Chapter One

Introduction

1.1 Overview

1.2 Project idea

1.3 Recognition of the Need

1.4 Risk Management

1.5 Time Plan

1.1 Overview

Due to the entry plastic in a lot of products and ease of composition and cheap price, has become a reliable significantly, this lead to the presence in abundance in life, which resulted waste of plastic, this waste has become a negative impact on environmental life, where it has become difficult to get rid of this plastic, because it is Non-biodegradable materials do not decompose in nature, but there are systems are trying to benefit from this plastic, through recycling. Thus leading us to take advantage of this waste plastics and get rid of it, by transforming that waste plastics into energy, in the form of fuel can be used in cars and electric generators…. etc , without needing to recycle.

1.2 Project Idea

The idea of the project is to convert waste plastic into energy through a pyrolysis system, called **WPTE** (**W**aste **P**lastic **T**o **E**nergy) system, so that, there are many waste plastic materials are not recycled also difficult to recycle specially in Palestine , and for that taking advantage of these materials by convert it into energy in the form of fuel, so.. the idea is to design a system that works on used engine oil "as input energy", and the purpose of this ; is to take advantage of this oil to generate the energy that required to operate the system.

1.3 Recognition of the Need

1- Disposal the plastic materials that are Non-recyclable or which is difficult to be recycled.
2- Disposal the auto oil used and use it as energy to the Pyrolysis system.
3- Produce the Fuel.

1.4 Risk Management

1- Heat needed to melt the plastic in the furnace (400 - 600) ℃ ,So we need to isolate the furnace by using isolate material .

2- High pressure could be formed by heating the plastic, so we will put pressure sensor to monitoring the system.

3- The smell of Cast plastic dangerous to human health, Wear masks is one of solution of this problem .

1.5 Time Plan

The time plan explains the stages in designing and building the system components.

This section includes the table that shows the activities and task scheduling for the first semester.

Table (1-1): Time table for the first semester__ time (week)

Process	**Week**															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Selected the project	■	■	■													
Collocation the need data				■	■	■	■	■								
Mechanical and electrical modeling						■	■	■	■	■	■	■	■			
Write document												■	■	■	■	■

Table 1-1

Table (1-2): Time table for the second semester__ time (week)

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Correction the introduction of project	■	■													
Buy tools and equipment			■	■	■	■									
Building the structure						■	■	■	■	■	■	■	■		
Compilation tools to structure									■	■					
Programming and testing										■	■	■	■		
Writing& typing										■	■	■	■	■	
Project presentation															■

Chapter Two

Plastics and Pyrolysis system

2.1 Introduction to Plastic

2.1.1 Definition of Plastic

2.1.2 Types of plastic and their uses

2.2 Acrylonitrile Butadiene Styrene (ABS)

2.2.1 Chemical composition of (ABS)

2.2.2 (ABS) properties

2.2.3 (ABS) Products

2.3 Problems with Disposal of Plastic Wastes

2.3.1 Landfill

2.3.2 Recycling

2.3.3 Disposal of plastic in Palestine

2.4 Definition of pyrolysis

2.5 Previous studies

2.5.1 Preamble

2.5.2 factors affect the pyrolysis process

2.5.3 Some of (ABS) pyrolysis products

2.6 Pyrolysis pollution

2.1 Introduction To Plastic

2.1.1 Definition of Plastic

A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are malleable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural [7].

Due to their relatively low cost, ease of manufacture, versatility, and imperviousness to water, plastics are used in an enormous and expanding range of products, from paper clips to spaceships. They have already displaced many traditional materials, such as wood, stone, horn and bone, leather, paper, metal, glass, and ceramic, in most of their former uses. In developed countries, about a third of plastic is used in packaging and another third in buildings such as piping used in plumbing or vinyl siding. Other uses include automobiles (up to 20% plastic), furniture, and toys [7].

2.1.2 Types of plastic and their uses

Because of its ability to form , there are a several types of plastic ,and here the most types and their using [7].

Polyester (PES) – Fibers, textiles .

Polyethylene terephthalate (PET) – Carbonated drinks bottles, peanut butter jars, plastic film, microwavable packaging .

Polyethylene (PE) – Wide range of inexpensive uses including supermarket bags, plastic bottles .

High-density polyethylene (HDPE) – Detergent bottles, milk jugs, and molded plastic cases .

Polyvinyl chloride (PVC) – Plumbing pipes and guttering, shower curtains, window frames, flooring .

Polyvinylidene chloride (PVDC) (Saran) – Food packaging .

Low-density polyethylene (LDPE) – Outdoor furniture, siding, floor tiles, shower curtains, clamshell packaging .

Polypropylene (PP) – Bottle caps, drinking straws, yogurt containers, appliances, car fenders (bumpers), plastic pressure pipe systems .

Polystyrene (PS) – Packaging foam/"peanuts", food containers, plastic tableware, disposable cups, plates, cutlery, CD and cassette boxes .

High impact polystyrene (HIPS) -: Refrigerator liners, food packaging, vending cups.

Polyamides (PA) (Nylons) – Fibers, toothbrush bristles, tubing, fishing line, low strength machine parts: under-the-hood car engine parts or gun frames .

Acrylonitrile butadiene styrene (ABS) – Electronic equipment cases (e.g., computers , monitors, printers, keyboards), drainage pipe.

2.2 Acrylonitrile butadiene styrene (ABS)

2.2.1 Chemical composition of (ABS)

Is a common thermoplastic polymer (its chemical formula $(C_8H_8)_x \cdot (C_4H_6)_y \cdot (C_3H_3N)_z$) . Its glass transition temperature is approximately 105 °C (221 °F). ABS is amorphous and therefore has no true melting point [8] .

ABS is a terpolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The proportions can vary from 15 to 35% acrylonitrile, 5 to 30% butadiene and 40 to 60% styrene. The result is a long chain of polybutadienecriss-crossed with shorter chains of poly(styrene-co-acrylonitrile). The nitrile groups from neighboring chains, being polar, attract each other and bind the chains together, making ABS stronger than pure polystyrene[8].

ABS is derived from acrylonitrile, butadiene, and styrene. Acrylonitrile is a synthetic monomer produced from propylene and ammonia; butadiene is a petroleum hydrocarbon obtained from the C4 fraction of steam cracking; styrene monomer is made by dehydrogenation of ethyl benzene — a hydrocarbon obtained in the reaction of ethylene and benzene[8] .

According to the European plastic trade association Plastics Europe, industrial production of 1 kg (2.2 lb) of ABS resin in Europe uses an average of 95.34 MJ (26.48 kW·h) and is derived from natural gas and petroleum[8].

2.2.2 (ABS) properties

The most important mechanical properties of ABS are impact resistance and toughness, its impact resistance does not fall off rapidly at lower temperatures . final properties will be influenced to some extent by the conditions under which the material is processed to the final product .fibers (usually glass fibers) and additives can be mixed in the resin pellets to make the final product strong and raise the operating range to as high as 80 °C (176 °F) [8].

2.2.3 (ABS) Products

ABS's light weight and ability to be injection molded and extruded make it useful in manufacturing products such as drain-waste-vent (DWV) pipe systems, musical instruments (recorders, plastic clarinets, and piano movements), golf club heads (because of its good shock absorbance), automotive trim components, automotive bumper bars, medical devices for blood access, enclosures for electrical and electronic assemblies, protective headgear, whitewater canoes, buffer edging for furniture and joinery panels, luggage and protective carrying cases, small kitchen appliances, and toys, including Lego and Kre-O bricks. Household and consumer goods are the major applications of ABS[8].

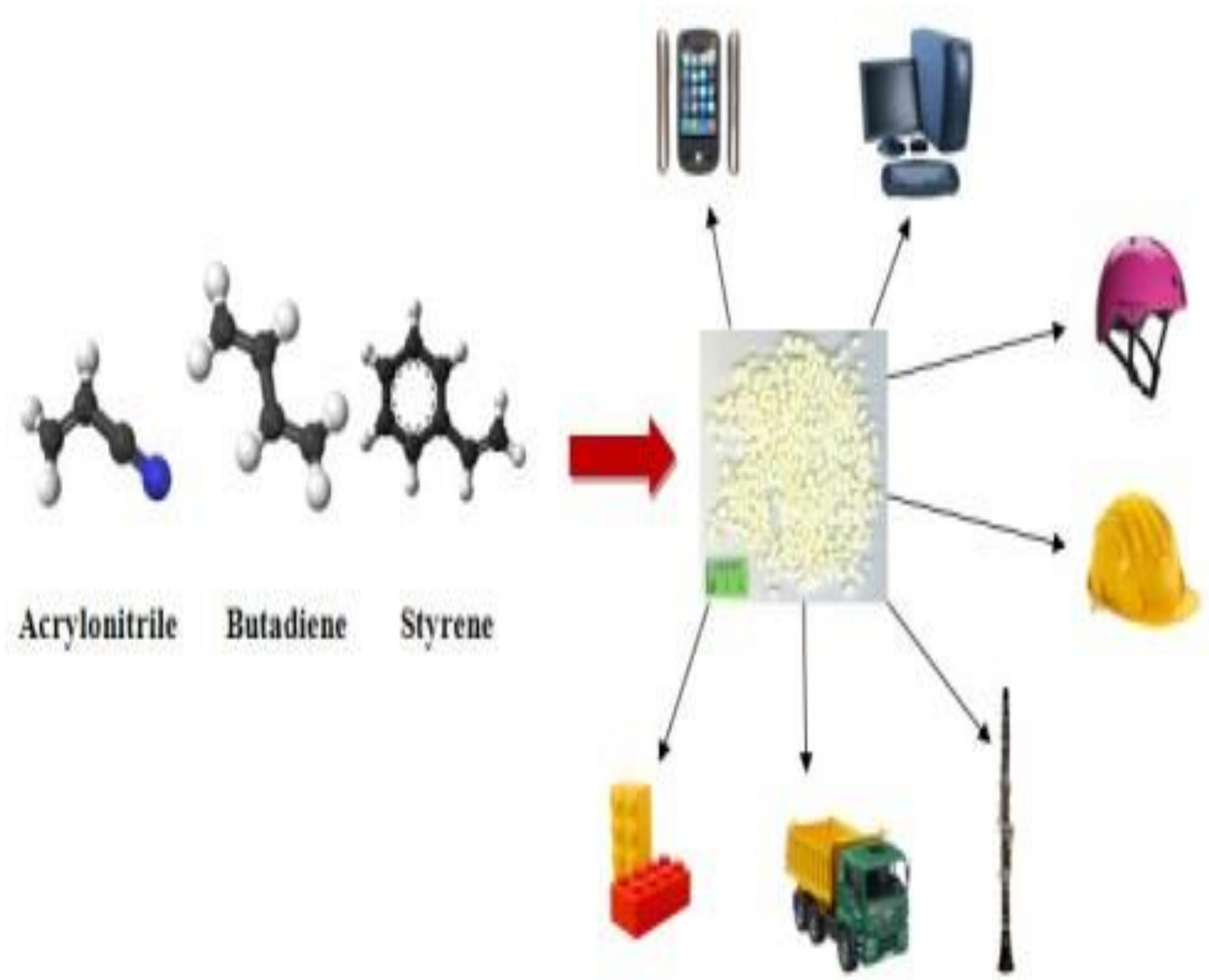

Figure 2.1 ABS Products

Figure 2.2 ABS pipe

Figure 2.3 ABS front car bumper

2.3 Problems with Disposal of Plastic Wastes

Plastic consumption has grown at a tremendous rate worldwide. Plastics now play an increasingly important role in all aspects of modern life. and used in the manufacture of all sorts of items including protective packaging, mobile phones, domestic appliances, furniture items, medical devices etc. Each year around 1trillon plastic bags are used worldwide with most of them ending up in landfills, dumpsites and water bodies. Due to the rising demand, the global plastic consumption is expected to reach 300 million tons by 2015 [2] .

Disposal of plastic waste has emerged as an important environmental challenge and its recycling is facing roadblocks due to non-degradable nature. Because plastic does not decompose biologically, the amount of plastic waste in our surroundings is steadily increasing. Plastic waste is often the most objectionable kind of litter and will be visible for long time in landfill sites without degrading[2] .

