Chapter One

1. Introduction.

1.1 Introduction.

1.2 Importance of The Project.

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1.5 General Block Diagram.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Steam system is considered the main component for many Industrial factories mainly dairy and drinks. The system consists of the steam boiler, burner and steam piping system. Most of the Palestinian factories are working on LPG (Liquefied Petroleum Gas) not Diesel due to saving in running cost and due to the fact that LPG is less harmful to environment.

Steam systems are mainly used to supply steam for Pasteurization system. During Pasteurization, the system required stable quantity of steam with significant Pressure. Usually the factory faces problems in maintaining both quantity and pressure required. If they increase the steam pressure above the required pressure; they will pay more for running cost due to heat losses and they will increase the risk in the system due to high pressure. Also, if the use bigger steam boiler they will pay more for running cost due to the amount of energy required to heat the amount of water Inside it addition to the higher investment cost.

The second main issue is during no –load or smaller load when these boilers serve several applications. In the normal situation, the factory needs to start the boiler regardless the load which cost higher running cost.

The current gas burners installed on steam boilers are two stage burners. That means that burner start and stop at a certain rang of pressure –low pressure- high pressure- regardless the load required. The proposed change from two stages to modulating mode will give the system the ability to react according to the load required. This will be obtained by changing the pressure switch (on- off) to pressure transducer to give continuous reading for pressure to increase and decrease the rating of the burners accordingly.

The challenge when working on modulating mode is to predetermined the ratio between Air and gas. The proposed project will install O2 sensor at chimney. The reading of the sensor will be analyzed by controller which will control two stepper motors for burner Gas and air cams until we reach the right ratio.

This project aims to increase the efficiency of steam system and insure of complete combustion of gas.

1.2 Importance of the project.

- Increase efficiency of steam system.
- Reduce running cost when working on modulating mode instead of two stages mode. In modulating mode the burner capacity will be decided according to the load not on full load as in two stages mode.
- Insure complete combustion of gas to reduce emissions to environment.

1.3 Project objectives.

- Convert two stage gas burners to modulating burner.
- Auto adjustment of gas and air ratio.
- Monitoring of combustion gas flue.

1.4 Beneficiaries – consumers

- All factories that work on gas burners.

1.5 General Block Diagram

The burner contains main control box that control the sequence of operation for the burner. The proposed controller will be connected to the burner control box. The main signal to start the burner and running steam pressure will come from the proposed pressure transducer. The proposed controller will decide the required load according to the pressure reading.

The burner main control box will continue the operation of the burner including starting the fan motor and checking the gas valves. The burner main control box will send signal to start spark ignition and open gas valves and check that the burner flame exists. The proposed controller will operate the gas and air stepper motors which are connected to the burner cams according to pre- Programed angles. The O_2 sensor will send the reading to the proposed controller and in case the combustion is not complete, the controller will change the angles of the steppers.

Figure 1.1 shows the general block diagram for the project.

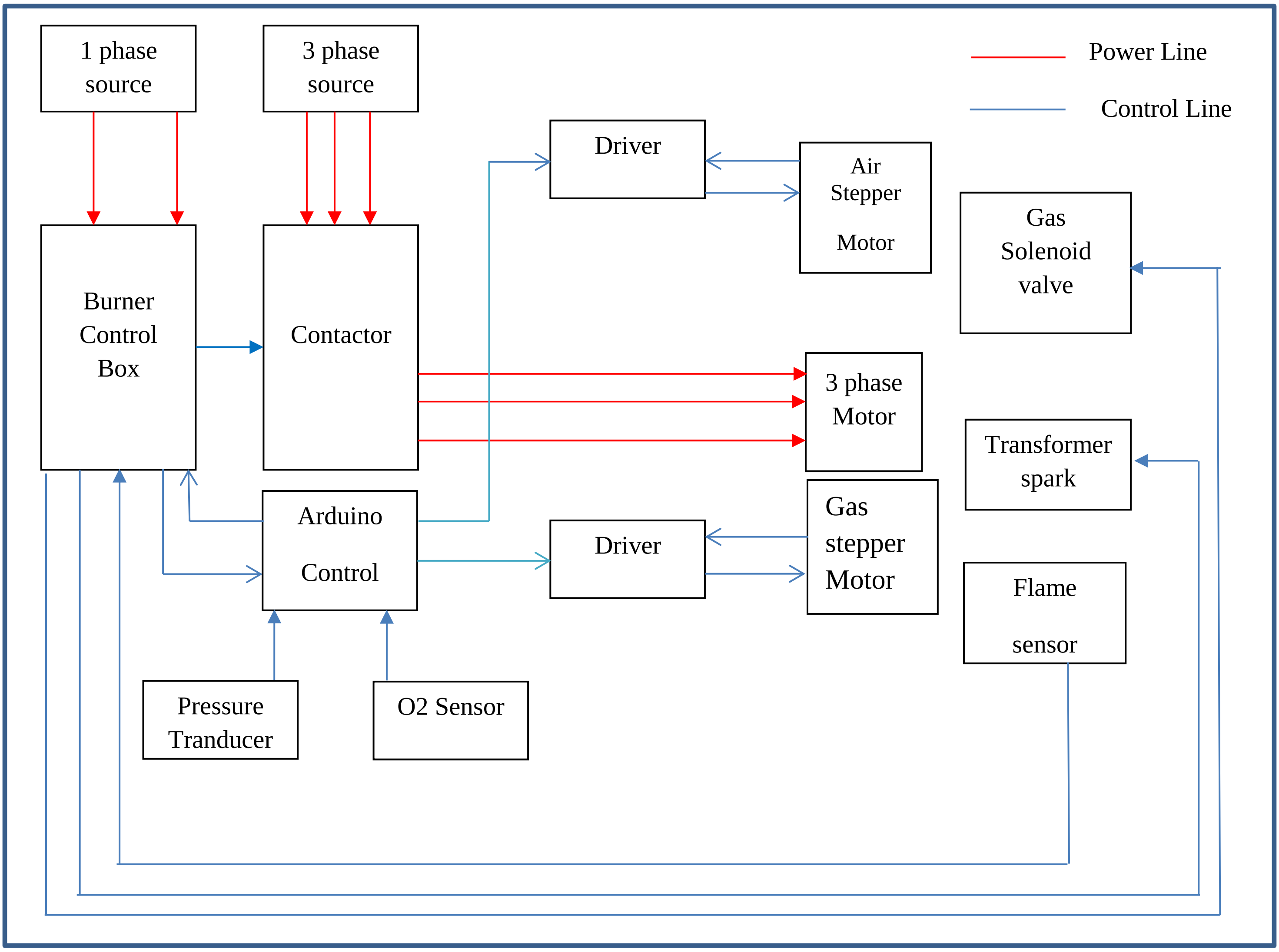


Figure 1.1 General Block Diagram

Chapter Two

General Overview of System Components.

2.1Gas Burners.

2.2Feeding gas system.

2.3Steam Boilers.

2.4Difficulties and Operation problems.

Chapter Two

General Overview of System Components.

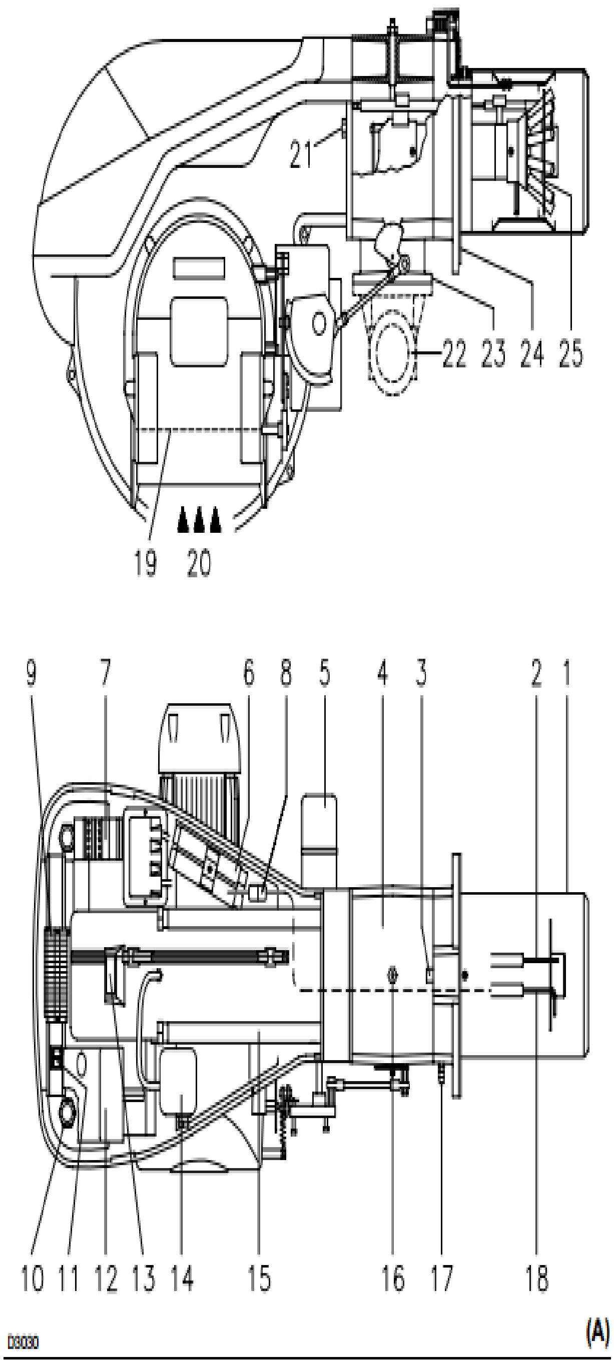
2.1 Gas Burners.

Burners work on the basis of fluid whether its liquid or Gas. For example, it works on diesel, crude oil, woods, natural Gas or industrial Gas (LPG GAS). Some of it operate with one flame to be used domestically at home for heat and some of it (with two stages) two flames operate in industrial facilities. For example, it can be used for heating oil as in food industry or for boiling water or to get steam for sterilization or pasteurization as in dairy products.

