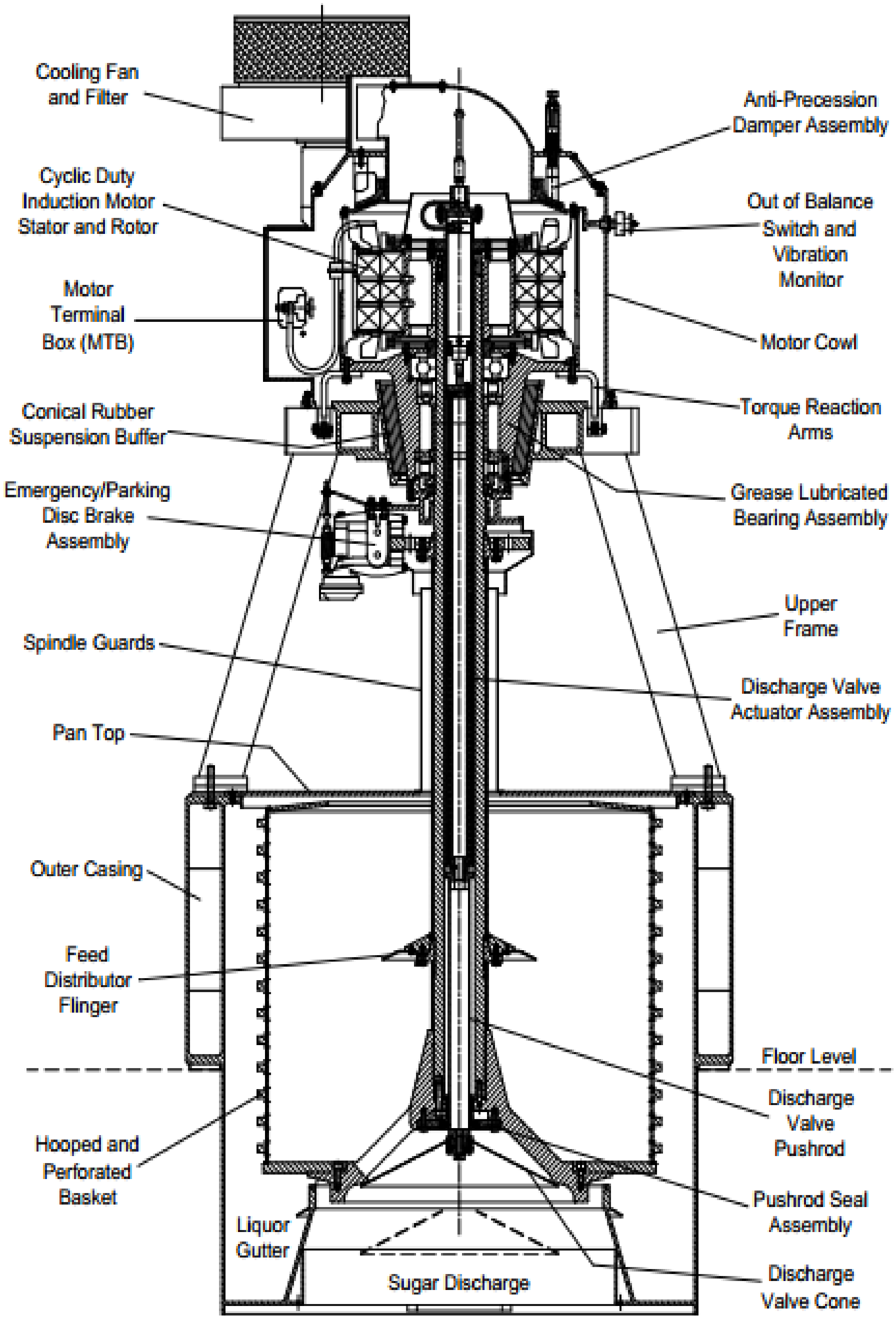
APPENDIX

Appendix A

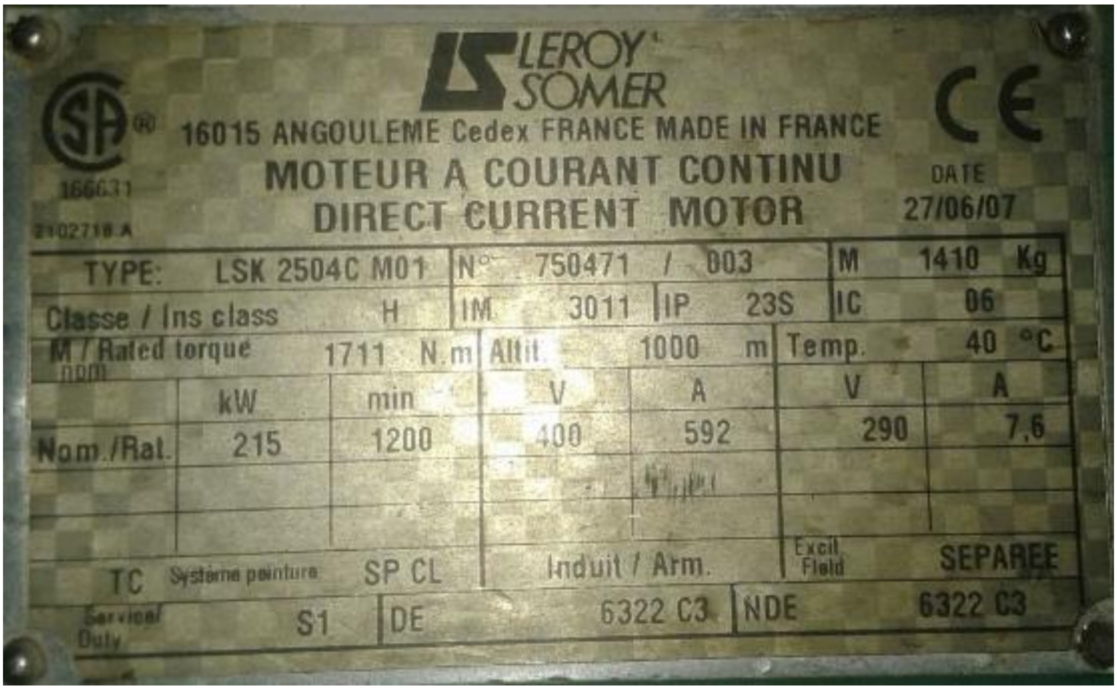
DC motor centrifugal system

Induction motor centrifugal system

Sectional arrangement of centrifuge



Name plate of DC motor



Appendix B

Convertor equation

$Edo = 1.35 * Erms$

$Ed = Edo * (\cos\alpha - Xpu/2)$

$Ed = DC\ out\ voltage\ Under\ load$

$Edo = open\ circuitDC\ voltage\ of\ convertor\ at\ (\alpha = 0)$

$Erms = AC\ line\ to\ line\ voltage$

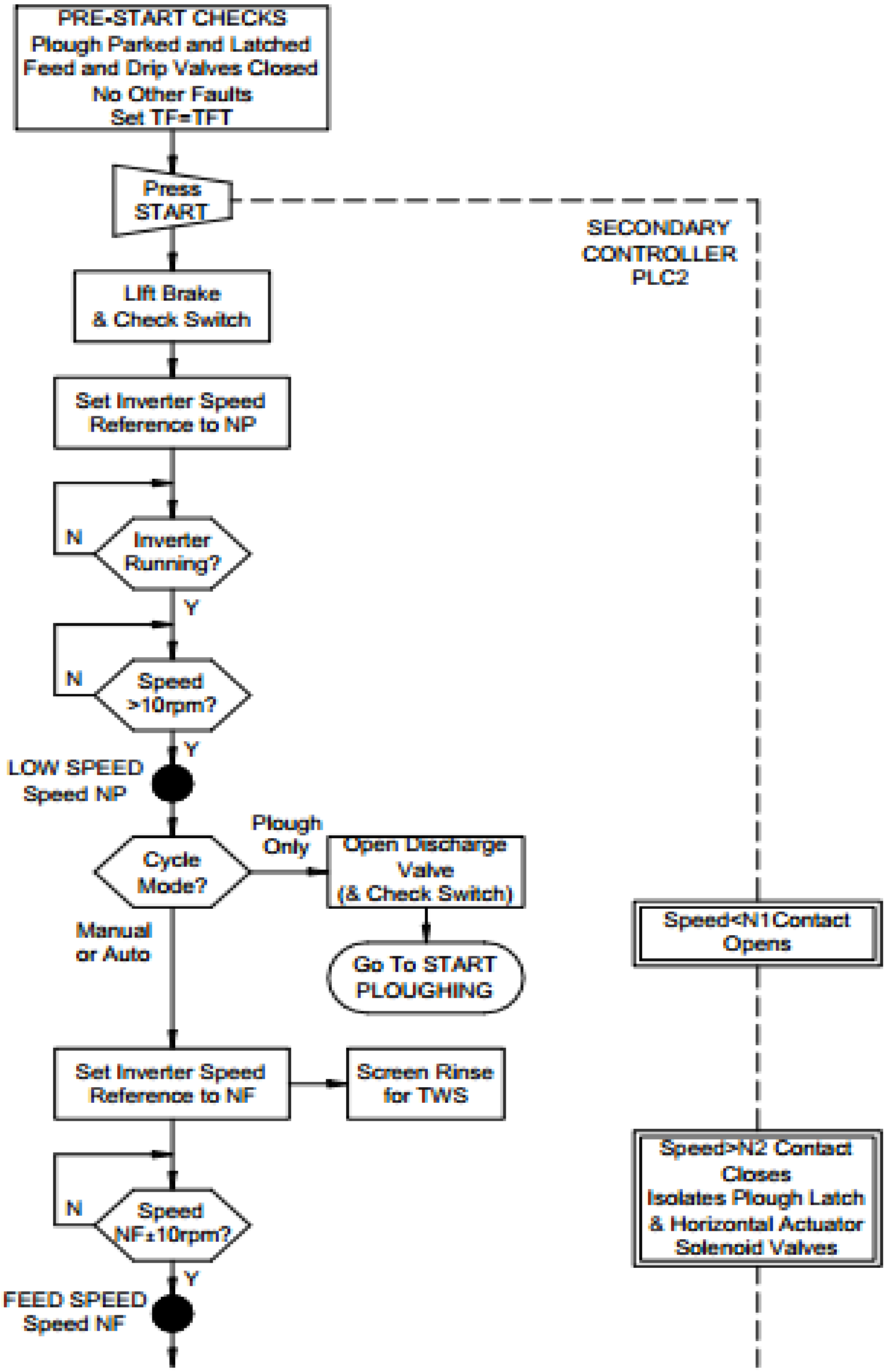
$\alpha = fireing\ angle$

APPENDIX C

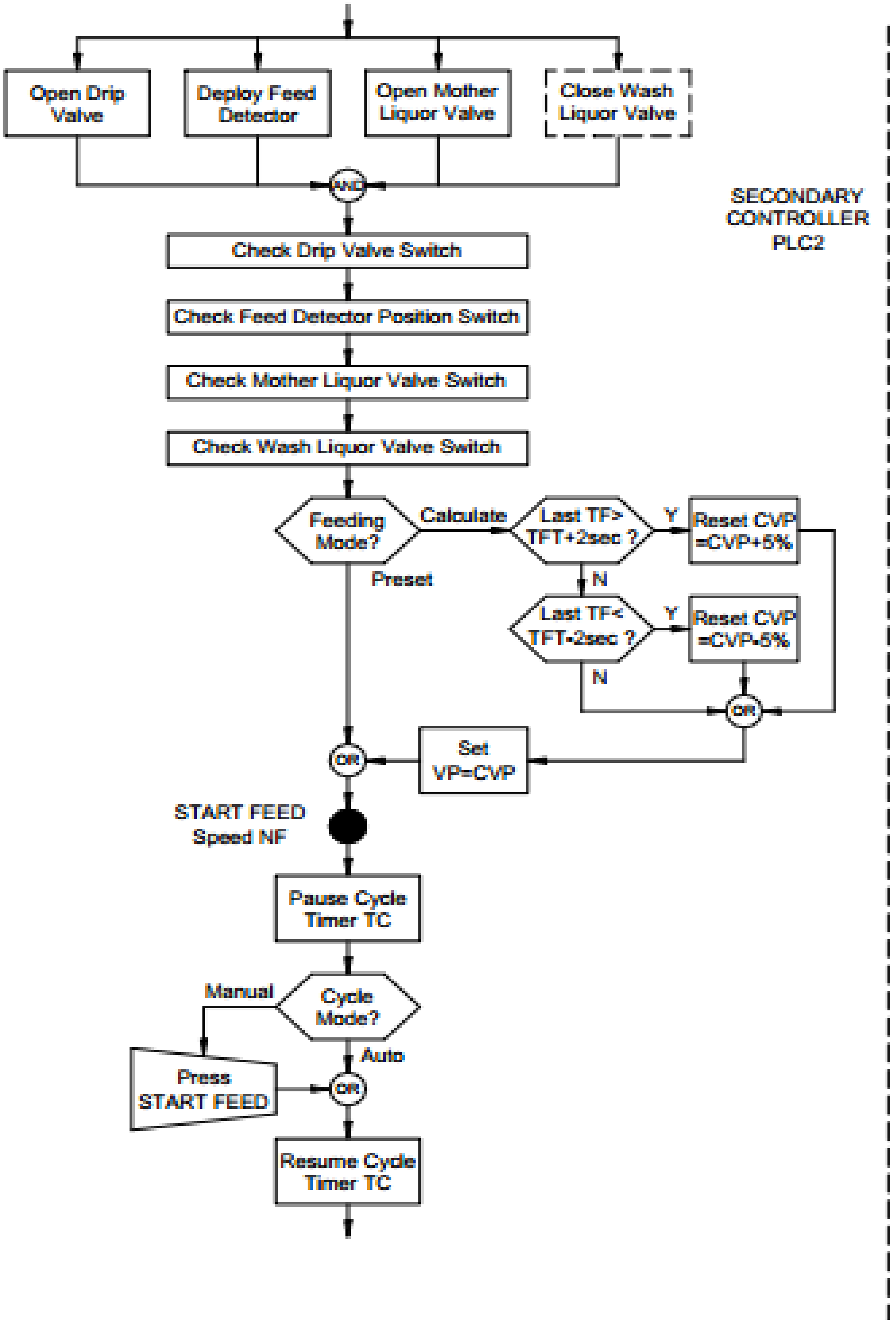
CONTROL SYSTEM