2.3.1 Landfill

A landfill site (also known as a tip, dump, rubbish dump or dumping ground and historically as a midden) is a site for the disposal of waste materials by burial and is the oldest form of waste treatment[3] .Millions of tons of plastic waste are carted off to landfills each year, and remain there for an indefinite period of time [5].Historically, landfills have been the most common method of organized waste disposal and remain so in many places around the world. Some landfills are also used for waste management purposes, such as the temporary storage, consolidation and transfer, or processing of waste material (sorting, treatment, or recycling) [3].

Poorly designed or poorly managed landfills can create a number of adverse environmental impacts such as wind-blown litter, attraction of vermin, and generation of liquid leachate. Another common product of landfills is gas (mostly composed of methane and carbon dioxide), which is produced from anaerobic breakdown of organic waste. This gas can create

odor problems, kill surface vegetation and is a greenhouse gas . also methane generated by decaying organic wastes may be released into the atmosphere. Methane is a greenhouse gas many times more potent than carbon dioxide, and can itself be a danger to inhabitants of an area because it is flammable and potentially explosive. Landfills may become a reservoir of disease organisms and disease vectors such as rats and flies, particularly from improperly operated landfills, which are more common in developing
countries [4].

2.3.2 Recycling

Recycling of plastics is one of the best methods for sustainable disposal of plastic wastes. Unfortunately, plastic is much more difficult to recycle than materials like glass, aluminum or paper. A common problem with recycling plastics is that plastics are often made up of more than one kind of polymer or there may be some sort of fiber added to the plastic (a composite) [2] . Plastic polymers require greater processing to be recycled as each type melts at different temperatures and has different properties, so careful separation is necessary. Moreover, most plastics are not highly compatible with one another. Apart from familiar applications like recycling bottles and industrial packaging film, there are also new developments like covering pipes, window frames, roofing membranes and flooring [2] . Also there are another problems with recycling plastic such as its cost of restarting which is high when we see its return , and its products quality is less than the original product ,also there isn’t mostly adequate financial support.

2.3.3 Disposal of plastic in Palestine

Burning, is the mostly common way used to disposal the waste plastic ,and it is considered the most polluting way of waste management , because it’s have a several negative effects not only on the air , but for the land and human .

It’s attract diseases and take a large area of land and it is smelly .

2.4 Definition of pyrolysis

Pyrolysis is a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen (or any halogen). It involves the simultaneous change of chemical composition and physical phase, and is irreversible. The word is coined from the Greek-derived elements pyro "fire" and lysis "separating" Pyrolysis is a type of thermolysis, and is most commonly observed in organic materials exposed to high temperatures[11].
The process is used heavily in the chemical industry, for example, to produce charcoal, activated carbon, methanol, and other chemicals from wood, to convert ethylene dichloride into vinyl chloride to make PVC, to produce coke from coal, to convert biomass into syngas and biochar, to turn waste into safely disposable substances, and for transforming medium-weight hydrocarbons from oil into lighter ones like gasoline. These specialized uses of pyrolysis may be called various names, such as dry distillation, destructive distillation, or cracking. Pyrolysis is also used in the creation of nanoparticles, zirconia, and oxides, utilizing an ultrasonic nozzle in a process called ultrasonic spray pyrolysis (USP) [11].

2.5 Previous studies

2.5.1 Preamble

There are a lot of studies that talk about pyrolysis and pyrolysis of plastic ,a lot of them are doing experimental procedure, The works reveal that the product distribution can be affected by a number of parameters which include the polymer source (plastic type), catalysts used, size of the catalyst, catalyst to polymer ratio, reaction temperature, reaction time, and reactor type[12] .

We will write down some matter that we concerned about during our research and experimental .

Pyrolysis can be conducted at various temperature levels, reaction times, pressures, and in the presence or absence of reactive gases or liquids, and of catalysts. Plastics pyrolysis proceeds at low (<400◦C), medium (400–600◦C) or high temperature (>600◦C). The pressure is generally atmospheric. Sub atmospheric operation, whether using vacuum or diluents, e.g. steam, may be selected if the most desirable products are thermally unstable [14].

Easily re-polymerizing, as in the pyrolysis of rubber or styrene's. The thermal decomposition of polymers yields gases, distillates and char, albeit in widely variable relative amounts. These can be applied as fuels, petrochemicals, and monomers. Depending on the polymers or polymer mixtures fed and the operating conditions used, yields can vary widely. As a rule both gaseous and liquid products are mixtures of numerous different compounds. The problem of fractionating these effluents and upgrading to commercial specifications, while separating undesirable impurities, must be investigated on a case-by-case basis[14].

2.5.2 Factors affect the pyrolysis process

2.5.2.1 Effects of temperature

Temperature is one of the most important operating variable, since the temperature dominates the cracking reaction of the polymer materials. Not all of the polymer materials can be cracked by increasing the temperature. Van der Waals force is the force between the molecules, which attracts molecules together and prevents the collapse of molecules. When the vibration of molecules is great enough, the molecules will evaporate from the surface of the object. However, the carbon chain will be broken if energy induced by van der Waals force along the polymer chains is greater than the enthalpy of the C-C bond in the chain. This is the reason why high molecular weight polymer is decomposed rather than is boiled when it is heated. In theory, the temperature of thermal breaking the C-C bonds should be constant for a given type of plastic (polymer). However, this temperature has been found to differ in different studies. For example, the temperature when PP starts cracking was reported at 380 ºC in Ciliz et al.'s result but it is measured to be 650 ºC in Demirbas's result. Both of them used similar batch process reactor and thermo gravimetric analysis[14] .

Cracking process breaks down the long polymeric chains into useful smaller molecular weight compounds. The products of this process are highly useful and can be utilized as fuels or chemicals in various applications[12] .

Thermal cracking or pyrolysis involves the degradation or cracking of the polymeric materials by heating them to a very high temperature. The heating should be carried out in the absence of oxygen to make sure that no oxidation of the polymer takes place .The range of temperature is between 350 and 900 ºC [12] , The cracking temperature for PE and PP in the pyrolysis is at 450 ºC, but that of PS is lower, at 320 ºC[12]. High reaction temperature and heating rate can significantly promote the production of light hydrocarbons [14] .

On the other extreme situation, if the operation temperature is very high, for example 800 to 1000 ºC, gasification process occurs and in this case, the plastics are directly converted to short chain gases and the yield of non-condensable gases in the product is maximized. High heating rate is required to minimize the proportion of solid char production and rapid quenching favours the liquid production before further cracking into gaseous products. [14].

The difference of the temperature on the surface in contact with the plastic and the temperature of the plastic close to the surface was measured by araduman, A., et al.[14].

For comparison, which is measured relatively minor and constant in this research study. Therefore, the temperature at the reaction surface is selected for monitoring the cracking temperature of plastics. In Shah et al.'s study, mixture of post-consumed plastics of PE, PP and

PS was pyrolyzed in a fixed-bed batch reactor at different temperatures for one hour. It was found that higher reaction temperature favours the gas production and production of heavy molecular weight products in the liquid [14] .

However, the overall gas proportion of gas product increased with increasing cracking temperature up to 730C while the liquid product proportion decreased with the cracking temperature in the full range of temperature used as shown in the figure below.

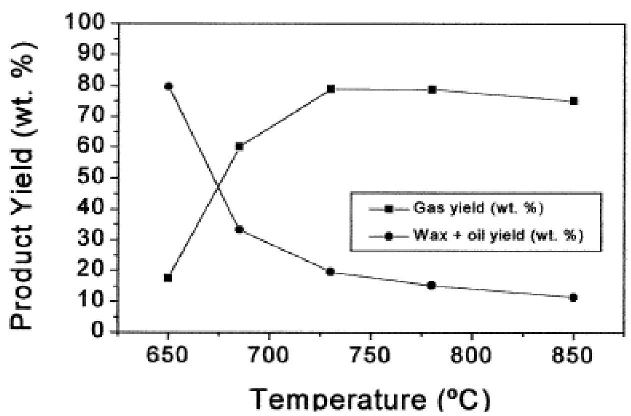

Figure 2.4 Influence of temperature on product distribution [14].

2.5.2.2 Effects of heating rate

The other operating thermal dynamic parameter is heating rate. The term “heating rate " in this field means the increase of temperature per unit time. The influence of the heating rate on the plastic pyrolysis process and product distribution varies in different studies due to the differences in the pyrolysis reactor, operation conditions (temperature and pressure), and temperature measurement location. Normally, in a fast or flash pyrolysis, heating rate refers to the temperature change of the plastic from it dropped on the hot surface till decomposed and vaporized. The hot surface remains the temperature while the amount of plastic dropped on to it is relatively small. In this situation, the heating rate is very high, up to 10,000 K/s[14]. This is hard to be measured precisely. Therefore, the surface temperature is normally applied as the reaction temperature indicator rather than heating rate in the flash and fast pyrolysis process. In a batch process, the plastic is normally heated from room temperature to the cracking temperature in several minutes. It is a slow pyrolysis process. Once the plastic feedstock is heated to the cracking temperature, the temperature remains relatively constant until all feedstock has been pyrolyzed. Therefore, heating rate is normally applied as the temperature indicator instead of reaction temperature in a slow pyrolysis process. It was found that heating rate usually varied from 10 to 100 ºC/minute in previous slow pyrolysis researches [14].

2.5.2.3 Effect of Catalyst

In our project we did not adding any of catalysts to the feedstock, however there is a lot of studies talk more about adding catalyst and its effects on the pyrolysis ,we mention it for the future works .

There exist two methods by which catalyst can be added to the pyrolysis reactor: liquid phase contact and vapor phase contact. In the liquid phase contact, the catalyst and polymer are mixed together, and then they are placed in the reactor and heated to the reaction temperature. However, in the vapor phase contact, the polymer is first subjected to thermolysis to produce the volatile fraction [12].

The catalyst is inserted in the path of the moving vapour, and as the vapour moves through the catalyst, the hydrocarbon vapour is degraded to get the required product distribution . However, the product yield is reported not to differ significantly with the two modes[12] .

The main important effects of adding catalyst is decreasing the temperature needed for the system ,also adding N_2 gas can expelled the oxygen when it is leaves the system through operating [12].

There are some catalysts used such as barium carbonate , zeolite 1 (pore size ∼4 ˚ A), silica alumina 1 (SA1) (silica(∼30 nm) 83.3%, alumina (∼30 nm) 16.7%)silica alumina 2 (SA2) (silica 21.1%, alumina 78.9%), SA1 + Z1 (70% SA1, 30% SA1, 30% Z1), and zeolite 2 (sodium Yzeolite) [12] .

2.5.2.4 Effects of pressure

Operating pressure has significantly effect on both the pyrolysis process and the products. The boiling points of the pyrolysis products are increased under higher pressure, therefore, under pressurised environment heavy hydrocarbons are further pyrolyzed instead of vaporized at given operation temperature.

Figure(2.5) shows the effect of pressure on hydrocarbon number and their fractions in the pyrolysis products of PE. In effect, under pressurized pyrolysis, more energy is required for further hydrocarbon cracking. It was also found that high pressure increases the yield of non-condensable gases and decreases the yield of liquid products. (Figure 2.6) The average molecular weight of gas product also decreases with the increase of pressure.

In summary, pressure has major effects on the pyrolysis reaction and the distribution of PE pyrolysis products, but has minor effect on the double bond components[14].

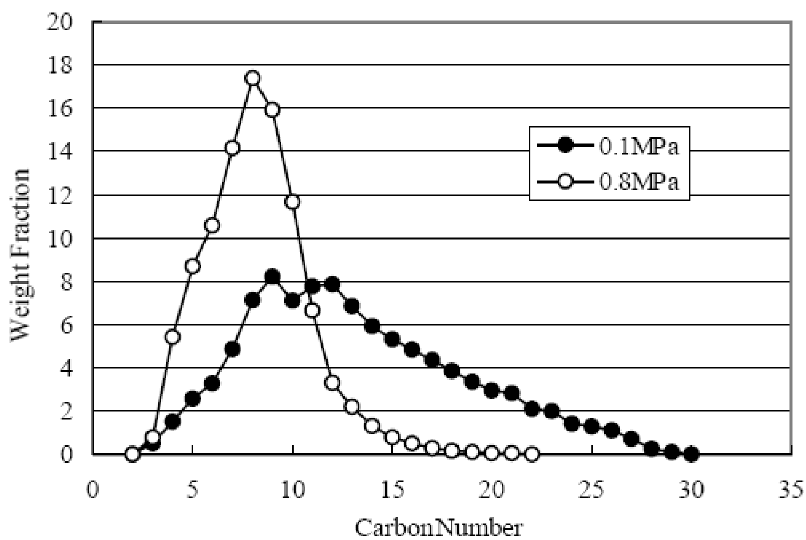

Figure 2.5 Effect of pressure on the distribution of PE pyrolysis products[14].