Burner consists of 5 components:

1- Air turbo engine
2- Spark for producing flame
3- Flame sensor to identify that there is a flame in order to keep supplying fuel/ gas and stop when there is not (flame)
4- Head mixer to mix the air and fuel
5- Stepper motor or servo motor to move the air gates from stage one to stage two

The burners consist of the following parts as shown in figure 2.1. (Riello RS 70 Catalog)



1 Combustion head
2 Ignition electrode
3 Screw for combustion head adjustment
4 Sleeve
5 Servomotor controlling the gas butterfly valve and of air gate valve
6 Extension for slide bars
7 Motor contactor and thermal cut-out reset button
8 Plug-socket on ionization probe cable
9 Terminal strip
10 Fairleads for electrical connections by installer
11 Two switches:
- one ≈burner off-onΔ
- one for ≈1st - 2nd stage operationΔ
12 Control box with lock-out pilot light and lock out reset button
13 Flame inspection window
14 Minimum air pressure switch

(differential operating type)
15 Slide bars for opening the burner and inspecting the combustion head
16 Gas pressure test point and head fixing screw
17 Air pressure test point
18 Flame sensor probe
19 Air gate valve
20 Air inlet to fan
21 Screws securing fan to sleeve
22 Gas input pipework
23 Gas butterfly valve
24 Boiler mounting flange
25 Flame stability disk

Figure 2.1 Gas burner Parts

Burner Operation

Table 2.1 shows the sequence of burner operation at starting.

Time (Sec)	Activity
	Control device TL closes. Servomotor starts: it rotates during opening up to the angle set on cam with orange lever. After about 3s:
0 s	The control box starting cycle begins.
2 s	Fan motor starts.
3 s	Servomotor starts: it rotates during opening until contact is made on cam with red lever. The air gate valve is positioned to 2nd stage output. Pre-purge stage with air delivery at 2nd stage output. Duration 25 seconds.
28 s	Servomotor starts: it rotates during closing up to the angle set on cam with orange lever.
43 s	The air gate valve and the gas butter-fly are positioned to 1st stage output. Ignition electrode strikes a spark. Safety valve VS and adjustment valve VR (rapid opening) open. The flame is ignited at a low output level, point A. Output is then progressively increased, with the valve opening slowly up to 1st stage output, point B.
45 s	The spark goes out.
53 s	If remote control device TR is closed or if it has been replaced by a jumper, the servomotor will continue to turn until the cam with red lever come into operation, setting the air gate valve and the gas butterfly valve to the 2nd stage operation position, section C-D. The control box starting cycle ends.

Table 2.1 Burner Operation

The two-stage mode burner works as shown in figure 2.2:

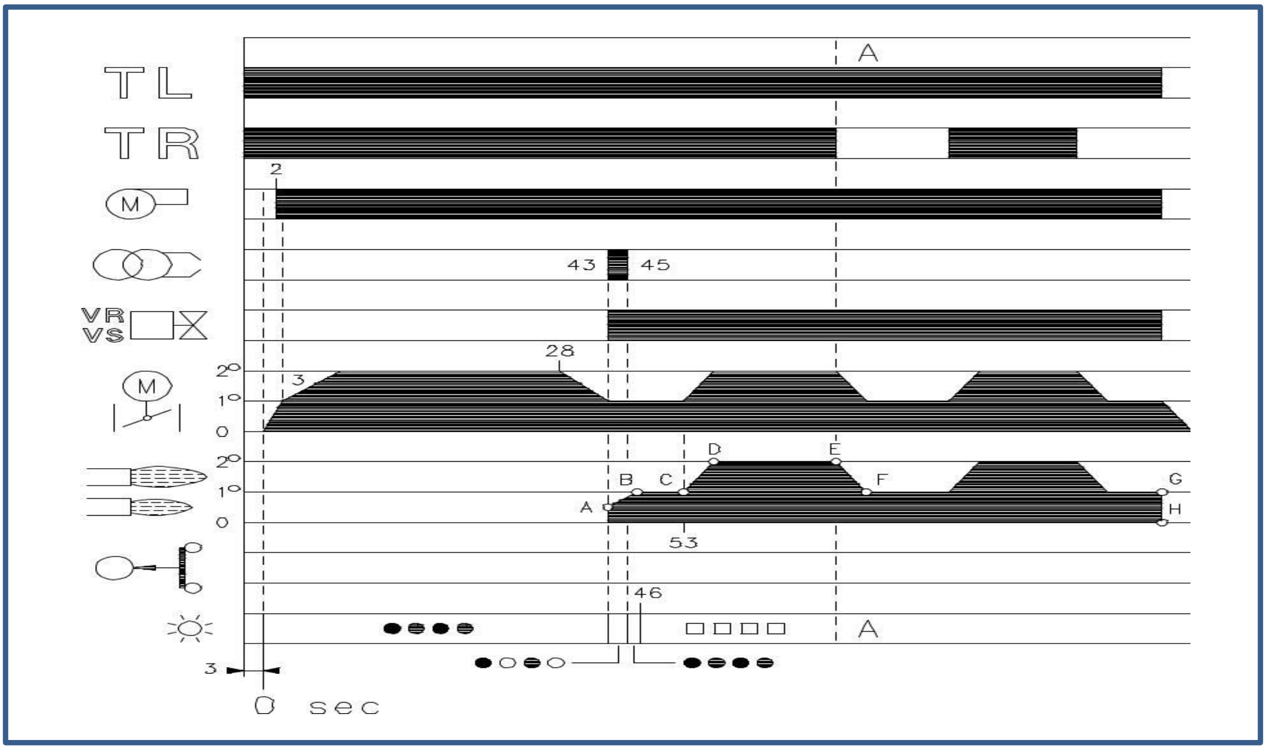


Figure 2.2 Two- stage burner operating mode

Burner Electrical Diagram:

The burner electrical diagram consists of the following:

- Power Supply; the main supply is three phase electrical connection which is connected to main overload protection switch in series to main contactor.
- Main control box; this control box is program to start/ stop the burner and control operation sequence.
- Transformer; the transformer aims to give the required spark for ignition.
- Fan motor; the main motor which is connected to the fan to supply the required air to the burner head.
- Air pressure switch; this switch sense the pressure of air supplied.
- Flame sensor / Ionization probe; this probe senses the existing of flame.

Figure 2.3 shows the main electrical diagram for the burner.

CMV - Motor contactor

DA - Control box (Landis RMG)

F1 - Protection against radio

interference

K1 - Relay

I1 - Switch: burner off - on

I2 - Switch: 1st - 2nd stage operation

MB - Burner terminal strip

MV - Fan motor

PA - Air pressure switch

RT - Thermal cut-out

SM - Servomotor

SO - Ionisation probe

SP - Plug-socket

TA - Ignition transformer

TB - Burner ground

XP1 - Connector for STATUS

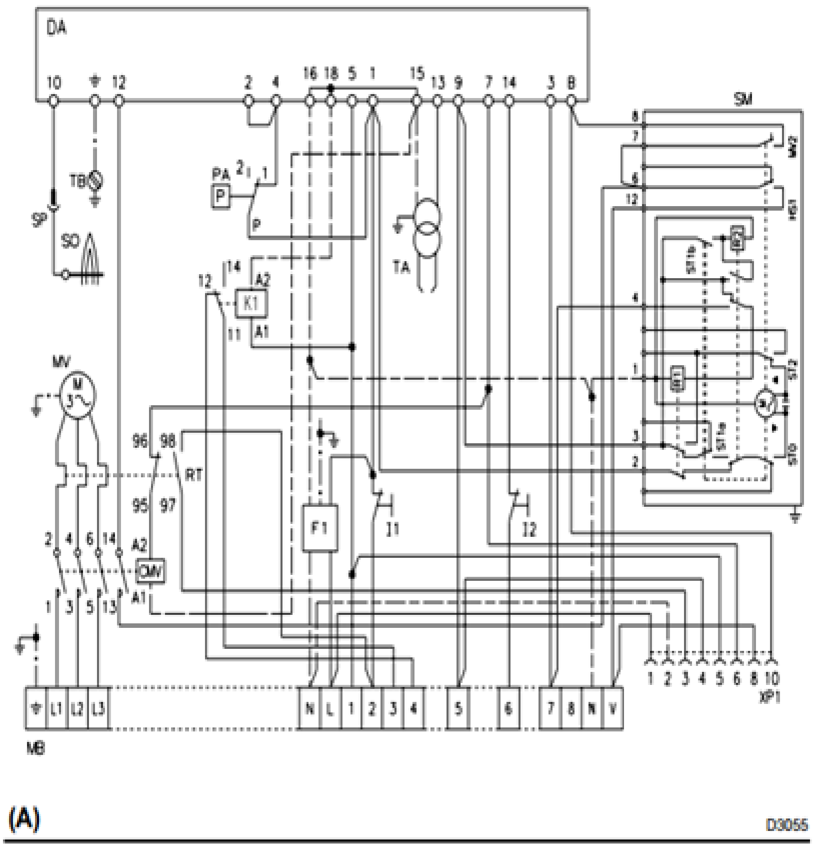


Figure 2.3 Burner Electrical Layout

2.3 Feeding gas system.

The gas system before burner is called gas train. The system should supply enough Quantity of gas with certain pressure according to the burner. The system consists of the following as shown in figure 2.3 and table 2.3.

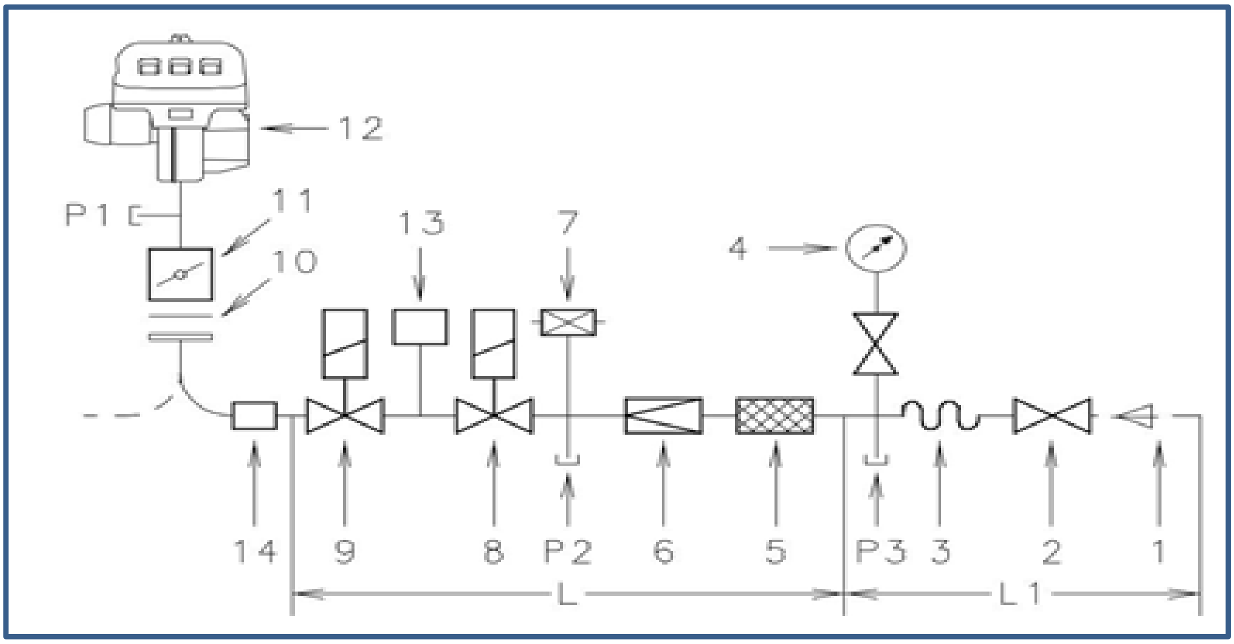


Figure 2.4 Gas Train

Part Number	Description
1	Gas input pipe
2	Manual valve
3	Vibration damping joint
4	Pressure gauge with pushbutton cock
5	Filter
6	Pressure governor
7	Minimum gas pressure switch
8	Safety solenoid
9	Adjustment solenoid

Table 2.2 Parts of Gas Train

2.4 Steam Boilers.

Steam boilers are selected according to the required steam quantity and working Pressure.