This Appendix details the control system for the centrifuge in the form of a flowchart and can be used to assist in diagnosing faults The whole production cycle of the machine, including operation of the inverter, feed valves, plough, discharge valve and process fitments is controlled by an electronic Main Programmable Logic Controller (PLC). The central processing unit (CPU) of the Main PLC holds the operating program for the centrifuge within its EPROM memory. The CPU scans the inputs to the PLC from the operator interface and the various sensors on the centrifuge, acts and then turns on the ‹upon these inputs as determined by the program appropriate outputs to the inverter and centrifuge actuators in acyclic manner. A .The program sequence and logic is detailed in the following flowcharts Main Cycle Sequence Program. This has sequential logic reflecting the cyclic A Stop Sequence Program which can be initiated by the operator at any times Several Continuous Loop Programs running in parallel. It is possible that faults in the Main PLC. Inverter or other electronic device could cause random, uncontrolled actions. To ensure that such faults cannot cause dangerous situation, an entirely independent Secondary Programmable Logic Controller (PLC2) from a different manufacturer is fitted. This is a simple pulse counting unit connected directly to a proximity switch measuring the It is configured to operate 6 sets of contacts corresponding to .centrifuge speed different speeds. One set of contacts isolates the plough actuators to prevent the plough deploying above low speed. Another set of contacts isolates the feed valve actuators to prevent feeding above medium speed. Two other sets of contacts first disable and then isolate the inverter to prevent over speeding. The operation of these contacts is illustrated on the flow chart for the Main Cycle Sequence Program. In addition, one of the Continuous Loop Programs continuously checks that the status of the PLC2contacts is consistent with the speed measurement used in the Main PLC and stops the centrifugle if a mismatch is detected.