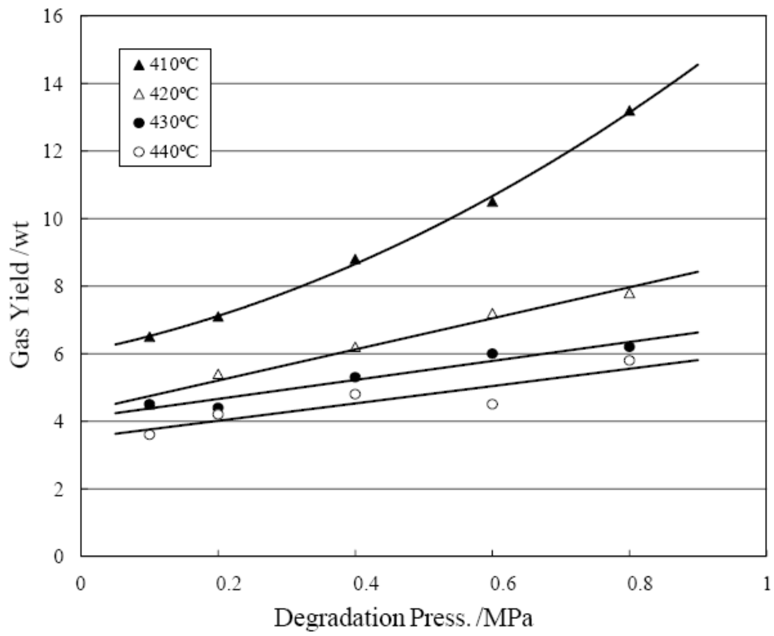

Figure 2.6 Effect of pressure on the yield of gas at different temperature [14].

2.5.2.5 Effect of type of plastic (feedstock)

Resin	Thermo Fuel system suitability
Polyethylene (PE)	Very good
Polypropylene PP)	Very good
Polystyrene (PS)	Very good (gives excellent fuel properties).
ABS resin (ABS)	Good. Requires off-gas counter measure
Polyvinylchloride (PVC)	Not suitable, should be avoided.
Polyurethane (PUR)	Not suitable, should be avoided
Fiber Reinforced Plastics (FRP)	Fair. Pre-treatment required to remove fibers.
PET	Not suitable, should be avoided.

Table (2.2) Selection of plastic [15].

2.5.3 Some of (ABS) pyrolysis products

2.5.3.1 Off Gas

Pyrolysis of plastics tends to occur on irregular basis hence the carbon chain lengths of the pyrolytic gases vary between 1-25. Most of the gas is liquefied in the condensers but some gas remains uncondensed. Hydrocarbons with carbon count of 4 and lower remain as a gas under room temperature. This off-gas contains methane, ethane, propane, butane, etc. The off gas is treated, then returned to the main furnace as an additional heat source, with minimal emissions to atmosphere [15].

2.5.3.2 Char

The carbonaceous char forms in the chamber during pyrolysis. The char residue produced is generally proportional to the level of contaminants which are adhering to the feed stocks[15]. Since the char passes acid leaching tests it can simply be land filled[15]. Inorganic additives such as cadmium pigments from the plastics end up in the char stream. The carbon matrix has a metal .fixing. effect and binds up the metal ions so that no leaching occurs after disposal[15].

2.6 Pyrolysis pollution

Thermo Fuel produces extremely low level of emissions due to the capture of almost all of the output, both liquid sand gases, inside the system[15].

Chapter Three

(WPTE) System

3.١ WPTE system

3.2 WPTE system working principle

This chapter explain the principle working of the project, and it contains parts needed to design and build the project.

3.1 WPTE system working principle

As shown in Fig 3.1 , the working principle of this system is the same of pyrolysis system , where the process is done in several stages;

The first stage ,is heating Furnace to a temperature around (50 ° C) by using diesel fuel to increase the temperature of the oil ,then the system will work on used motor oil, and temperature of the furnace it will be ranging between (400-600) ° C, and this is done through pumped that oil through the injector, Which in turn is based on the Ablation of oil into small particles. And in order to reach the desired temperature, using Air Blower to Inflatable the air to the furnace .

In the second stage the plastic will be heated, which is located in a special tank called 'plastic boiling tank', which located inside the furnace. The high temperature inside the furnace will melt the plastic inside boiling tank, and turns it into a liquid state closer to the liquid with high viscosity, and then begins turn into gas “Flammable gas”. This gas passes directly through cooling system, in order to condense this gas into a liquid, where part of this gas condenses, and the other part remains gas.

This gas is used as a source of fuel to run an electric generator working on gas for example.

3.2 WPTE system

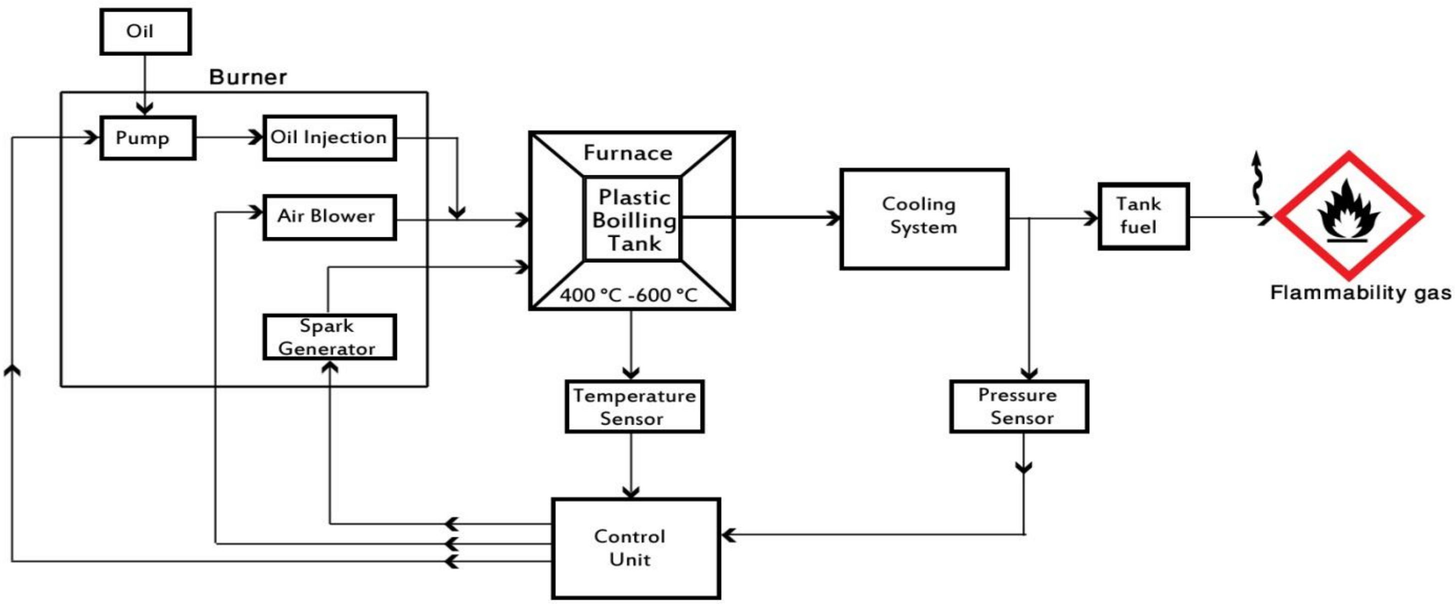

Figure 3.1 WPTE system

As shown in Fig 3.1 , the working principle of this system is the same of pyrolysis system , where the process is done in several stages;

The first stage ,is heating Furnace to a temperature around (50 ° C) by using diesel fuel to increase the temperature of the oil ,then the system will work on used motor oil, and temperature of the furnace it will be ranging between (400-600) ° C, and this is done through pumped that oil through the injector, Which in turn is based on the Ablation of oil into small particles. And in order to reach the desired temperature, using Air Blower to Inflatable the air to the furnace .

In the second stage the plastic will be heated, which is located in a special tank called 'plastic boiling tank', which located inside the furnace. The high temperature inside the furnace will melt the plastic inside boiling tank, and turns it into a liquid state closer to the liquid with high viscosity, and then begins turn into gas "Flammable gas". This gas passes directly through cooling system, in order to condense this gas into a liquid, where part of this gas condenses, and the other part remains gas.

This gas is used as a source of fuel to run an electric generator working on gas for example.

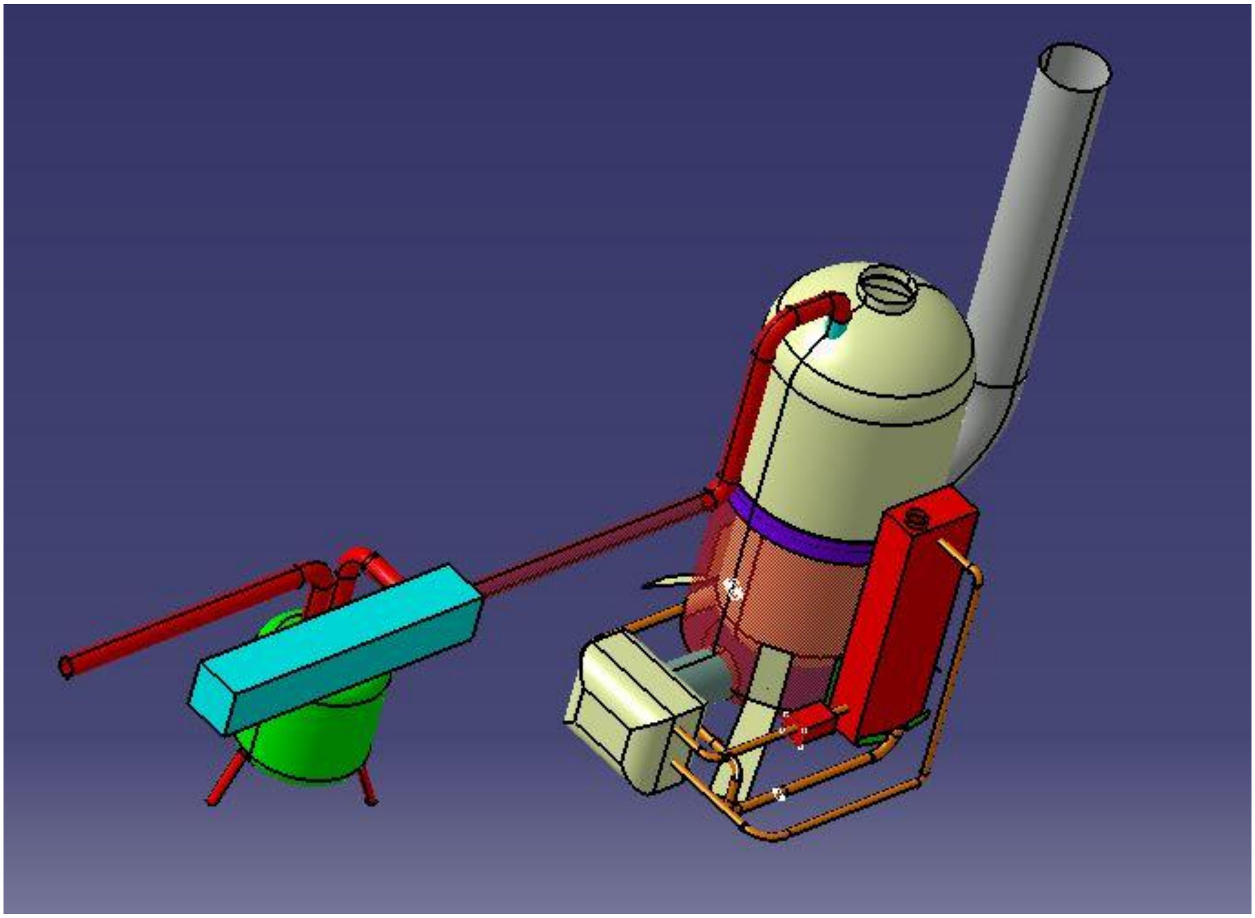

Figure 3.2 3D model of WPTE system.