2.4.1 Definition of Steam Boiler:

Steam boiler or simply a boiler is basically a closed vessel into which water is heated until the water is converted into steam at required pressure.

2.4.2 Working Principle of Boiler

The basic working principle of boiler is very simple and easy to understand. The boiler is essentially a closed vessel inside which water is stored. Fuel is bunt in a furnace and hot gasses are produced. These hot gasses come in contact with water vessel where the heat of these hot gases transfer to the water and consequently steam is produced in the boiler. Then this steam is piped to the turbine of thermal power plant. There are many different types of boiler utilized for different purposes like running a production unit, sanitizing some area, sterilizing equipment, to warm up the surroundings etc.

2.4.3 Steam Boiler Efficiency

The percentage of total heat exported by outlet steam in the total heat supplied by the fuel is called steam boiler efficiency.

$$Steam\ Boiler\ Efficiency(\%) = \frac{Heat\ exported\ by\ outlet\ steam}{Heat\ supplied\ by\ the\ fuel} \times 100$$

It includes with thermal efficiency, combustion efficiency & fuel to steam efficiency. Steam boiler efficiency depends upon the size of boiler used. A typical efficiency of steam boiler is 80% to 88%. Actually, there are some losses occur like incomplete combustion, radiating loss occurs from steam boiler surrounding wall, defective combustion gas etc. Hence, efficiency of steam boiler gives this result.

2.4.4 Types of Boiler

There are mainly two types of boiler – water tube boiler and fire tube boiler. In fire tube boiler, there are numbers of tubes through which hot gases are passed and water surrounds these tubes. Water tube boiler is reverse of the fire tube boiler. In water tube boiler, the water is heated inside tubes and hot gasses surround these tubes. These are the main two types of boiler but each of the types can be sub divided into many which we will discuss later.

2.4.5 Steam Boilers in the market.

The normal boilers used here in Palestine are fire type boilers; mainly two types:

- Reverse flame boilers.
- Three pass boilers.

- Reverse flame steam boiler:

This is a variation on conventional boiler design. The combustion chamber is in the form of a thimble, and the burner fires down the center. The flame doubles back on itself within the combustion chamber to come to the front of the boiler. Smoke tubes surround the thimble and pass the flue gases to the rear of the boiler and the chimney.

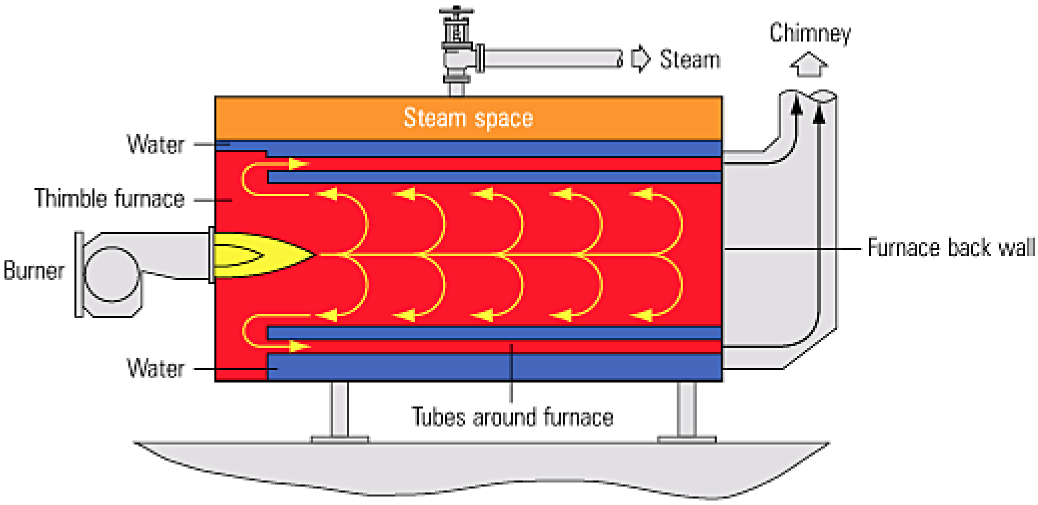


Figure 2.5 Reverse Flame Steam Boiler

- Three pass boiler

Each set of tubes that hot combustion flue gas travels through before making a turn within the boiler, is considered a "pass." A 3-pass fire tube boiler design consists of three sets of horizontal tubes, with the stack outlet located on the rear of the boiler. A downdraft design keeps the cooler water from having an effect on the hot surfaces within the boiler.

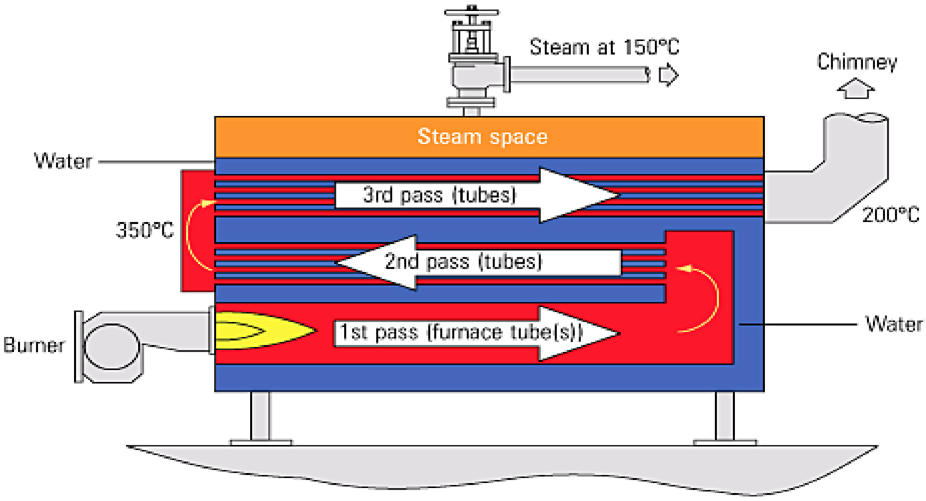


Figure 2.6 Three pass steam boiler

Usually steam boilers have two stage burners with Three pressure switches that control the burner start/stop.

Two of pressure switches will be replaced by pressure transducer.

The third will be used for safety.

2.5 Difficulties and Operation problems.

- Combustion is not complete.
- The burner is not compatible with the load change.

Chapter Three

General Design of The System

3.1 Air Cam Stepper Motor.

3.2 Gas Cam Stepper Motor.

3.3 Steam Pressure Transducer.

3.4 O2 Sensor.

Chapter Three

General Design of The System

The new proposed system consists of three main parts as shown below:

1- Replacing the existing servo motor that control air and gas cams with two stepper motors for each cam alone. This will allow to control each cam alone and get the desired angle for each cam.

2- Replacing the steam pressure switches with pressure transducer. This will allow to get the drop-in pressure according to the steam consumption at the factory and needed load.

3- Adding O_2 sensor at the chimney to measure O_2 percentage. This will allow to check that the combustion is complete.

3.1 Air cam stepper motor:

The required servo motor will be installed on the air cam, this cam regulates the Amount of air that enters the burner chamber.

3.1.1 Stepper Motor Construction

A Stepper Motor or a step motor is a brushless, synchronous motor which divides a full rotation into a number of steps. Unlike a brushless DC motor which rotates continuously when a fixed DC voltage is applied to it, a step motor rotates in discrete step angles. The Stepper Motors therefore are manufactured with steps per revolution of 12, 24, 72, 144, 180, and 200, resulting in stepping angles of 30, 15, 5, 2.5, 2, and 1.8 degrees per step. The stepper motor can be controlled with or without feedback. Figure 3.1 shows the stepper motor.

Figure 3.1 Stepper Motor

3.1.2 Stepper motor work principal

Stepper motors work on the principle of electromagnetism. There is a soft iron or magnetic rotor shaft surrounded by the electromagnetic stators. The rotor and stator have poles which may be teethed or not depending upon the type of stepper. When the stators are energized the rotor moves to align itself along with the stator (in case of a permanent magnet type stepper) or moves to have a minimum gap with the stator (in case of a variable reluctance stepper). This way the stators are energized in a sequence to rotate the stepper motor. Figure 3.2 shows stepper motor electrical coil and mechanical part.