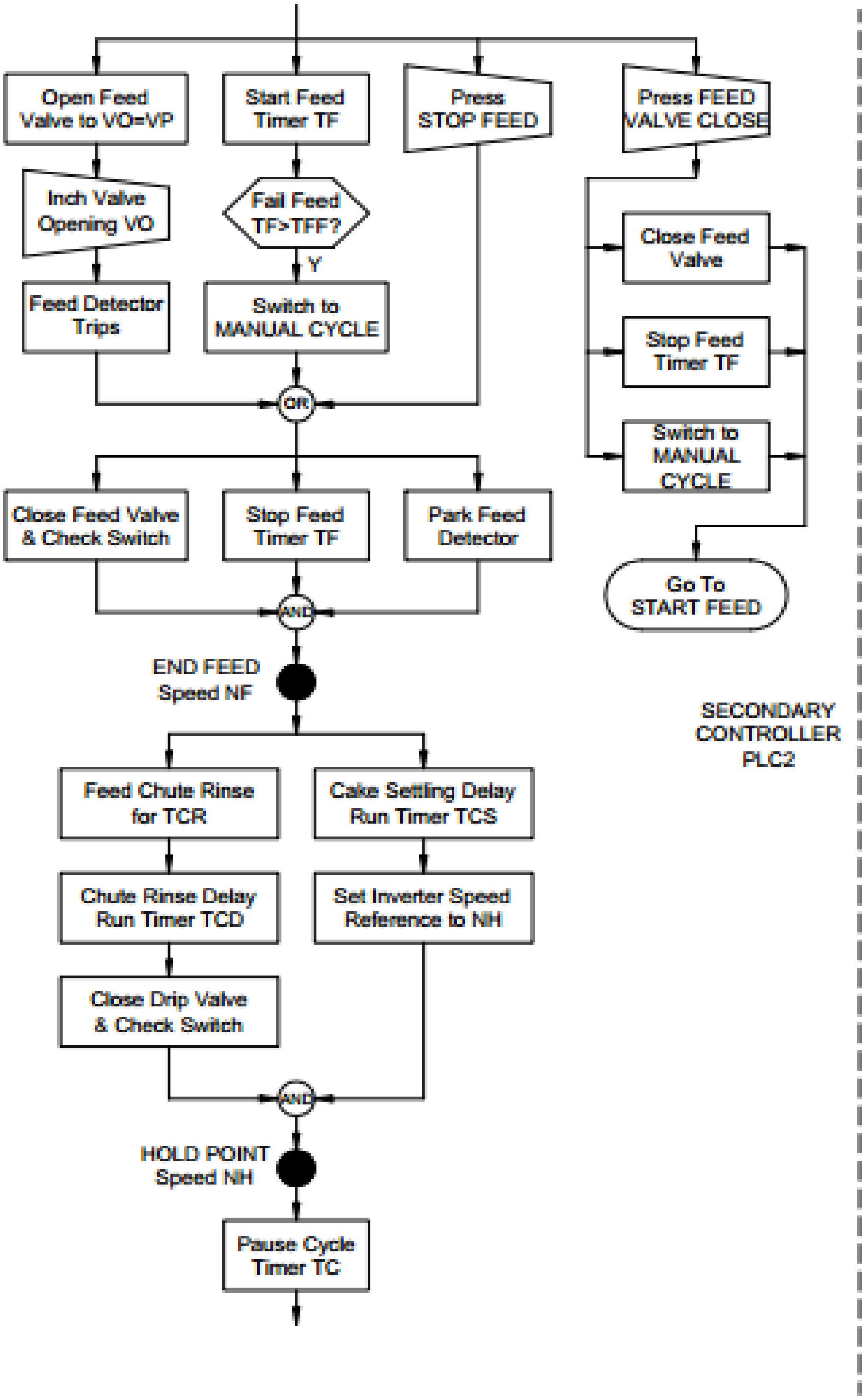
Main Cycle Sequence (1)