Chapter Four

System components

4.1 System components

4.1.1 Tanks

Appropriate tanks as shown in Fig4.1, are chosen to build the system, its used to handle the " Used Motor Oil " and the produced fuel .

Figure 4.1 Tanks

4.1.2 Oil Filter

it is used to pass the oil through a cleaning processes before it is passes through the pump, as shown in Figure 4.2.

Figure 4.2 Oil filter

4.1.3 Oil burner

An oil burner as shown in Fig4.3, is a heating device which burns fuel oil. The oil is atomized into a fine spray usually by forcing it under pressure through a nozzle. This spray is usually ignited by an electric spark with the air being forced through by an electric fan.

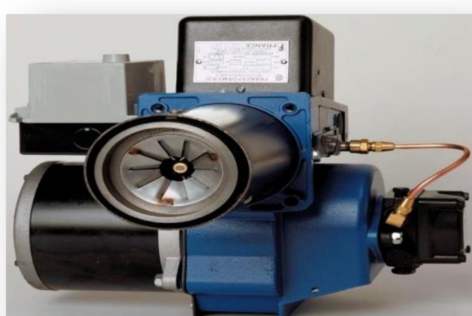

Figure 4.3 Oil burner

4.1.4 Fuel injection

The nozzles are usually supplied with high pressure oil. Because of problems with erosion, and blockage due to lumps in the oil, they need frequent replacement typically every year. Fuel nozzles are usually rated in fuel volume flow per unit time e.g. USGal/h (U.S. Gallons per hour).

A fuel nozzle is characterized by 3 features:

- A flow of 7 bar pump pressure (0.65 (USGal / h))
- The spray characteristic (S)
- The spray angle (60 °)

Alternatively fuel may be passed over a tiny orifice fed with compressed air. This arrangement is referred to as babington atomiser/nozzle after its inventor. As the oil flows over the nozzle, the fuel needn't be under any great pressure. If the pump can handle such the oil may even contain lumps such as scraps of food. Because it is only compressed air that passes through the orifice hole, such nozzles do not suffer much from erosion.

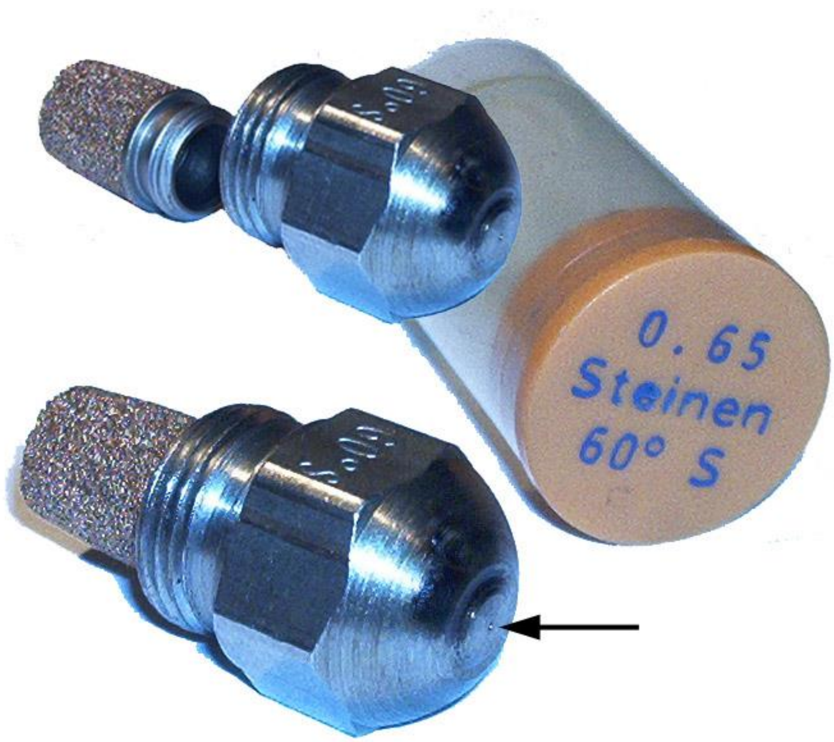

Figure 4.4 Nozzle

4.1.5 A fuel oil pump

A fuel oil pump consists of two parts:

- Gear pump type

This sucks the oil and increases the pressure in the nozzles to 15 bar maximum. Usually a gear pump of the sickle type is used. This type of pump is a simple and therefore cheap pump consisting of one or more radical pairs of gears and with a very small space between the gears and the pump casing. Gear pumps are used frequently in oil burners because of their simplicity, stability and low price.

- Pressure regulator

To set the heat output of the burner, the rate of fuel delivery via the nozzle must be adjustable. This is often achieved by an adjustable pressure relief valve between the pump and the nozzle. When the set pressure is reaches usually 10 - 11 bar, this valve opens and allows excess oil through a bypass back to the fuel tank or pump suction.

Figure 4.5 Pump

4.1.6 Electromagnetic valves

A small two-stage industrial burner. The blue cubes are the coils of the two electromagnetic valves, and it's located up the pump as shown in Fig 4.5 .

This enables fuel to be shut off from the sprayer by electrical control. This helps avoid drips when it is inactivated. It also eases the purging of the burner (and any boiler) of fuel mist, during start up, or while restarting after a misfire. If the burner were not purged the oil/air mixture could explode dangerously.

4.1.7 *Fan*

The fan blows air into the combustion chamber. The rotor of the fan is powered by an electric motor.

4.1.8 Ignitors

Use high voltage generated by a voltage-step up transformer and use a spark plug to initiate ignition.

4.1.9 Photocell

LDR

A light sensitive resistor (LDR) detects the flame. The LDR (or Light Dependent Resistor) resistor is an electrical resistor whose value changes by the amount of light that is present. The resistance value of an LDR becomes smaller, as the LDR is more and more exposed. The material is usually cadmium sulfide, the dark resistance is 1.10 MΩ resistor while the light resistance is about 75-300 Ω. LDR's have a relatively slow response time.

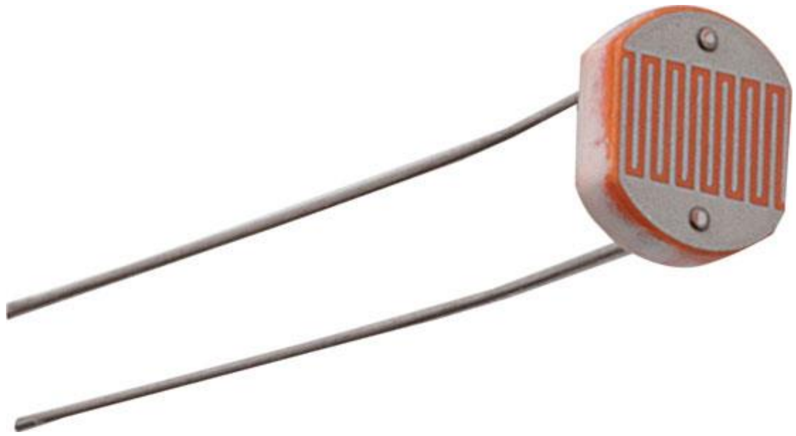

Figure 4.6 LDR

4.1.10 Capacitor start motor

The fan and motor which drives the oil pump is usually a capacitor start motor. It is a vortex shortage tank motor because it also contains a short cage or cage holds. The difference with a three-phase motor is in the stator. Where the vortex power motor has three coils aligned at 120° in the stator, the capacitor start motor holds one main winding and one auxiliary winding aligned at 90°. The phase shift of 90° between the main winding and the auxiliary winding is achieved by a connected capacitor which feeds the auxiliary winding and is connected on the single-phase AC mains. The capacitor will achieve a phase shift of 90° between the main and the auxiliary winding, producing an acceptable initial torque. This motor is intended for continuous operation.

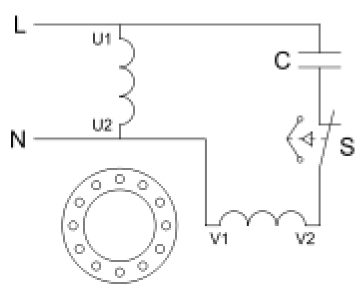

Figure 4.7 Capacitor start motor

4.2 Condenser

Used to condense the gas coming from the boiling tank as shown in Fig 4.8

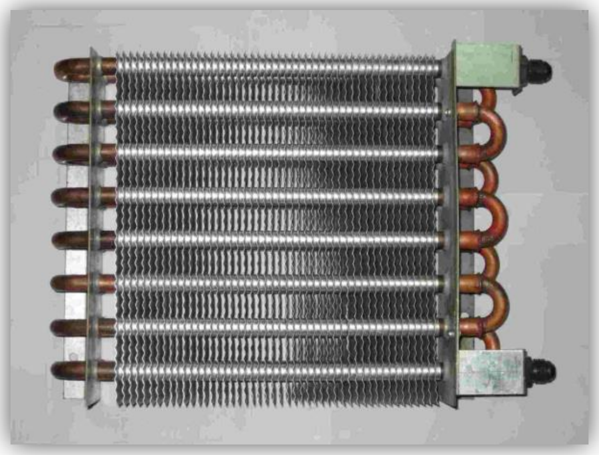

Figure 4.8 condenser

4.3 Temperature Sensor

k type thermocouple is chosen shown in Fig 4.9.
but the most important one is that it is can accommodate a very high temperature reaches up to 800 C˚. It will be used to read the temperature in the furnace, and send it to the microcontroller to do the required function .

Figure 4.9 k-type sensor

4.5 Pressure Sensor

With regard to pressure , and to keep the system safe in this side , a sensor of type " Boost Pressure Sensor " Just like one used in automobile is used shown in Fig4.10 .

This sensor will read the pressure in the gas pipes and send the data to the microcontroller to do the required function.

Figure 4.9 Pressure sensor

Chapter Five

System Design

5.1 Introduction

5.2 Parts of System

- **5.2.1 Plastic Boiling Tank**
- **5.2.2 Furnace design**
- **5.2.3 Pipe design**
- **5.2.4 Oil tank**
- **5.2.5 Fuel tank**

5.1 Introduction

Design is an iterative process with many interactive phases. Many resources exist to support the designer, including many sources of information, and an abundance of computational design tools.

In this chapter the overall system is designed as shown in Fig 5.1 and the concept of designing of mechanical and hydraulic parts .