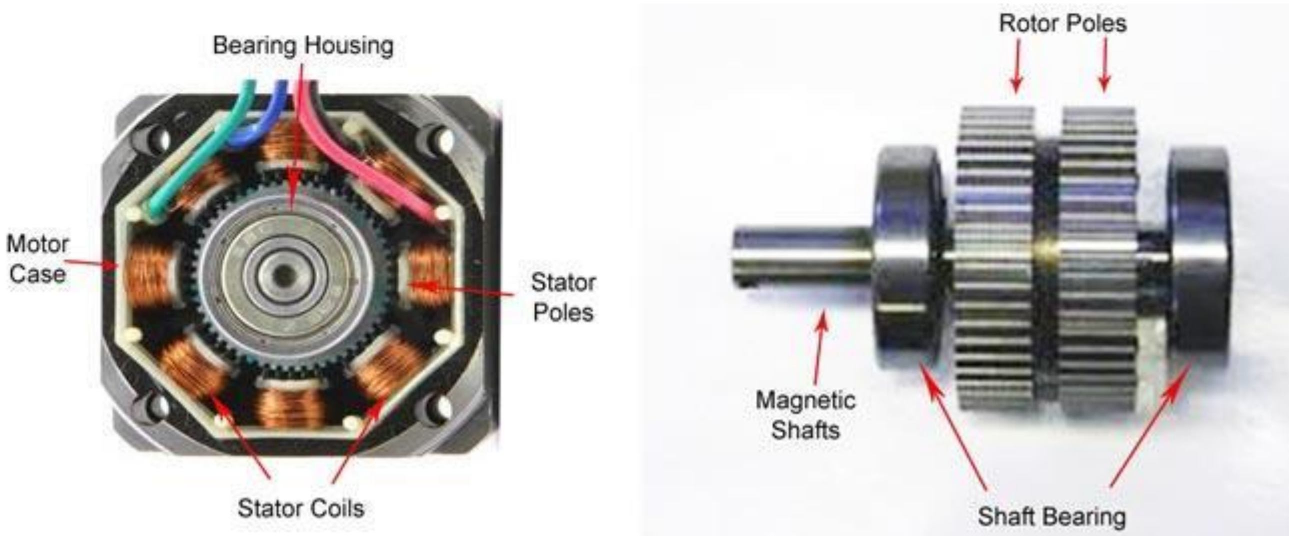


Figure 3.2 Stepper motor Electrical coils & Mechanical Parts

3.1.3 Types of Stepper Motor

By construction the step motors come into three broad classes:

1. Permanent Magnet Stepper
2. Variable Reluctance Stepper
3. Hybrid Step Motor

3.1.4 Types of Winding and Lead-out

The step motors are mostly two-phase motors. These can be unipolar or bipolar. In unipolar step motor, there are two winding per phase. The two winding to a pole may have one lead common i.e. center tapped. The unipolar motor so, have five, six or eight leads. In the designs where the common of two poles are separate but center tapped, motor have six leads. If the center taps of the two poles are internally short, the motor has five leads. Eight lead unipolar facilitates both series and parallel connection whereas five lead and six lead motors have series connection of stator coils. The unipolar motor simplifies the operation because in operating them there is no need to reverse the current in the driving circuit. These are also called bifilar motors. Figure 3.3 shows unipolar stepper motor.

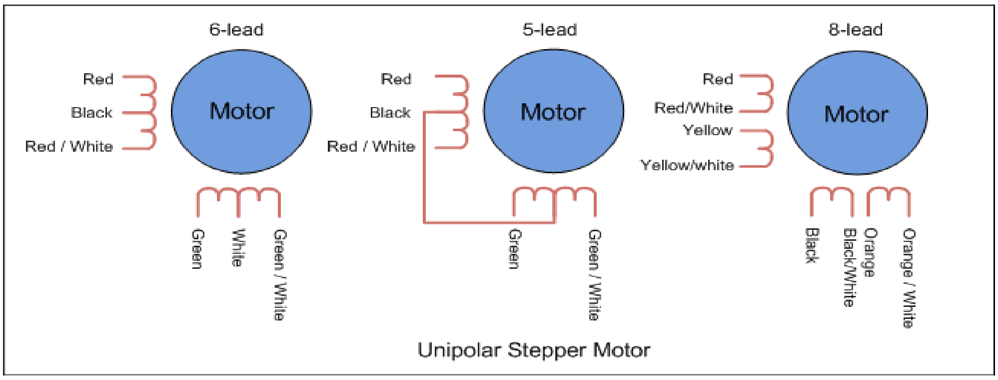


Figure 3.3 Unipolar Stepper Motor

In bipolar stepper, there is single winding per pole. The direction of current need to be changed by the driving circuit so the driving circuit of the bipolar stepper becomes complex. These are also called unifiliar motors. Figure 3.4 shows bipolar stepper motor.

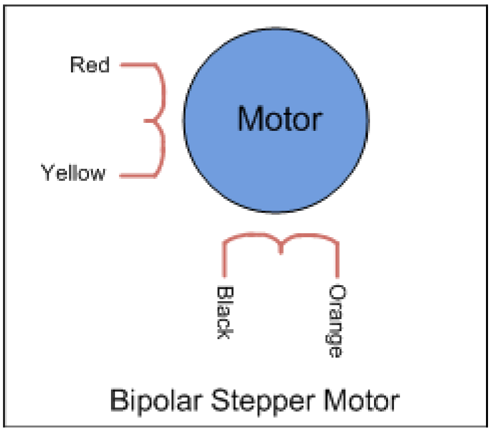


Figure 3.4 Bipolar Stepper Motor

For the required application, we need stepper motor able to produce torque not less than 1.2 -3 N/m.

The maximum only should be 0-90° also it should have holding torque to stable the Opening.

3.2 Gas cam stepper motor:

The required stepper motor will be installed on the gas cam, this cam regulates the Amount of gas that enters the burner chamber.

The stepper should be able to produce torque not less than 1.2 -3 N/m.

The maximum only should be 0-90° also it should have holding torque to stable the Opening.

3.3 Steam pressure transducer:

The pressure transducer should have a measuring range of 0-12 bar and should be for Steam without put of 4-20 mA.

3.4 O2 Sensor:

The sensor will be installed in the chimney, so it should be able to will stand To 450°.

Percentage of O2 from 0-21 % in volume.

Chapter Four

Hardware & Equipment Selection.

4.1.1 Air Cam Stepper Motor Selection.

4.1.2 Gas Cam Stepper Motor Selection.

4.1.3 Steam Pressure Transducer Selection.

4.1.4 O2 Sensor Selection.

4.1.5 New Burner Electrical & Mechanical Layout.

Chapter Four

Hardware & Equipment Selection.

4.1 Air Cam Stepper Motor Selection.

After searching the available models in market; and after matching the required torque to control the air cam according to burner manufacturer. We select Stepper motor Nema 23 double stack, the output torque is 2.3 N/m which suitable to the needed application. The figure 4.1 below shows the stepper motor. The whole stepper data is shown in Appendixes B. Table 4.1 shows the data for the stepper motor.

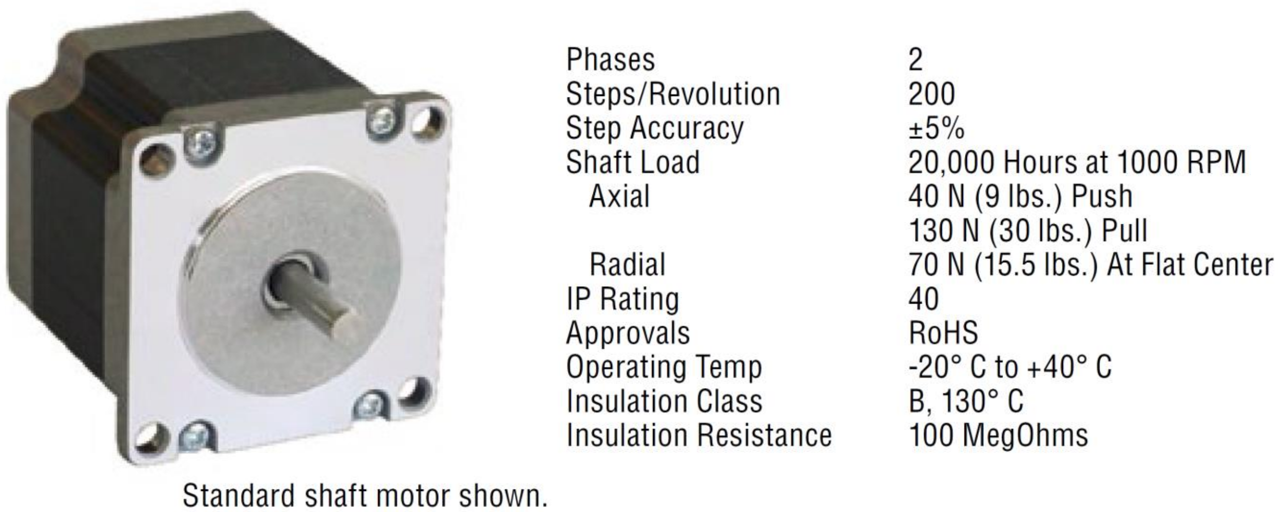


Figure 4.1 Stepper motor Nema 23

Description	Length	Mounted Rated Current	Mounted Holding Torque		Winding Ohms	Winding mH	Detent Torque		Rotor Inertia		Motor Weight	
(Stack)	"L" Max	Amps	Nm Typ.	oz-in Typ.	±10% @ 20°C	Typ.	mNm	oz-in	g cm2	oz-in2	kg	lbs
Single	55.0 mm (2.17 in)	2.2	1.50	210	1.6	6.9	45	6.4	220	1.2	0.6	1.3
Double	77.0 mm (3.03 in)	3	2.30	330	1.1	4.5	75	11	390	2.1	1	2.2
Power Plus (Triple)	77.0 mm (3.03 in)	3	3.30	470	1.1	3.7	150	21	390	2.1	1.1	2.4

Table 4.1 Stepper Motor Data

4.2 Gas Cam Stepper Motor Selection.

The gas cam stepper motor was selected the same as air cam stepper motor.

4.3 Steam Pressure Transducer Selection.

The Pressure transducer was selected according to the available models at the market to match the required pressure and temperature. The Model is Danfoss Pressure transmitter type EMP 2. The measuring range is up to 25 bars and the output is 4-20 milliamp. The figure 4.3 shows the selected transducer. The whole data is shown in Appendixes D.

Figure 4.2 Pressure Transducer

4.4 O2 Sensor Selection.

The O2 sensor was selected to the available models in the market and required measuring range. The selected sensor is Bosch Lambda sensor model VW AG 19 2 031 90662.

An output voltage of 0.2 V (200 mV) DC represents a "lean mixture" of fuel and oxygen, where the amount of oxygen entering the chimney is sufficient to fully oxidize the carbon monoxide (CO), produced in burning the air and fuel, into carbon dioxide(CO_2). An output voltage of 0.8 V (800 mV) DC represents a "rich mixture", one which is high in unburned fuel and low in remaining oxygen. The ideal set point is approximately 0.45 V (450 mV) DC. This is where the quantities of air and fuel are in the optimum ratio, which is ~0.5% lean of the stoichiometric point, such that the exhaust output contains minimal carbon monoxide.

The voltage produced by the sensor is nonlinear with respect to oxygen concentration. The sensor is most sensitive near the stoichiometric point (where $\lambda = 1$) and less sensitive when either very lean or very rich. Figure 4.3 shows the voltage characteristic of the Lambda sensor. Figure 4.4 shows the sensor description.