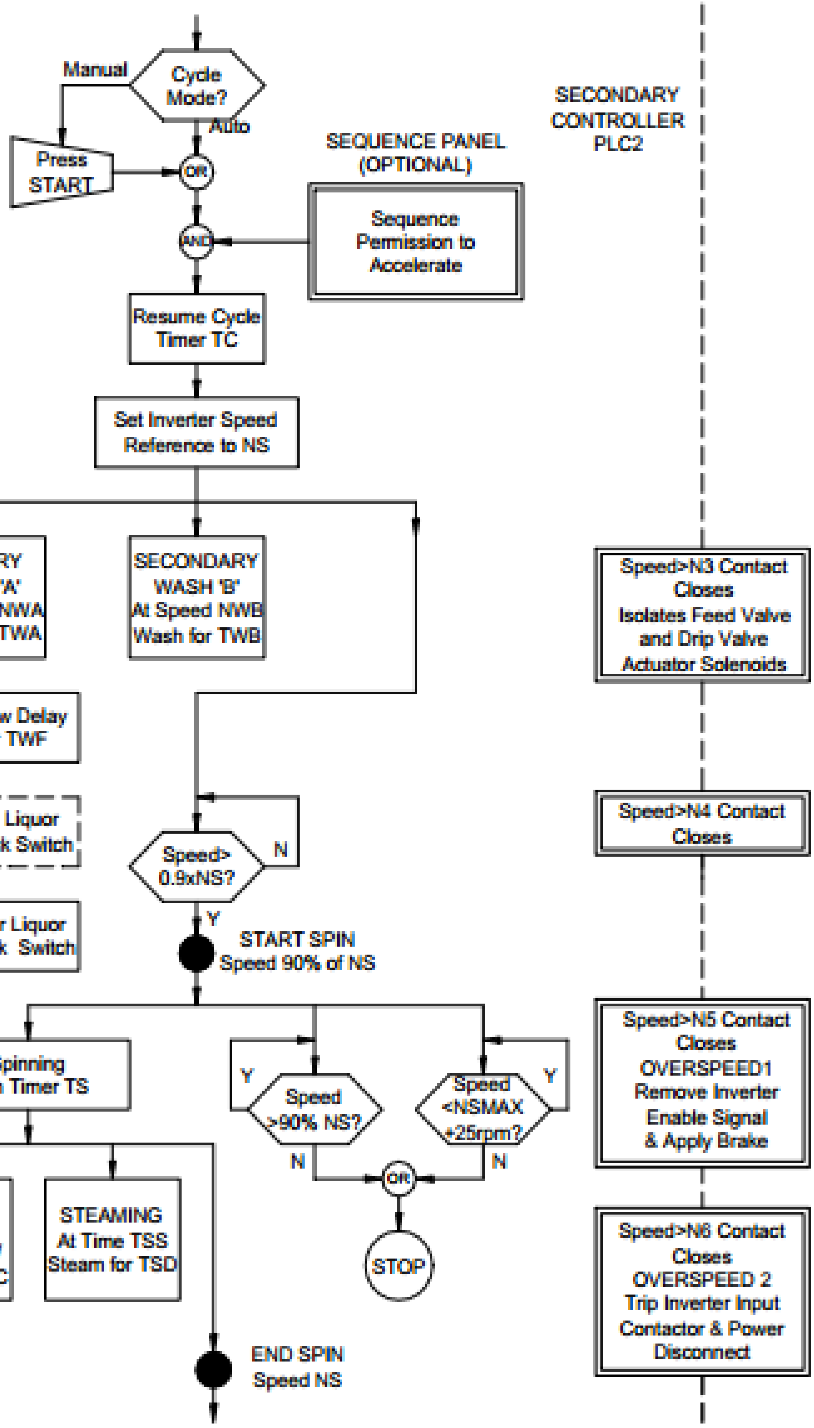
Main Cycle Sequence (2)