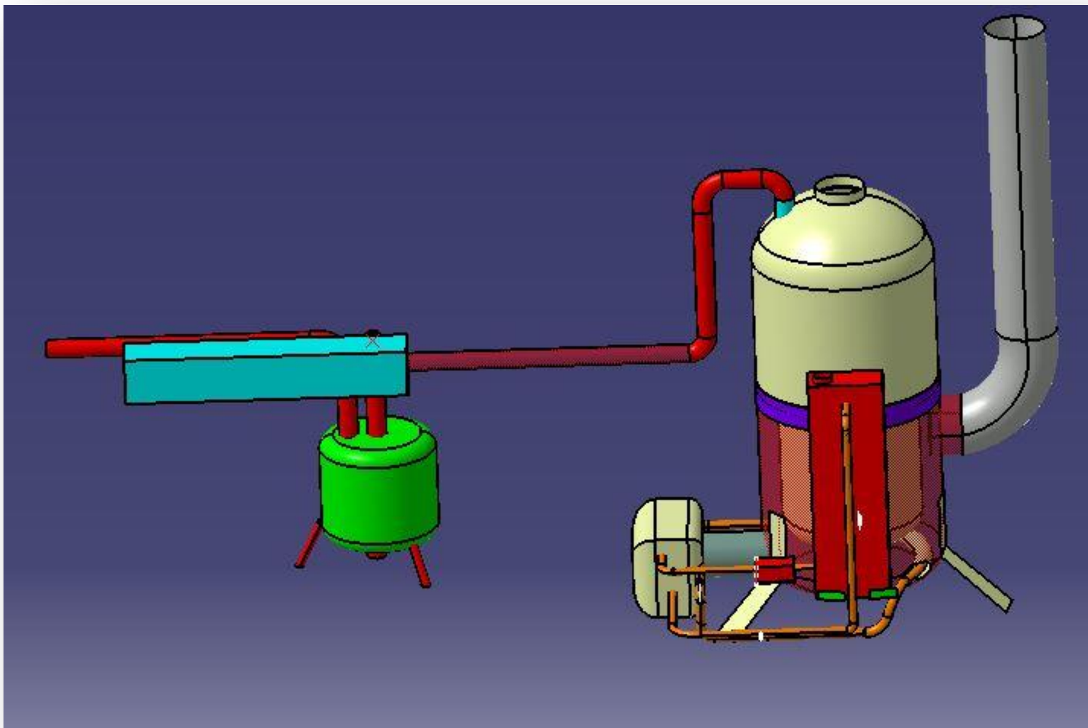

Figure 5.1 Scheme of the WPTE system

5.2 Parts of System

The system parts as shown in Fig5.2

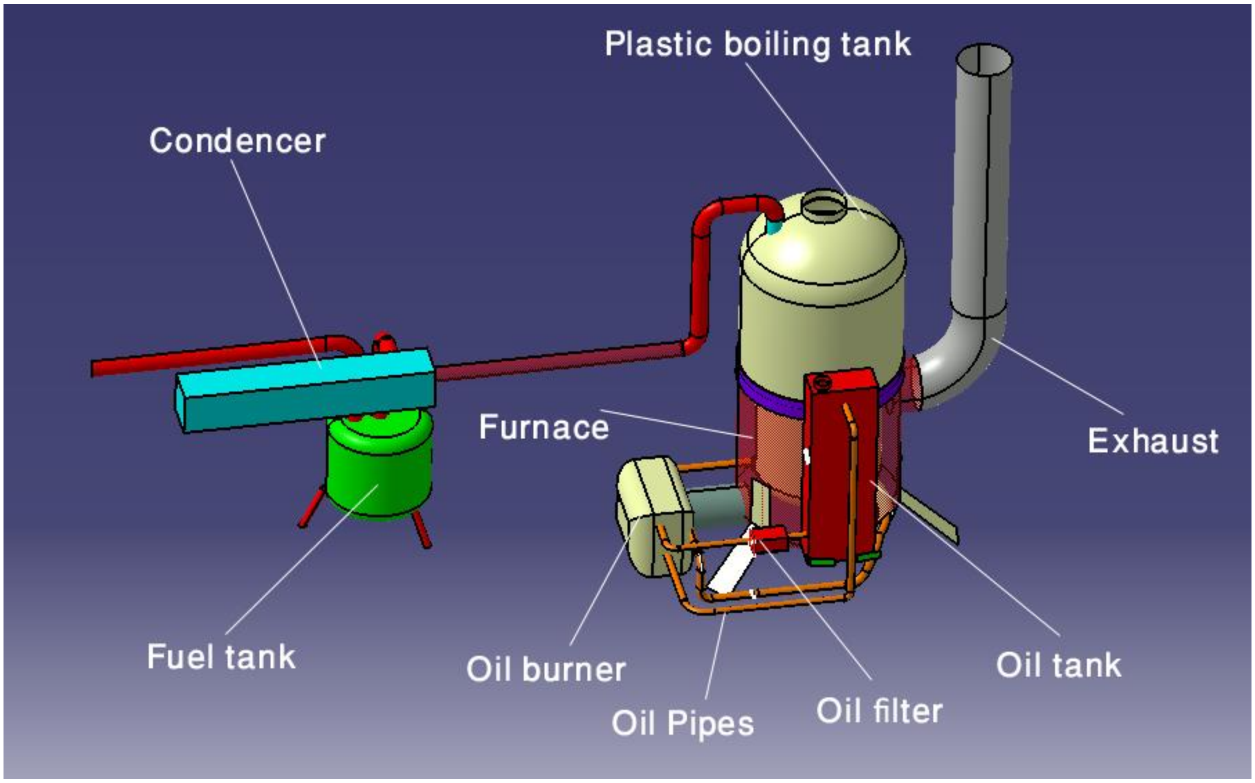

Figure 5.2 System parts

5.2.1 Plastic Boiling Tank

The plastic boiling tank is designed to be composed of two pieces: the upper segment, as shown in the Fig5.3, which consists of openable and shutdown slot to insert the plastic on it, and also a small outlet that the gas which produced, get out from it. And the other piece, welded with the upper segment as shown in Fig5.5 .

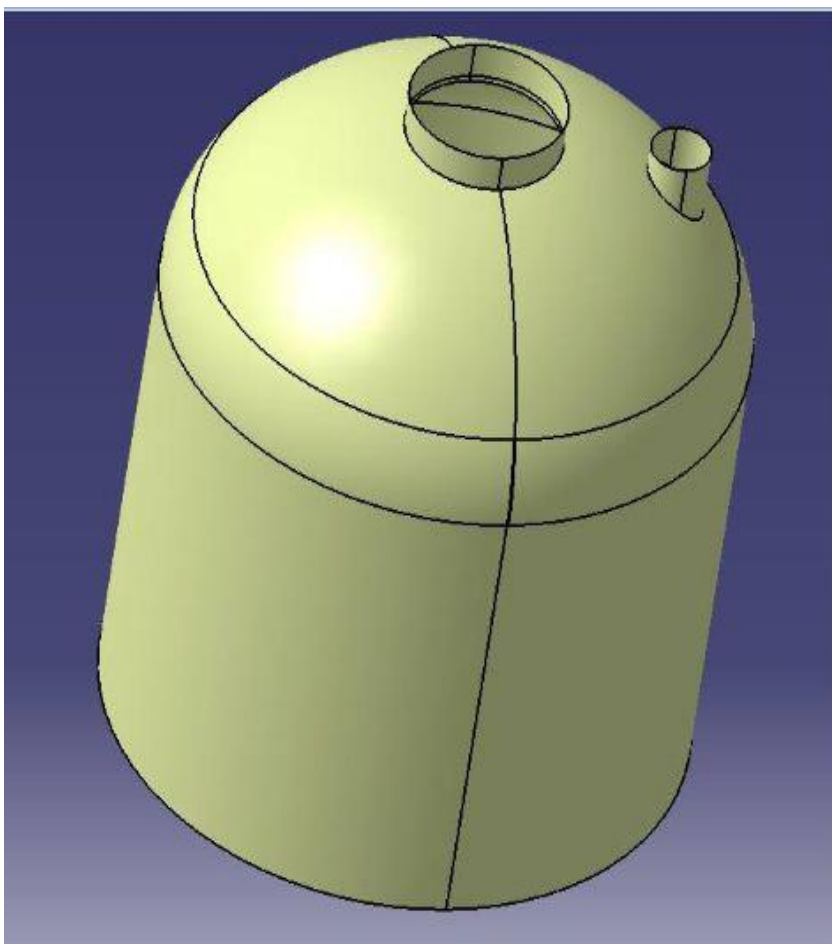

Figure 5.3 upper part of Plastic Boiling Tank

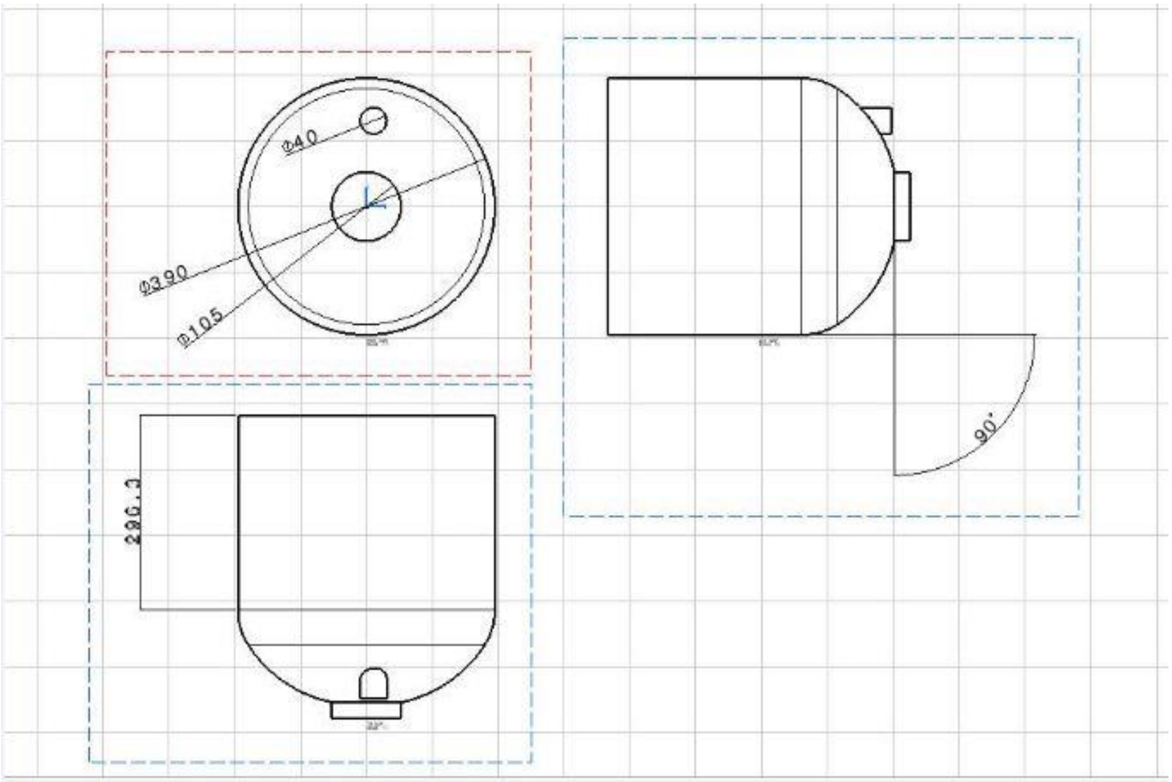

Figure 5.4 Diminution of the upper part of Plastic Boiling tank

- **the diminution of the part is in cm.**

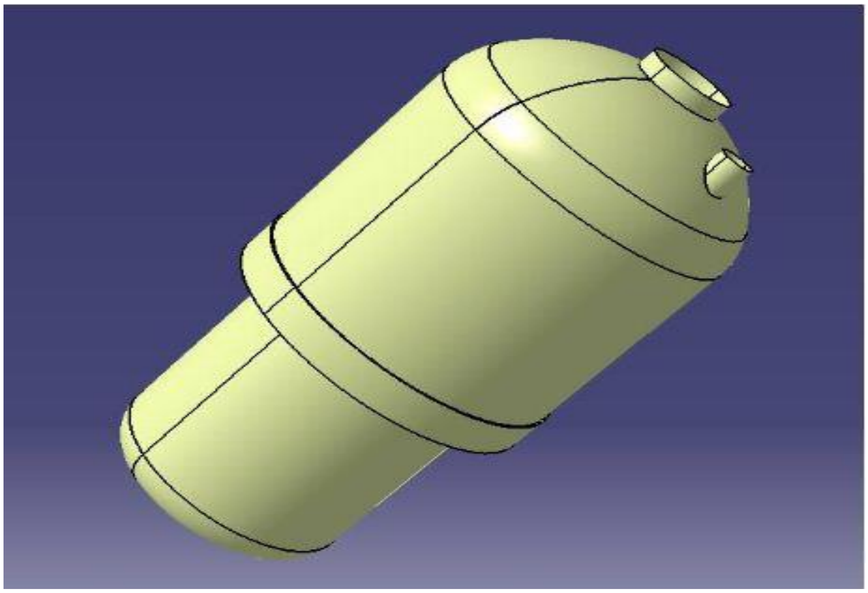

Figure 5.5 Plastic Boiling tank

5.2.2 Furnace Design

Is one of the most important parts in the design phase, which contains the oil burner system and a pipe heating system.

Also it's contain the temperature sensor. Where" Plastic Boiling tank " designed inside the Furnace.