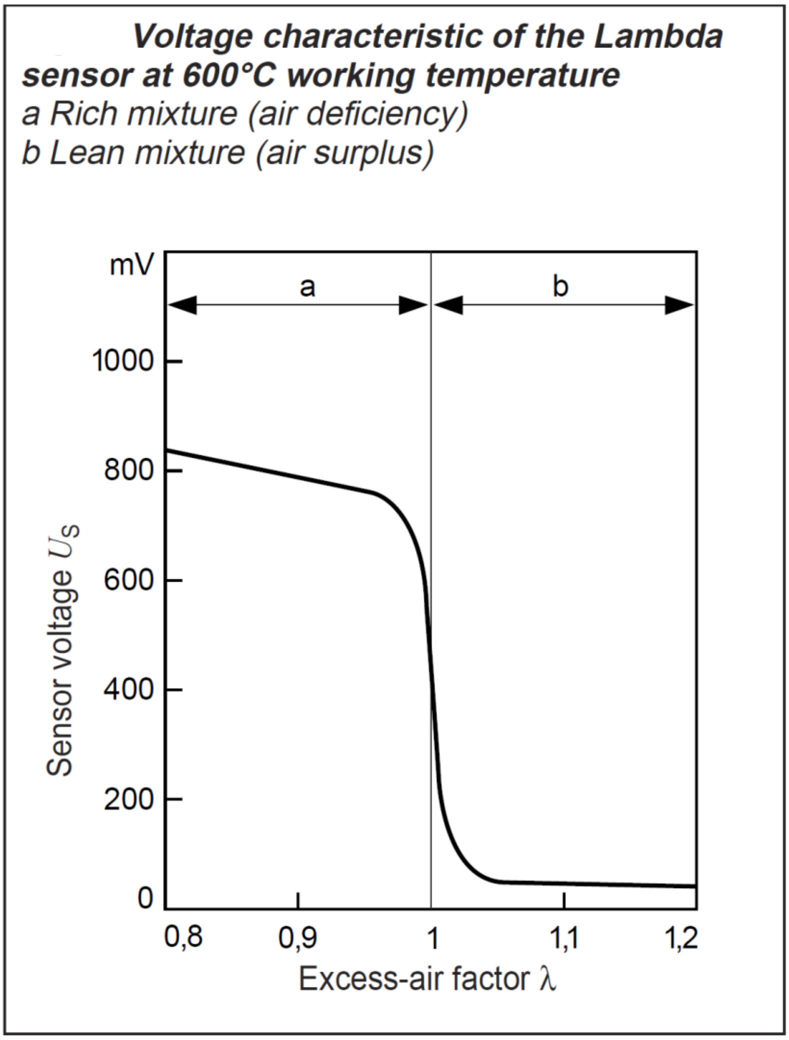


Figure 4.3 Voltage Characteristic for Lambda Sensor

Heated Lambda sensor LSH

1 Connection cable, 2 Disc spring, 3 Ceramic support tube, 4 Protective sleeve, 5 Clamp connection for the heating element, 6 Heating element, 7 Contact element, 8 Sensor housing, 9 Active sensor ceramic, 10 Protective tube.

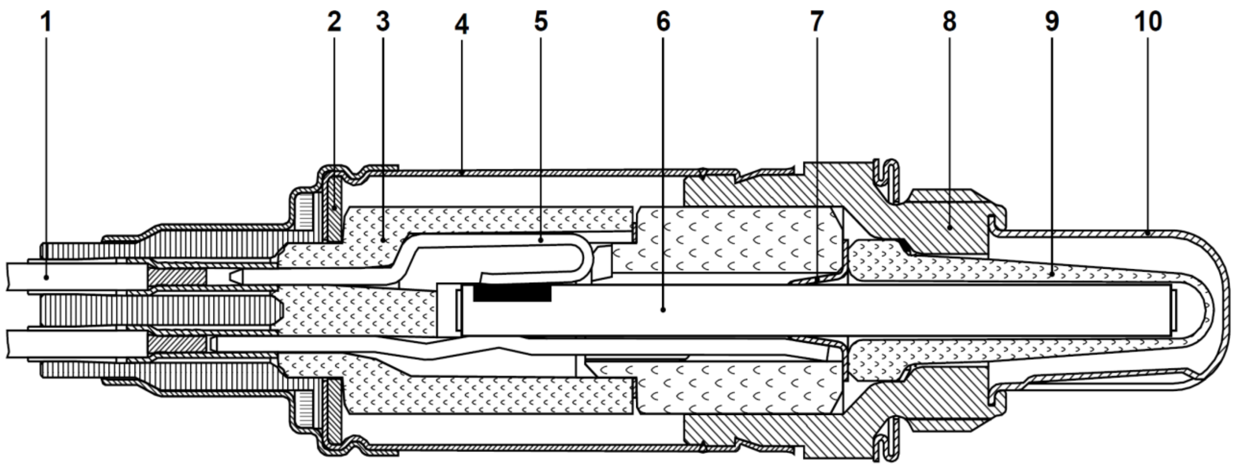


Figure 4.4 Sensor Description

4.5 New Burner Electrical & Mechanical Layout.

- Mechanical Layout:

The main servo motor that controls the air and gas both cams will be replaced by two stepper motors to control each cam alone. Figure 4.5 shows the new burner mechanical layout.

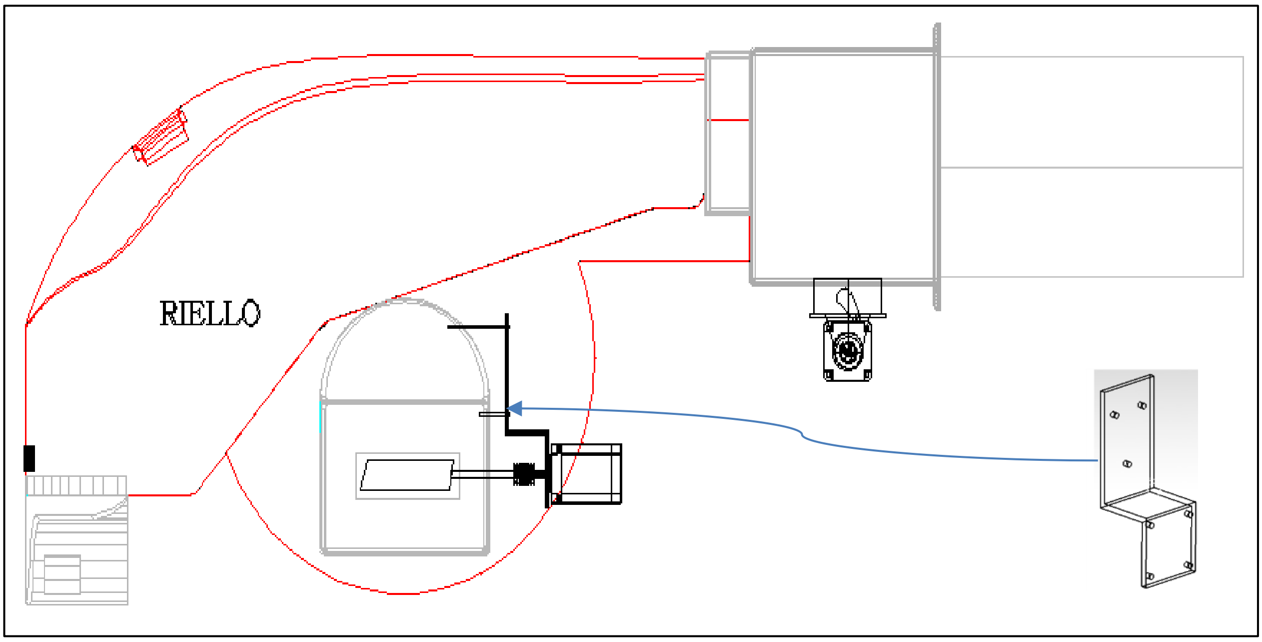
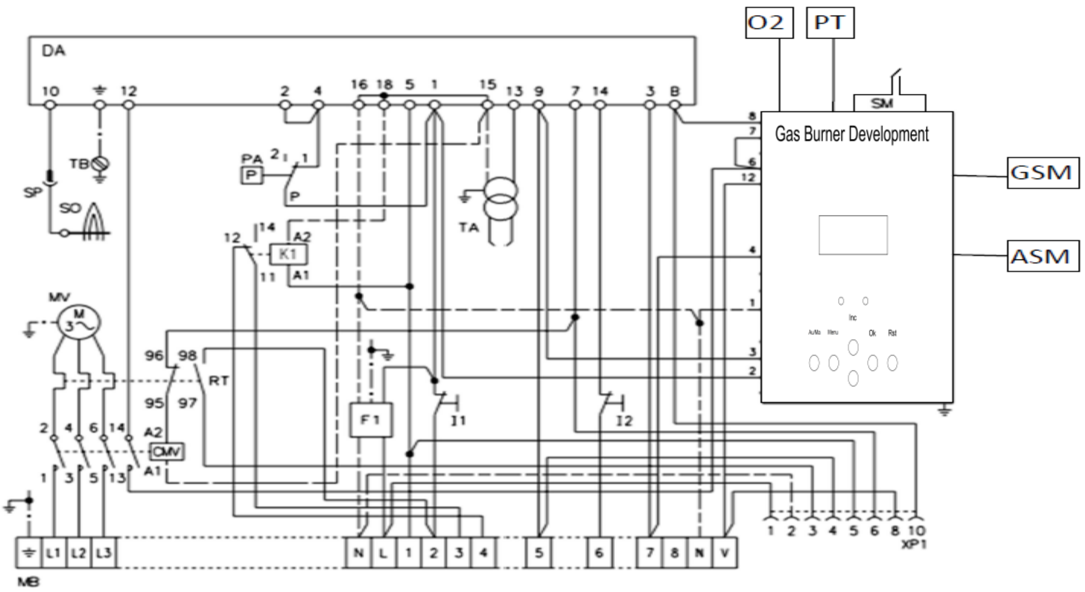


Figure 4.5 Burner Mechanical layout

- Electrical Layout:

The electrical connections of the removed servo motor will be connected to the ports of the Arduino controller. Some of the outputs of the Arduino will be connected to the stepper motors drivers. The O2 sensor and steam pressure transducer will be connected to one of the Arduino ports. Also, a manual selector switch will be connected to the Arduino. Figure 4.6 shows the new electrical layout. Figure 4.7 shows the electrical diagram for the new control box. All drawings were done using Proteus 8 Professional Program.