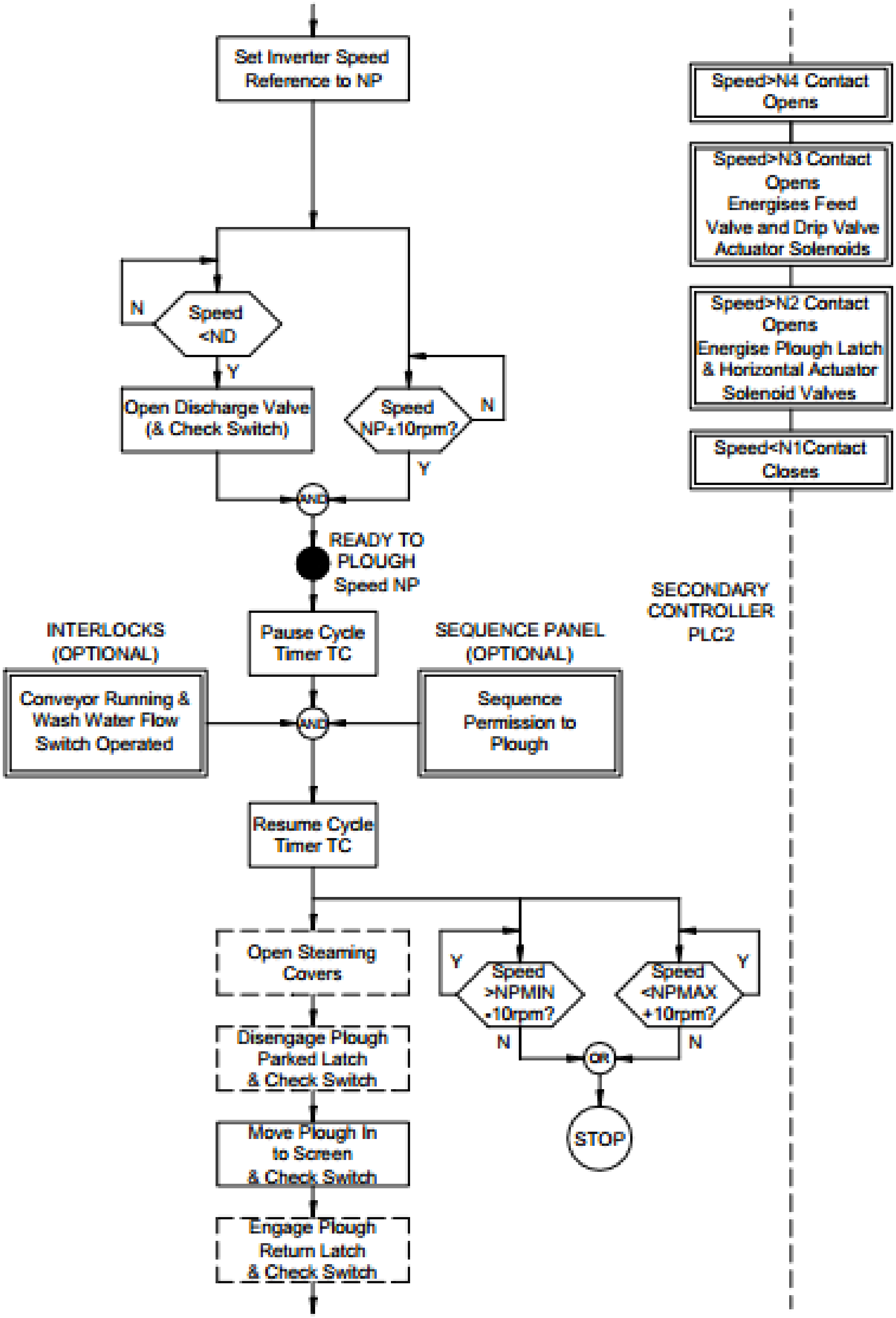
Main Cycle Sequence (3)