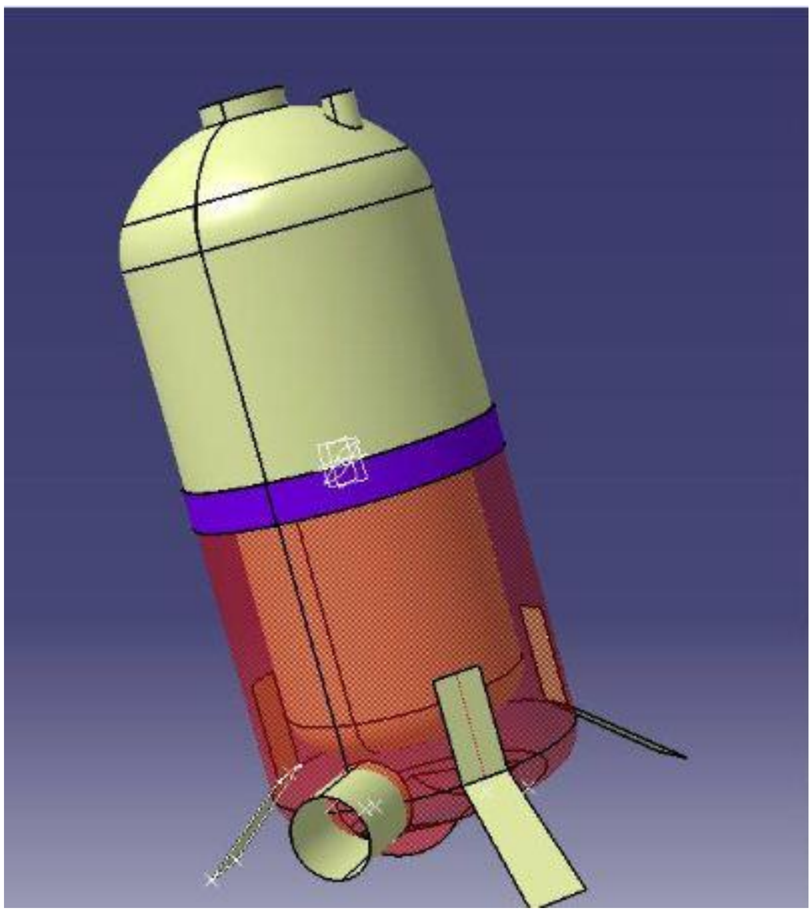

Figure 5.6 Plastic Boiling Tank inside the Furnace

So that the system designed to pump an air and oil into the Furnace, in a smooth manner as shown in Fig 5.6.

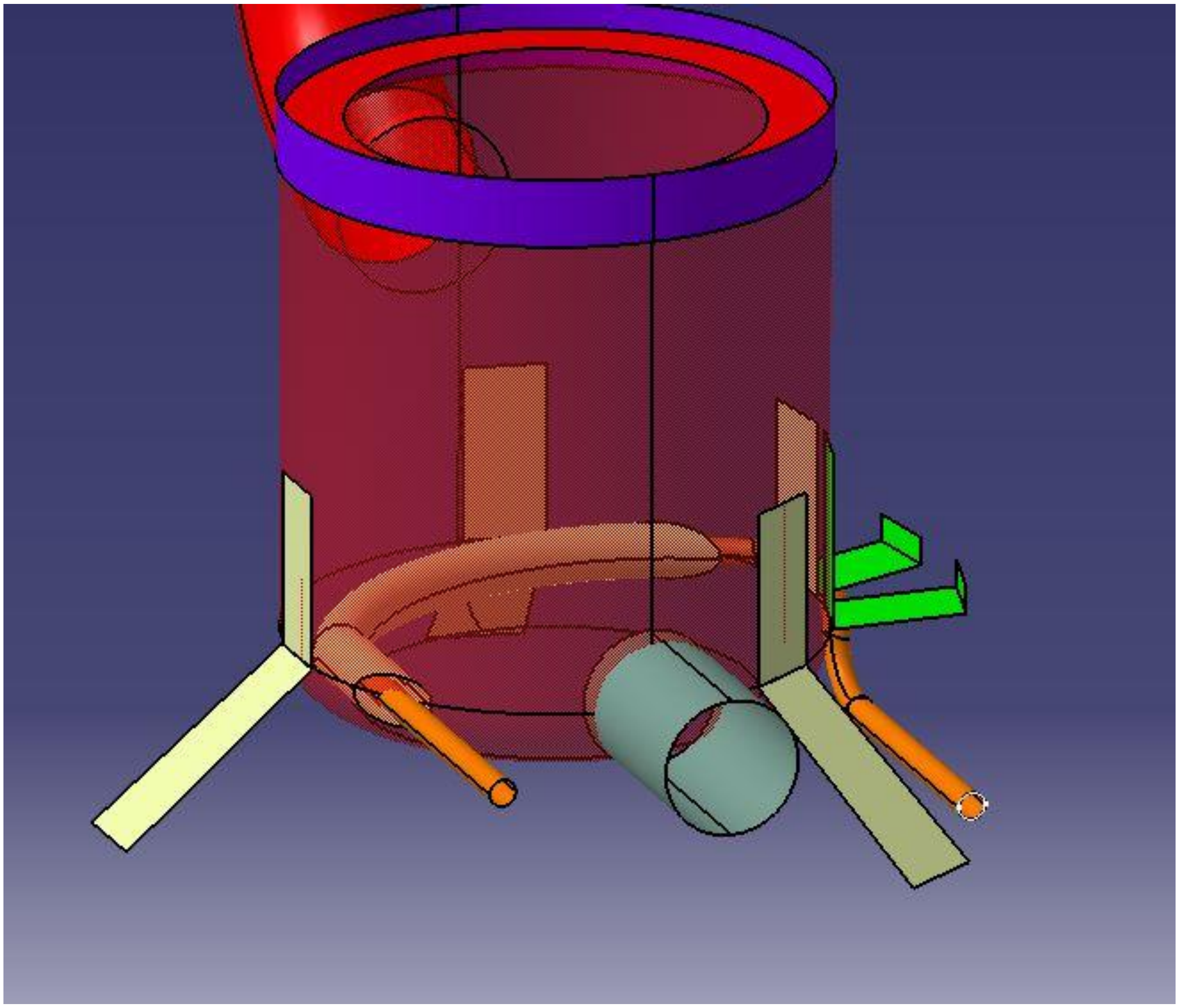

Figure 5.7 Furnace design

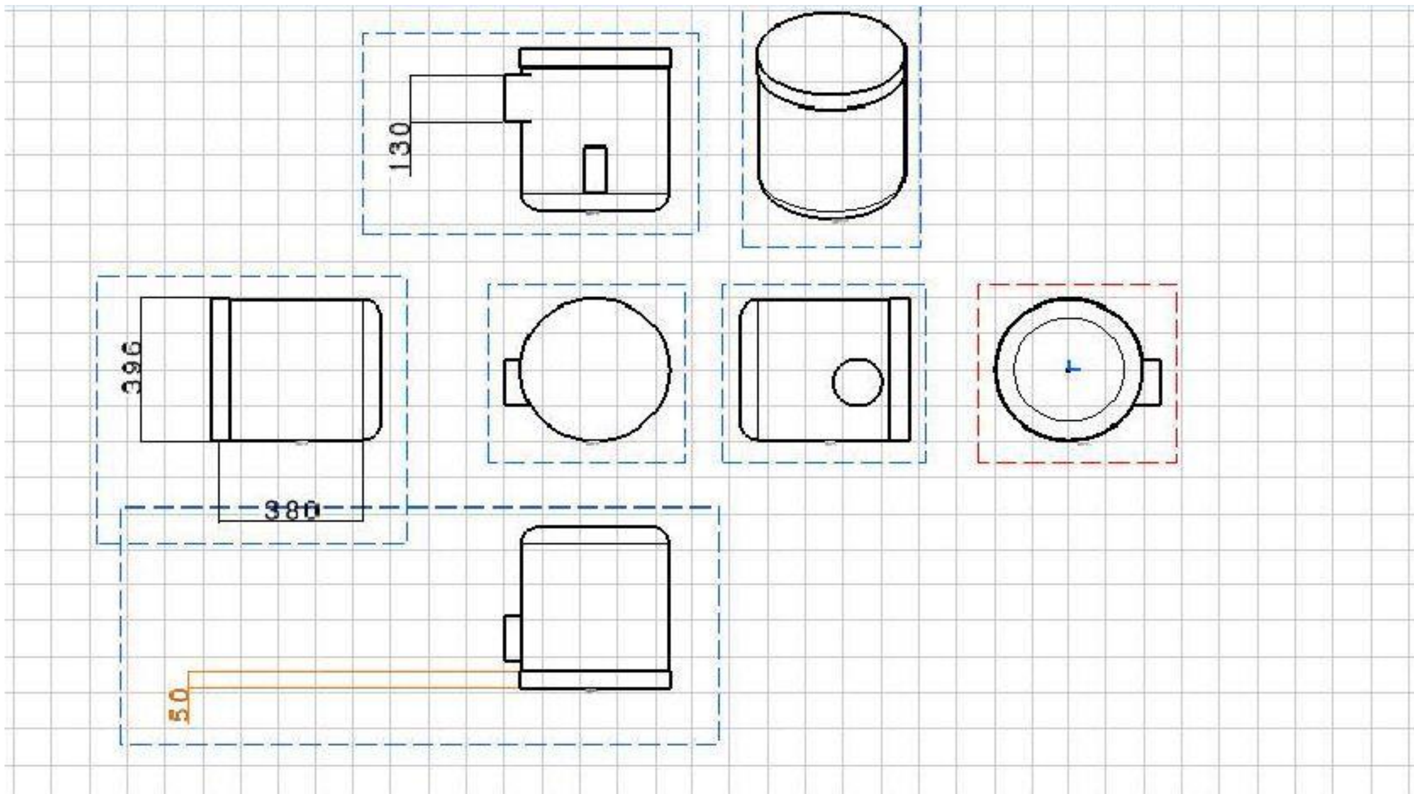

Figure 5.8 Dimensions Furnace design (cm)

5.2.3 Pipes Design

The oil pipe after the pump, where placed inside another large pipe inside the furnace to make the "used motor oil" gaining heat as shown in figure 5.3, this design has a significant impact on the efficiency of the system, where the heat makes this oil with a viscosity Close to diesel viscosity, in order to get the better burning.

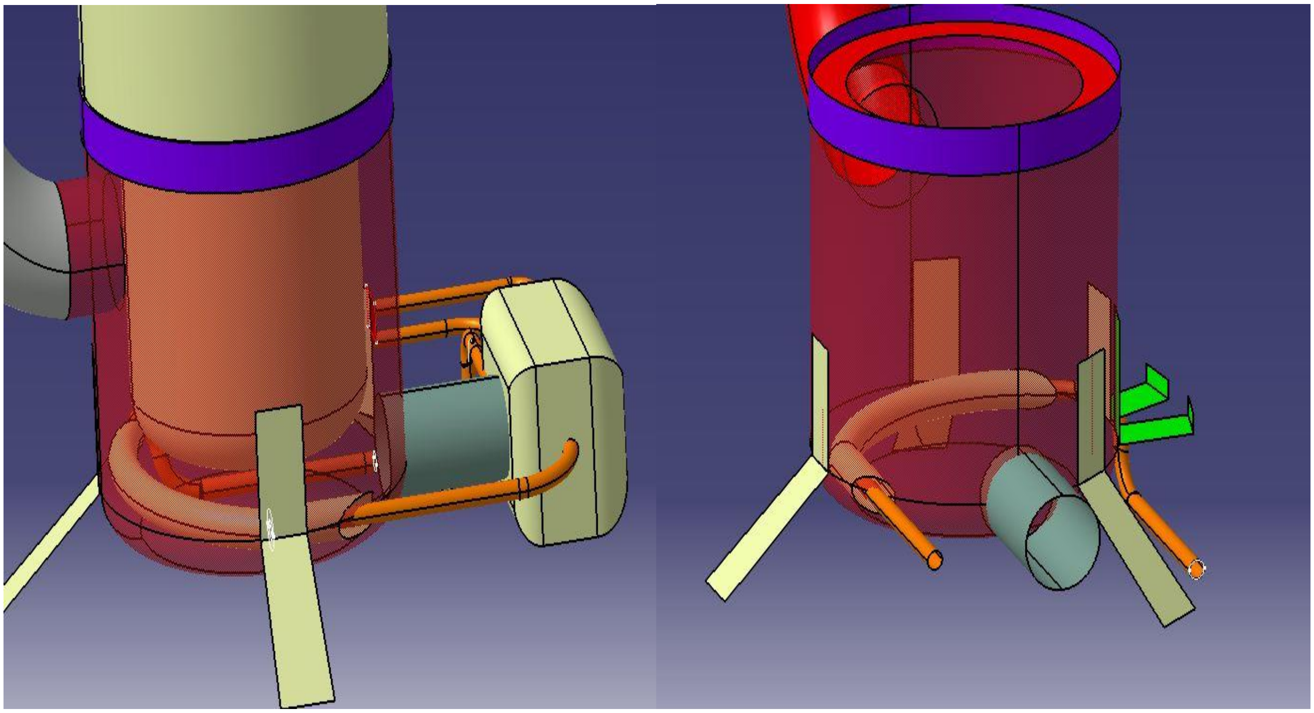

Figure 5.9 Pipes heating system

5.2.4 Oil tank

The tank is designed closer to the furnace to heat the oil inside it, and to make the oil with low viscosity, as shown in Fig 5.10.