CMV - Motor contactor

DA - Control box (Landis RMG)

F1 - Protection against radio interference

K1 - Relay

I1 - Switch: burner off - on

I2 - Switch: 1st - 2nd stage operation in manual

MB - Burner terminal strip

MV - Fan motor

PA - Air pressure switch

RT - Thermal cut-out

SM – switch :auto-manual

SO - Ionization probe

SP - Plug-socket

TA - Ignition transformer

TB - Burner ground

XP1 - Connector for STATUS

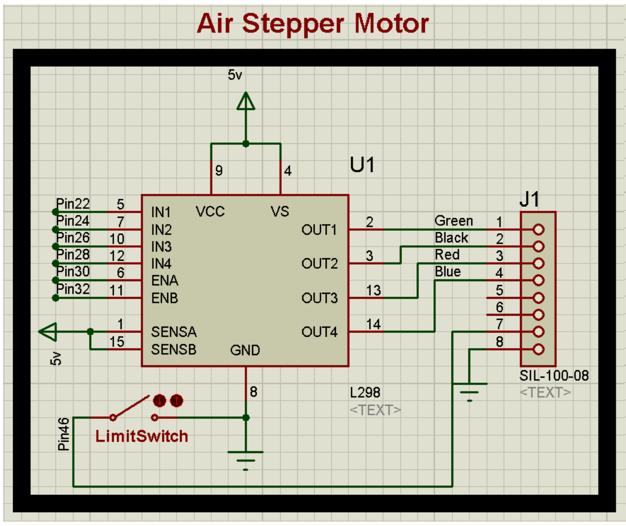
O2 – O2 Sensor

PT – Pressure Transducer

GSM – Gas Stepper Motor

ASM – Air Stepper Motor

Figure 4.6 New Electrical Layout


Air Stepper Motor
5v
U1
J1
Pin22
Pin24
Pin26
Pin28
Pin30
Pin32
IN1
IN2
IN3
IN4
ENA
ENB
VCC
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L298
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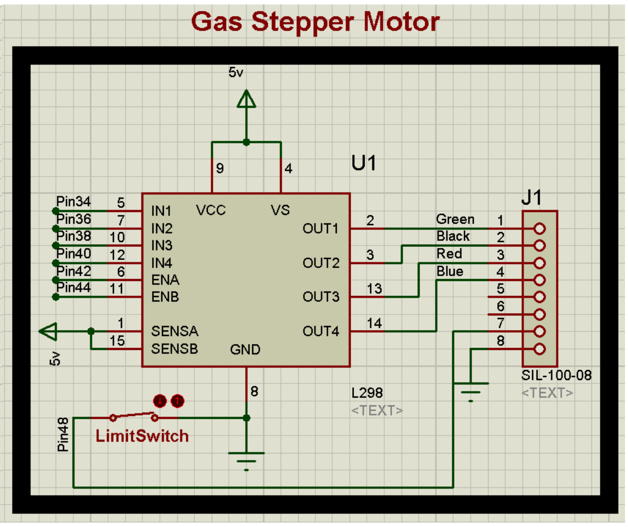
Pin46
LimitSwitch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Pin40
Pin42
Pin44
IN1
IN2
IN3
IN4
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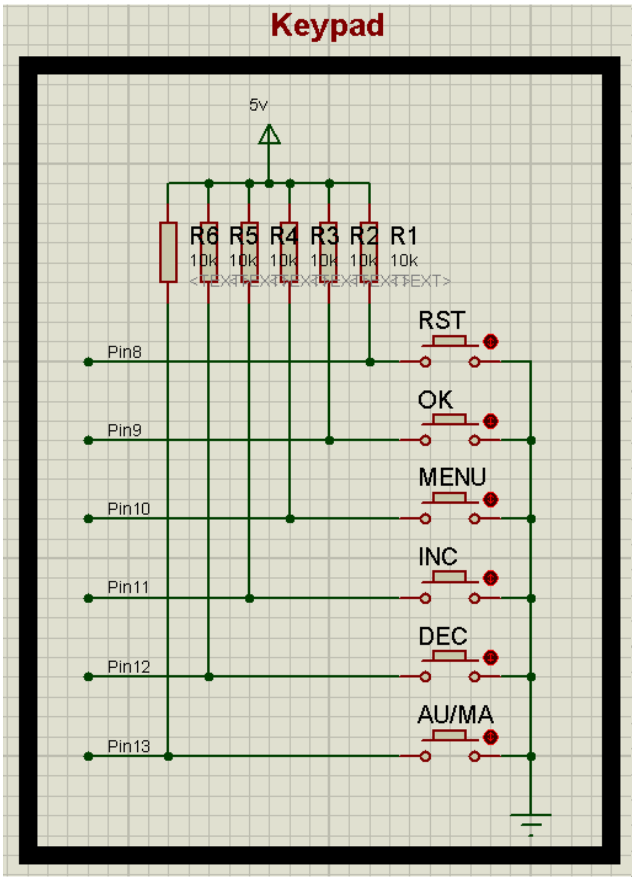
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R5
R4
R3
R2
R1
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RST
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MENU
INC
DEC
AU/MA
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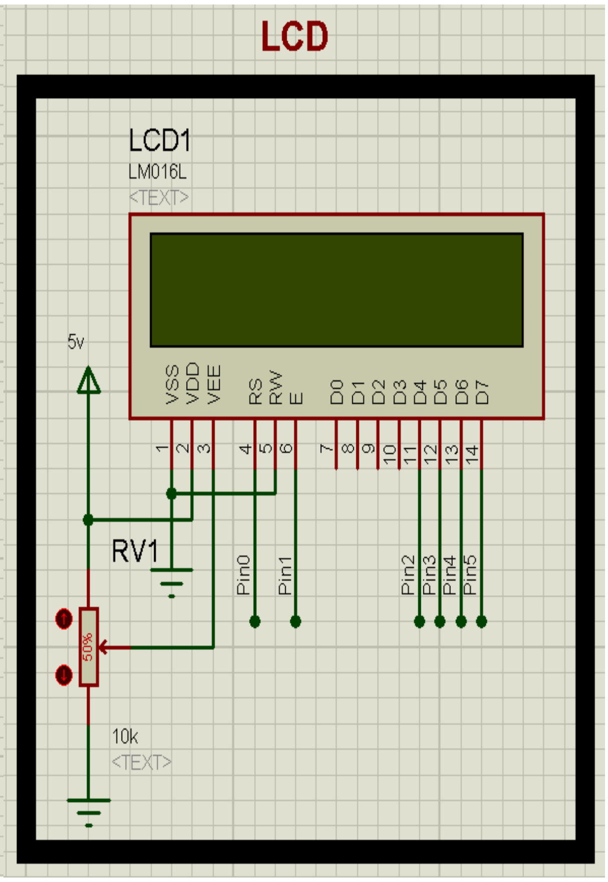
Pin10
Pin11
Pin12
Pin13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VEE
RS
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D4
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D6
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Pin2
Pin3
Pin4
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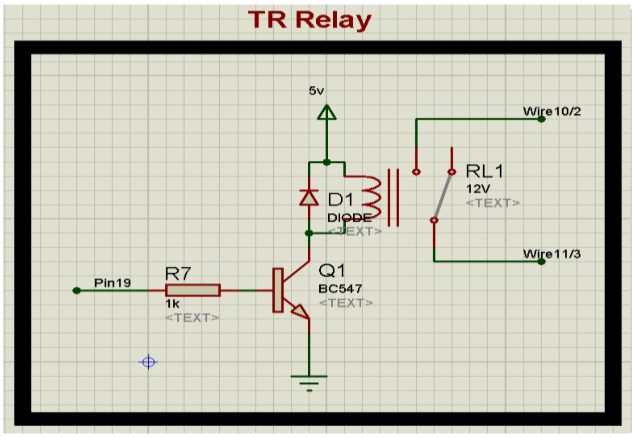
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Wire11/3
RL1
12V
D1
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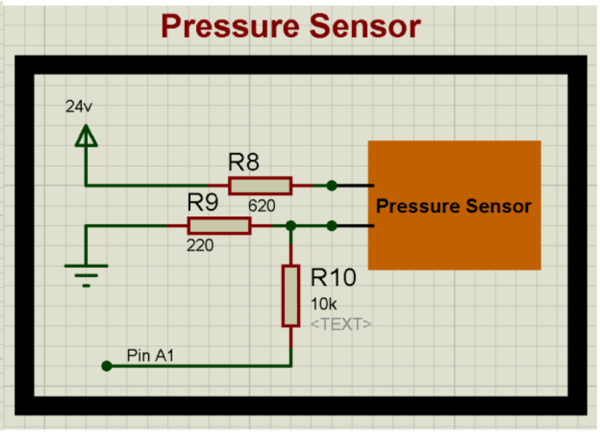
Q1
BC547
Pin19
R7
1k
<TEXT>


Pressure Sensor
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R8
620
R9
220
R10
10k
<TEXT>
Pressure Sensor
Pin A1