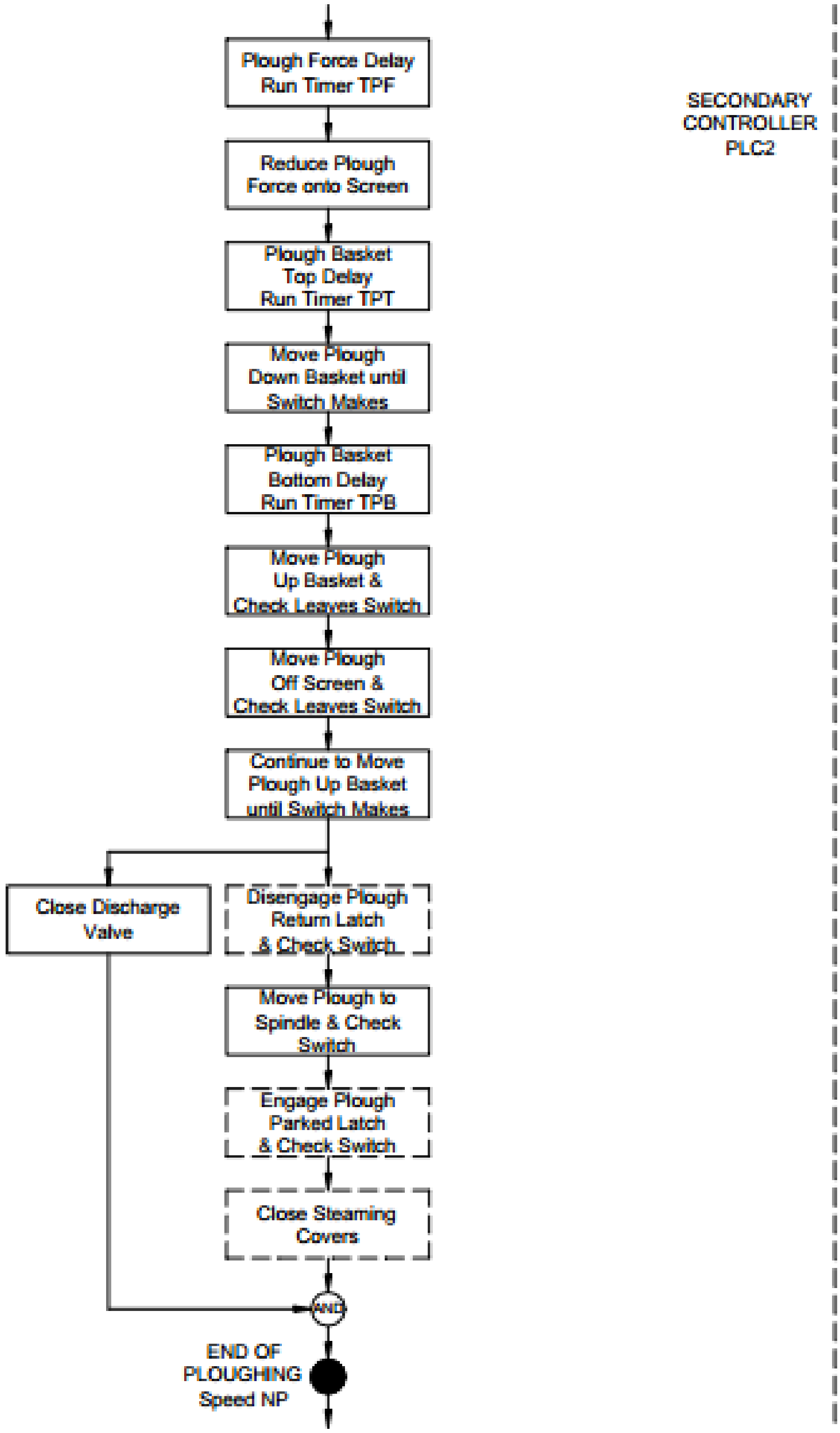
Main Cycle Sequence (4)



Main Cycle Sequence (5)



Main Cycle Sequence (6)



Main Cycle Sequence (7)