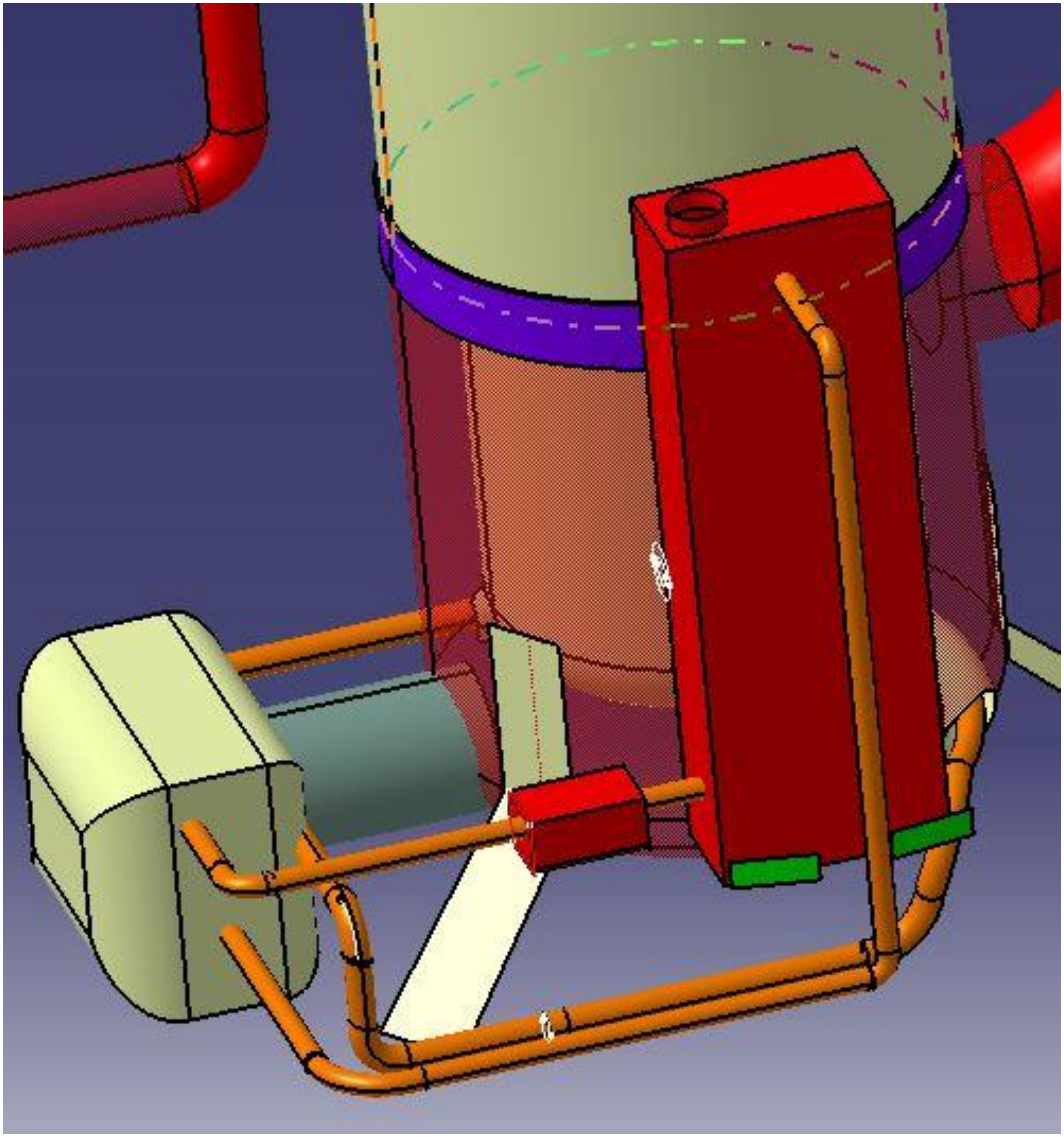

Figure 5.10 Pipe site

5.2.5 fuel tank

The Fuel that condensed by the condenser it will collected in this tank as shown in Fig 5.11

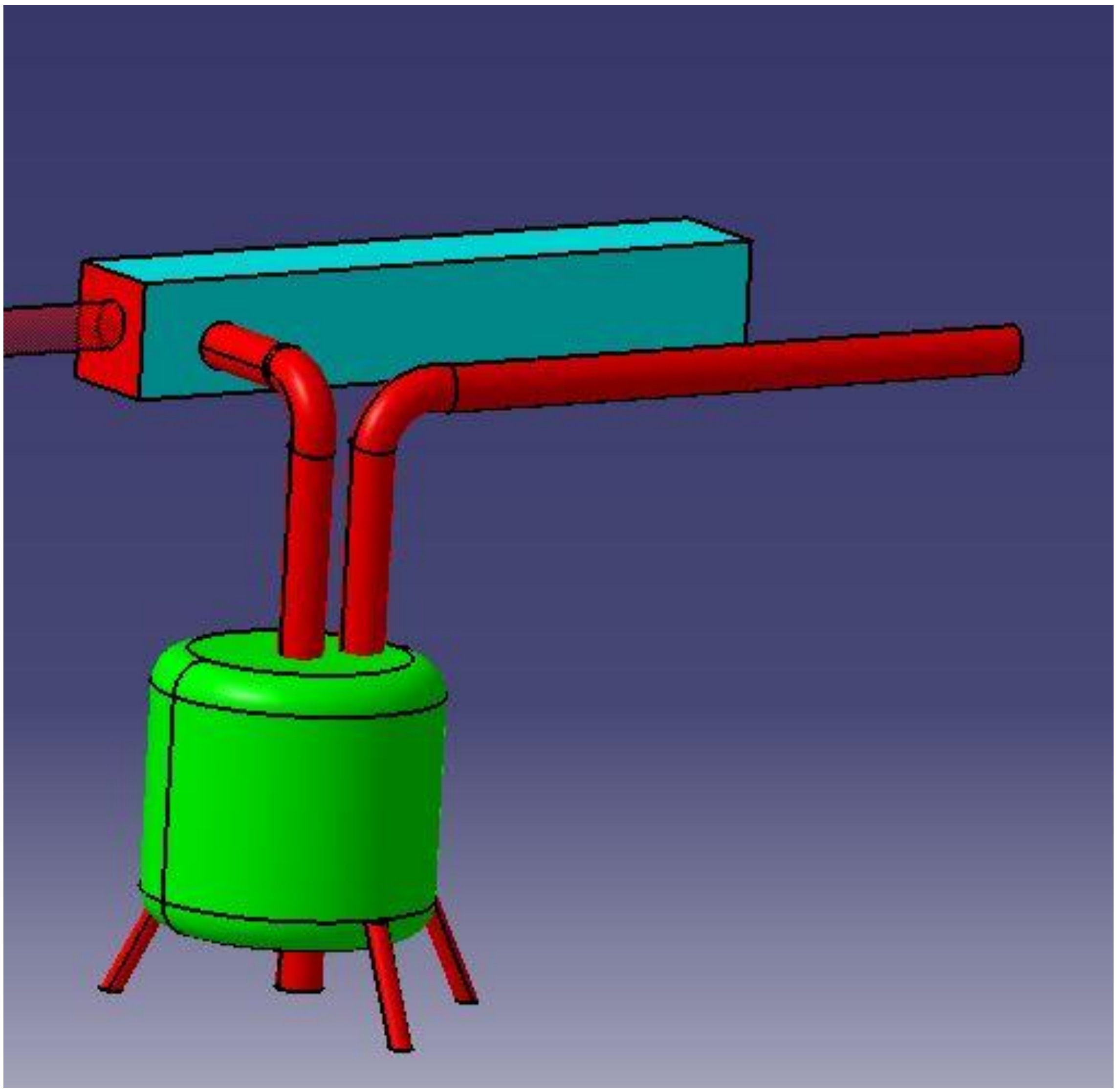

Figure 5.11 fuel tank and condenser

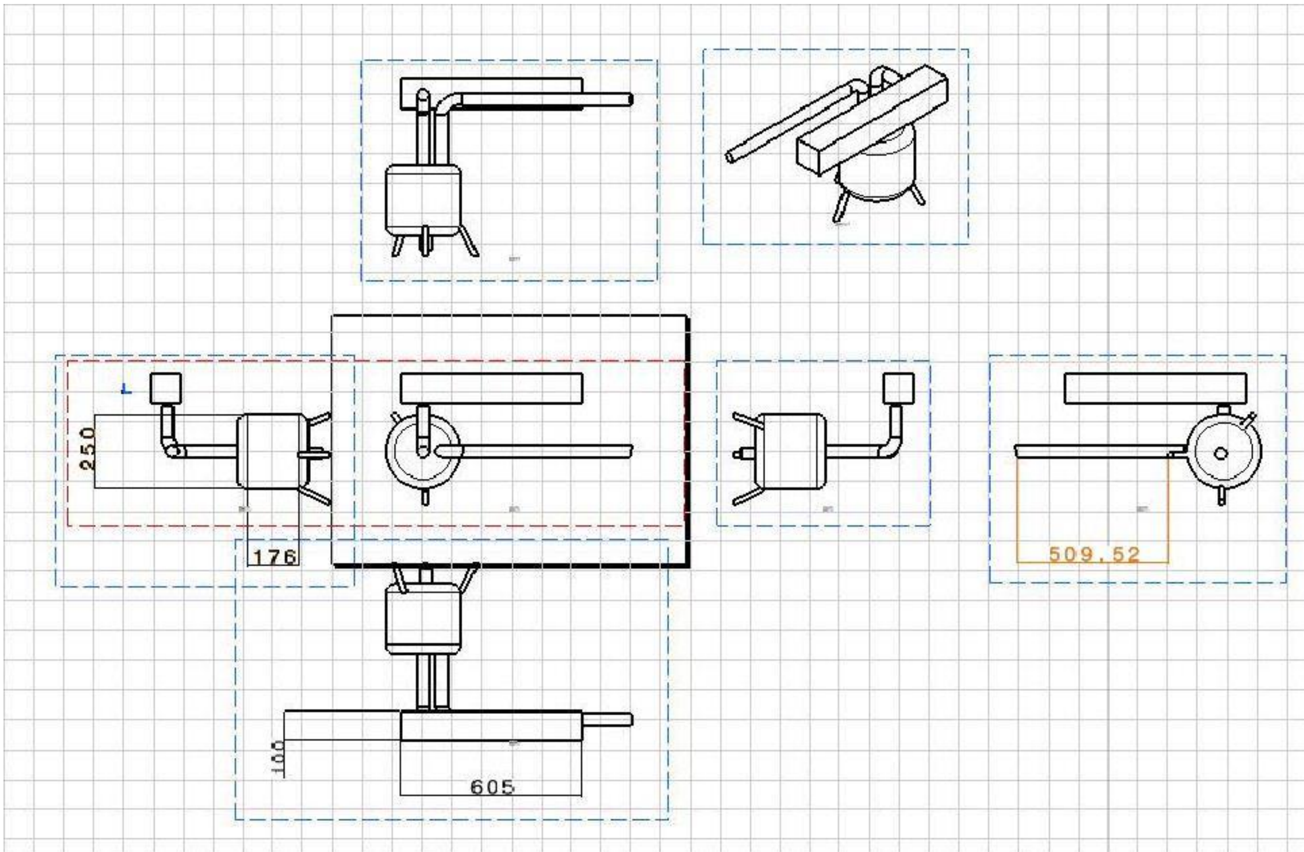

Figure 5.12 dimensions of fuel tank and condenser (cm)

Chapter Six

Software Design

6.1 Introduction

PIC18F4550 Microcontroller will used in the system to ensure that the system Works well and to monitoring the system such that the temperature, controlling on the oil burner and other inputs it will take about it in this chapter.