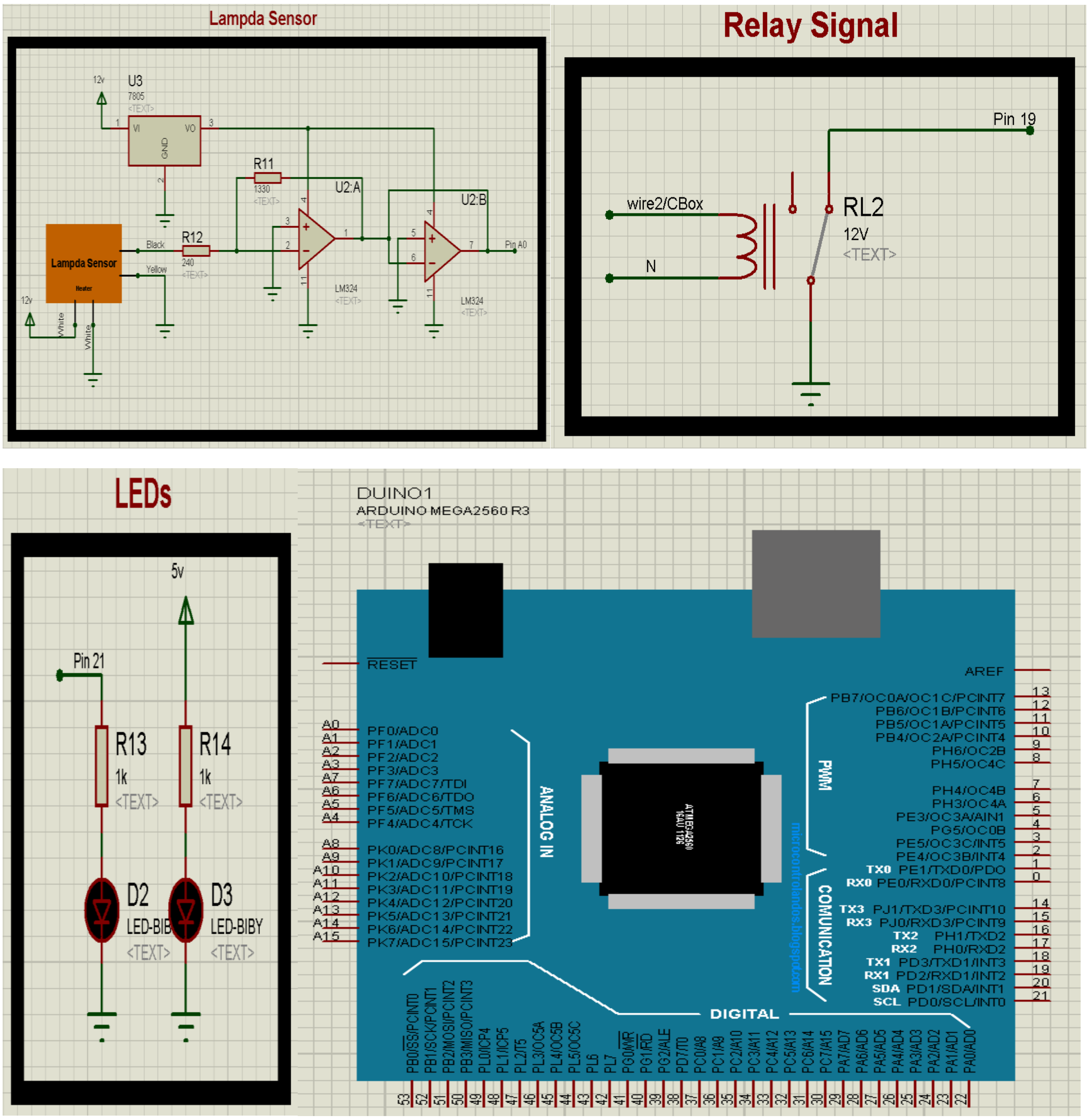

Figure 4.7 Control box Electrical Layout

Chapter Five

Main Controller Selection & Programing

5.1 Main Controller Requirement.

5.2 Main Controller Selection

5.3 Main Controller Flow Chart.

5.4 Arduino Program Structure.

Chapter Five
Main Controller Selection & Programing.

5.1 Main Controller Requirement.

The main controller to be added to the main burner control panel should be able to get readings from the proposed new sensors and to send orders to the new proposed parts. Also, the controller should be able to be connected to the main control panel. The below table 5.1 shows the main inputs and outputs to help in the selection of the controller.

Input Description	Input #	Output #
Air Stepper motor	1	6
Gas stepper motor	1	6
LCD	0	6
TR Relay	0	1
Pressure Transmitter	1	0
O2 Sensor	1	0
Relay signal	1	0
Led	0	2
	Total: 5	Total: 21

Table 5.1 Controller Requirements

5.2 Main Controller Selection.

According to the needs of the inputs and outputs and control features required; and to the available models at market. The model selected is Arduino Microcontroller. Arduino is open-source electronics prototyping platform based on flexible, easy-to-use hardware and software.

Arduino can be used to develop stand-alone interactive objects or can be connected to software on your computer. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.

Arduino have several types according to each application as follows:

- Arduino BT:

The Arduino BT is an Arduino board with built-in bluetooth module, allowing for wireless communication.

- LilyPad Arduino:

The LilyPad Arduino is a microcontroller board designed for wearables and e-textiles. It can be sewn to fabric and similarly mounted power supplies, sensors and actuators with conductive thread.

- Arduino Mega:

Arduino Mega is a surface mount breadboard embedded version with integrated USB. It is a smallest, complete, and breadboard friendly. It has everything that Diecimila has (electrically) with more analog input pins and onboard +5V AREF jumper.

The selected type is Mega because it matches with our application. Figure 5.2 shows Arduino Mega.

Figure 5.1 Arduino Mega.

The following board overview shows the Arduino board as shown in figure 5.2.

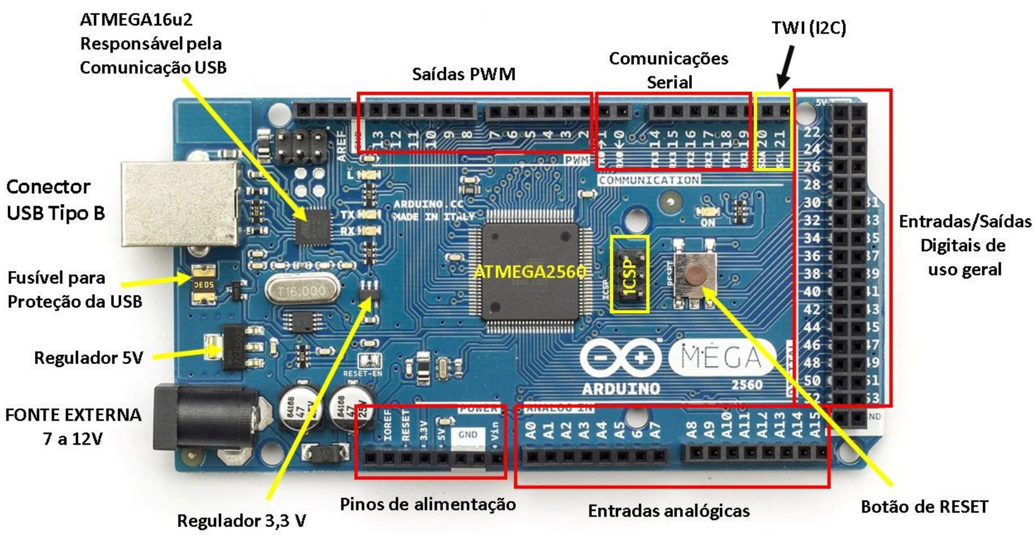

Figure 5.2 Arduino board overview

Data sheet for Arduino Mega is in appendixes F.

5.3 Main Controller Flow Chart.

The main controller flow chart aims to show the sequence of operation for the burner after the add of the new components to the system. After the burner start according to the reading of the steam pressure transducer; the standard checkup should be done as follows:

1. Air stepper motor min & max.
2. Gas stepper motor min & max.
3. Gas pressure switch
4. Air pressure switch.

After the checkup, the burners go to starting cycle including the startup of the fan motor.

After that the air stepper motor is open at max angle to insure sufficient air flow.

The burner then goes to low flame programed angle via opening the air and gas stepper motors. The control box gives signal to start the spark and open the gas solenoid valve.

After the ionization probe sense the existing of flame the spark stop and the burner continue running. In case there is no flame the burner will stop.

The burner after that start to react according to reading of the steam pressure transducer; in case of low pressure reading it will goes to the max and will continue working proportionally to the load. The burner will decide the angle of both stepper motors according to each pressure reading. At each step the burner will get feedback of the O2 percentage in the chimney and will correct the air stepper motor angel if needed. The burner will stop after the pressure reach the set point and will start again when pressure reading drop.

The below flow chart shows the sequence of operation in figure 5.3.

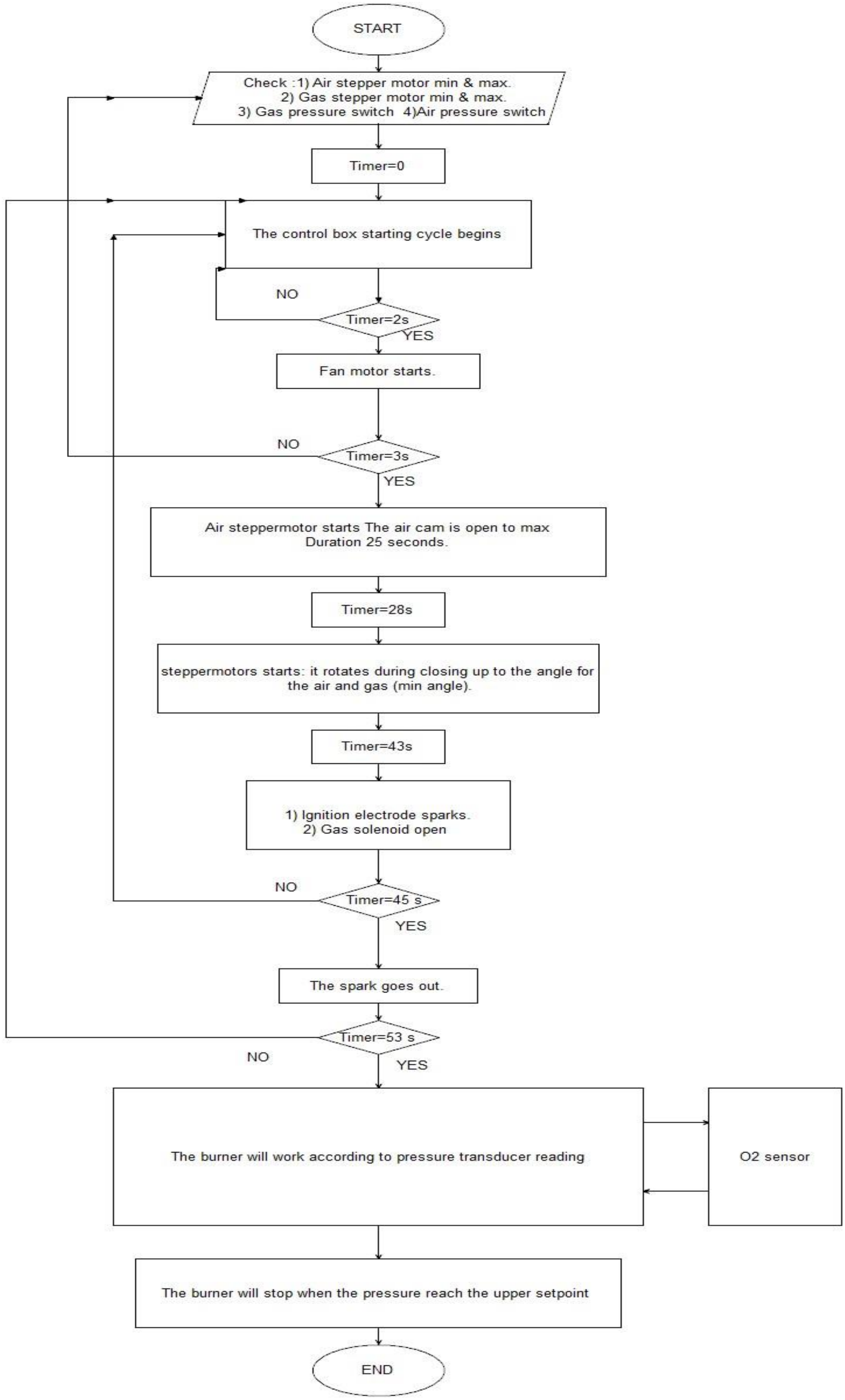

Figure 5.3 Project Flow Chart

5.4 Arduino Program Structure

The program was built with the following aspect:

1- Boiler steam preasure:

The maximum operating pressure is 8 bar.

The intermideiate operating pressure is 7.5 bar.

The second intermidiate operating pressure is 7 bar.

The minumum operating pressure is 6 bar.

The shut off pressure is 12 bar.

2- Gas Stepper motor angels:

The maximum operating angle is 90 degree.

The intermideiate operating angle is 75 degree.

The second intermidiate operating angle is 65 degree.

The minumum operating angle is 30 degree.

The shut off angle is 0 degree.

3- Air Stepper Motor angels:

The maximum operating angle is 90 degree.

The intermideiate operating angle is 75 degree.

The second intermidiate operating angle is 65 degree.

The minumum operating angle is 30 degree.

The shut off angle is 0 degree.

The O2 sensor reading will auto correct the angle if needed.

3- Manual Selection:

In addition to pre stored values there is an option to change the angle manually by inserting the values for both pressure and angle.

The complete code of preogramming is in apendixes G.

Chapter Six

Protection System.

6.1 Burner Existing Protection Components.

6.2 New Protection Components.

Chapter Six

Protection System.

6.1 Burner Existing Protection Components.

The burner has the following protections:

- The pressure of gas at inlet.
  The pressure sensor installed at the main gas valve of the burner sense the pressure of the inlet gas. In case of low pressure, the burner stop working.
- The No flame sensor.
  The flame sensor senses the flame existing. In case of no flame, the burner stop.
- Main fuse at the main control box.
  The main fuse protects the burner from any over current in electrical supply.
- Overload protector.
  The over load sense the over current of the burner blower motor. This is cause due to damage in motor windings or phase failure.
- Max steam pressure.
  This switch turns off the burner in case of max steam pressure in case the running pressure switch fail to stop the burner.
- Max water level.
  This water probe stops the burner in case the boiler is over field with water.
- Low water level.
  This water probe stops the burner in case the boiler has no water inside it.
  Figure 6.1 shows the general block diagram with the above protections.
  Figure 6.2 shows the steam boiler with pressure transducer and O 2 sensor.

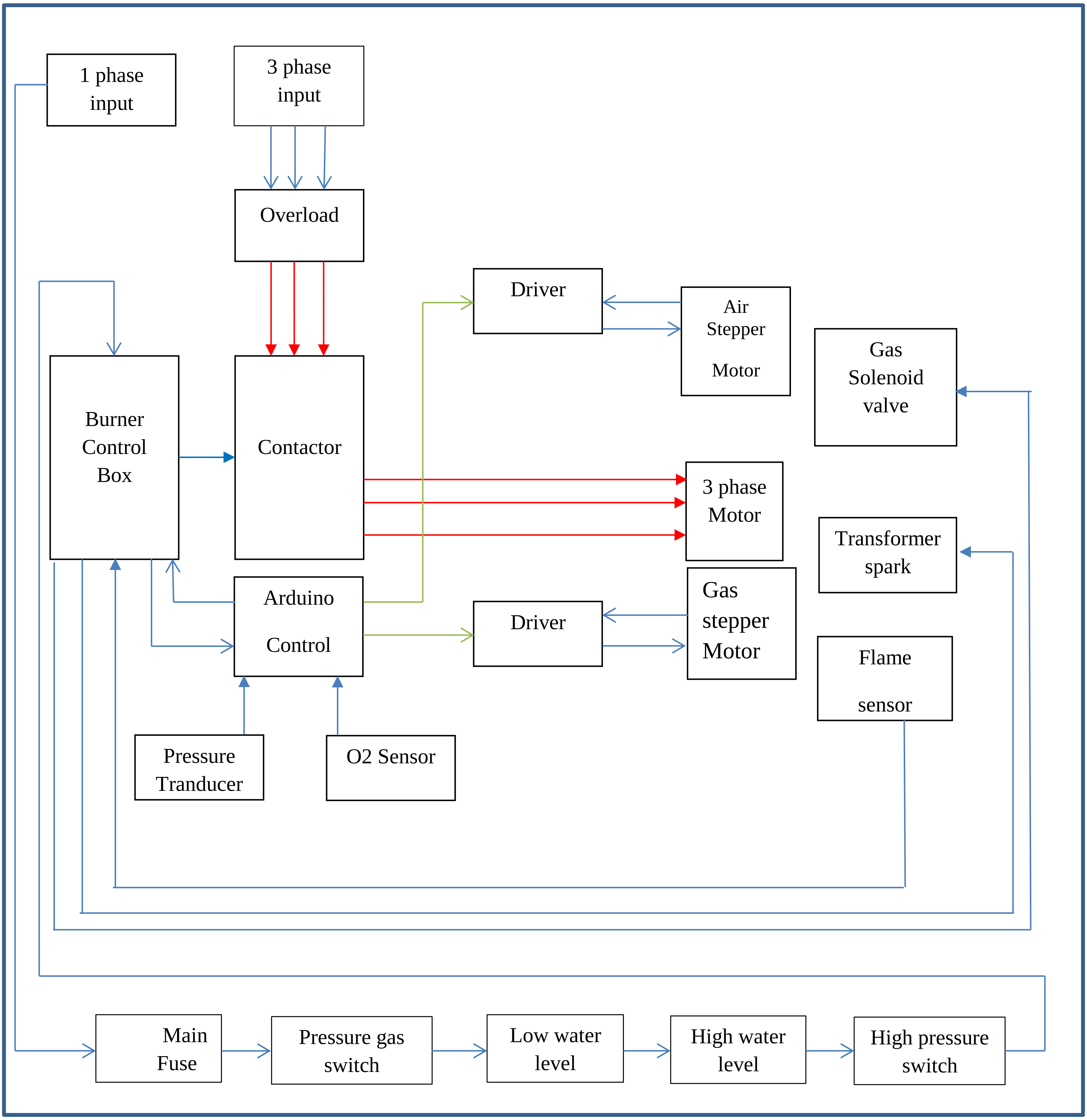

Figure 6.1 General block diagram with protections *(Same as Figure 1.1 with modifications)*

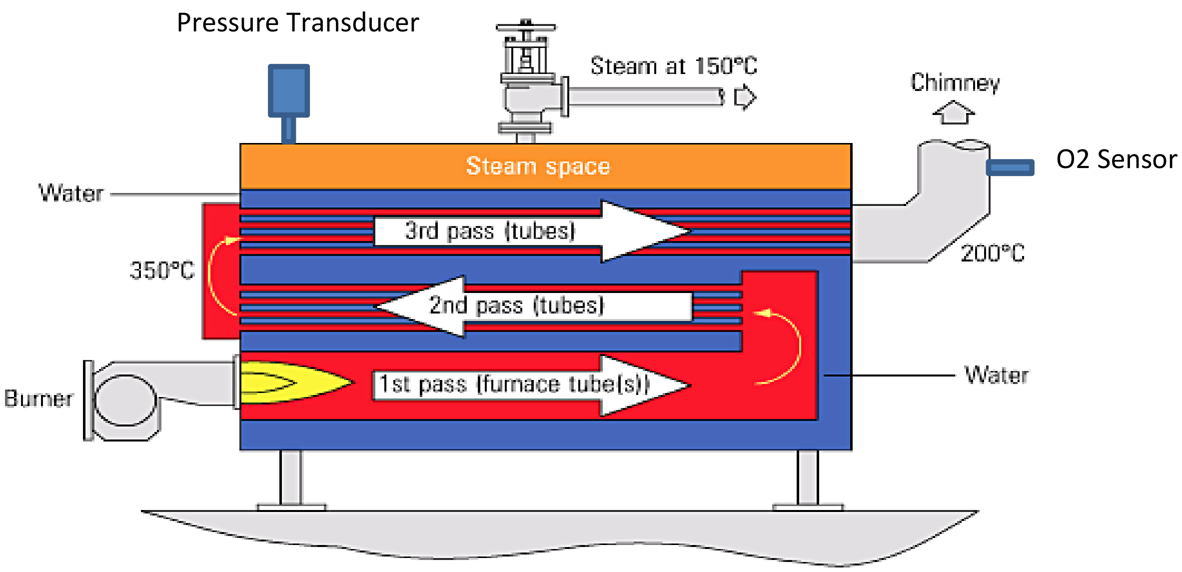

Figure 6.2 Steam boiler with Pressure Transducer and O2 sensor

6.2 New Protection Components.

The main protection to be added is the monitoring of burner combustion flue. In case the burner fails to calibrate itself. This will be cause due to the failure of O2 sensor or a problem in the programing. The burner will stop automatically and gives alarm to the operator. A manual selector switch gives the operator the option to start the burner on two stage mode till the service team came to check the problem.

Chapter Seven

Results.

7.1 Main Results

7.2 Main difficulties.

7.3 Recommendations.

Chapter Seven

Results

7.1 Main Results.

- the change of burner from two stage mode to modulating mode is achievable with auto calibration.
- The implantation of the project will decrease the running costs.
- The implementation of the project will reduce the CO emissions.
- The implementation of the project will reduce the operation problems.

7.2 Main Difficulties.

- To find the required sensors and transducer that match the required application.
- To find the suitable stepper motors with the required torque.

7.3 Recommendations.

The project will introduce several advantages to the Palestinian factories such as cost saving and reducing the emissions to the environment. Also, the project will reduce the problems in the operation of steam systems. Accordingly, this project should be adopted by the Palestinian factories working on LPG gas. In addition to the ability to improve the project components to control more features and get more accurate control and results.

Conclusion

The change of two stage burner to fully modulating burner is possible and can be done with relatively low cost which is around 1000 Usd. The change also allows to monitor the level of O2 in the chimney which will reduce the emissions to the environment. If the factories adopt the system they will save the running cost and operational problems.

References

References:

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2. (http:// www.spiraxsarco.com)
3. (http:// www.engineersgarage.com)
4. (http:// www.electrozep.ro)
5. (http:// www.jasoceania.co.nz)
6. (https:// www.arduino.cc)

Appendixes

Appendixes:

Appendix A - Riello Burners; Installation, use and maintenance instructions.

Appendix B – Stepper Motor Nema 23.

Appendix C - Stepper Motor Driving.

Appendix D – Danfoss Pressure Transmitter.

Appendix E – Bosch O2 Sensor.

Appendix F – Arduino Mega Data Sheet.

Appendix G – Programming Code.