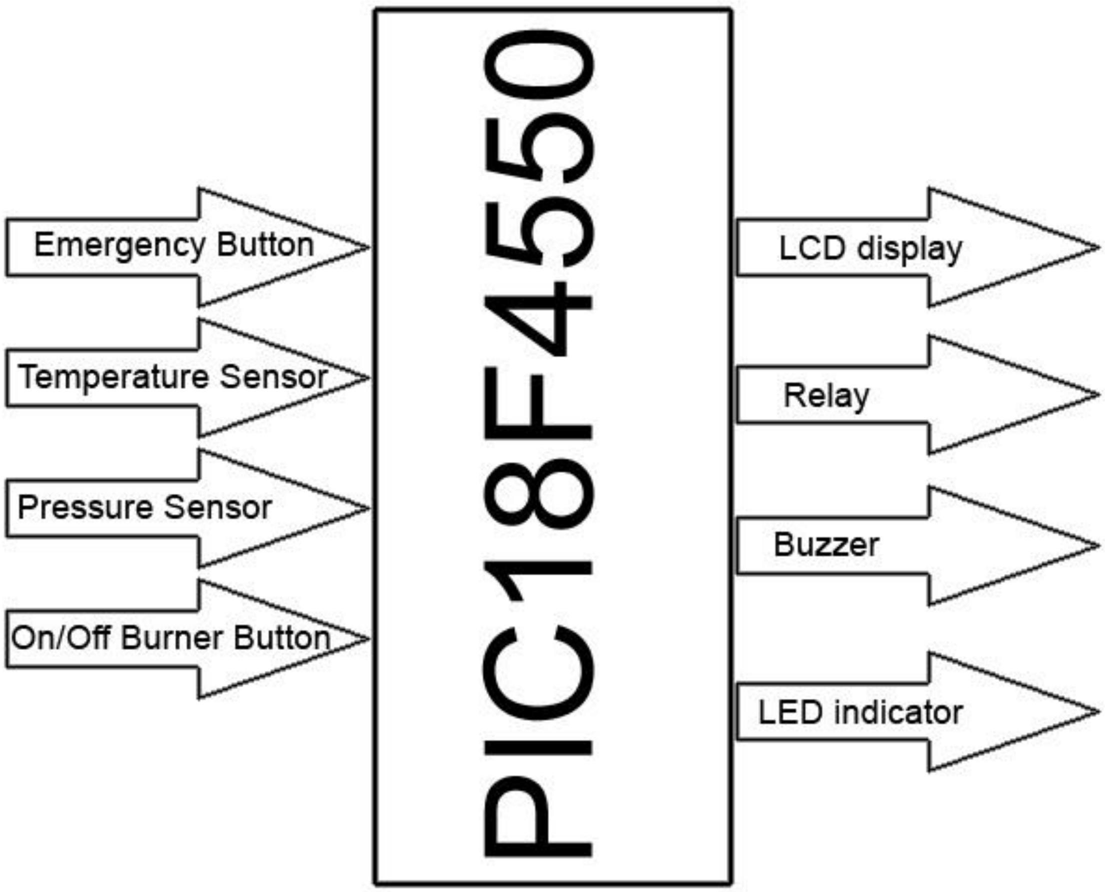

Figure 6.1 Inputs and outputs of the system.

According to the figure above these are the inputs and outputs of the system:

- **Inputs**

  - Emergency Button: That turn off the system in dangerous situation.
  - Temperature sensor: Detects the temperature in the furnace .
  - Pressure Sensor : Detects the the pressure in the tank.
  - On/Off Burner Button: The button that On/Off the oil burner.

- **Outputs**

  - Relay: This relay that connect between the microcontroller and oil burner power supply .
  - LED indicators: To indicate which operation selected.
  - Buzzer : This part indicating the user for dangerous situation.
  - LCD: Is the display screen.

6.2 Pin mapping

To interface with the outputs as denoted the address of each part must be known and named in the software, the following figure 4.2 shows the wiring of the peripherals and their pin number.

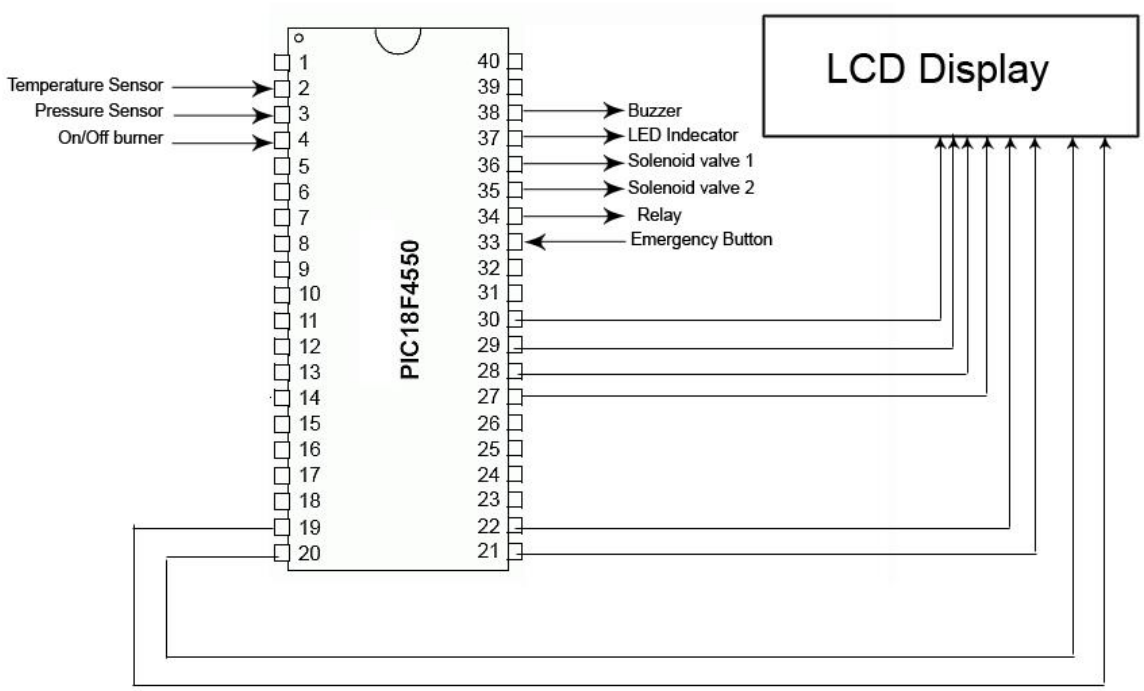

Figure 6.2 Pin mapping Input and outputs of the system.

6.3 16x2 LCD Display

To interface with the outputs as denoted the address of each part must be known and named in the software, the following Fig 4.2 shows the wiring of the peripherals and their pin number.

Pin NO.	Symbol	Function
1	Vdd	Power supply(+5V)
2	Vss	GND
3	Vo	Contrast Adjustment
4	RS	H/L Register select signal
5	$R/\overline{W}$	H/L Read / write signal
6	E	H→L Enable signal
7	DB0	H/L Data bus line
8	DB1	H/L Data bus line
9	DB2	H/L Data bus line
10	DB3	H/L Data bus line
11	DB4	H/L Data bus line
12	DB5	H/L Data bus line
13	DB6	H/L Data bus line
14	DB7	H/L Data bus line

Figure 6.3 LCD Pin function.

The following table show LCD pins connections with Microcontroller pins:

Table (6-1)

Microcontroller	LCD
D0	LCD_EN
D1	LCD_RS
D2	LCD_RW
D3	Not connect
D4-D7	D4-D7(Data)

6.4 K type thermocouple temperature Sensor

The advantage of this sensor is the ability to measure high temperature above 600C$^{\circ}$,and it is suitable for the system as shown in the figure

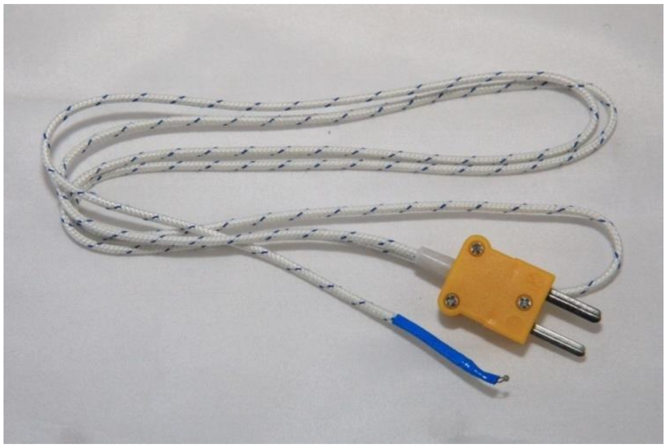

Figure 6.4 K-type sensor.

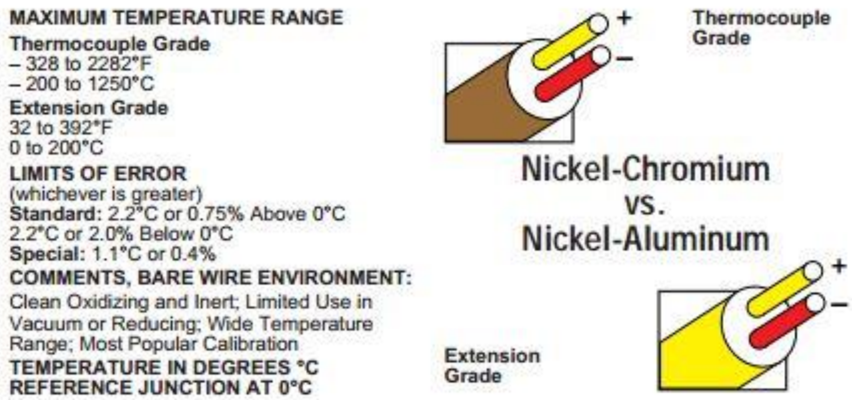

Figure 6.5 datasheet K-type sensor.

6.5 Pressure Sensor

This pressure sensor(HPT907 series) Able to withstand high temperatures up to 100 C˚.

Figure 6.6 HPT907 series Pressure sensor.

Specifications

Parameter:	HPT907A/B/C					
Pressure Range	0 ~ 4bar/5bar/6bar/7bar/8Bar/9Bar/10Bar/16Bar optional					
Body materials:	PA66≤30GF(HPT907A)	Brass and PA66 ≤30GF(HPT907B)	Brass(HPT907C)			
Overload	20 Bar or 40 Bar					
Accuracy	≤1.5%F.S.(Typical)					
Max Error:	±3%F.S. (including 0 ~ 90 °C temperature error)					
Working Temp	-30°C~100 °C					
Storage Temp	-40°C~85°C					
Temperature Compensation	0°C~60°C					
Supply voltage	5.0 ± 0.5VDC (default)	6 ~ 25VDC				
Supply current	<10mA					
Output impedance	≥2.5kΩ					
Output type:	radiometric					
Output voltage	0.5 ~ 4.5VDC (default)	0.5 ~ 3.5VDC	1.125 ~ 3.325VDC			
Pressure cycle life	>100,000					
Protection	IP65					
Pressure port	G1/4-19	G1/8-28	G3/8-19	φ14 faster access	φ16 quick access options	By customized
Measures media	Air, water, oil and other non-corrosive, non-solvent medium					
Vibration	10Hz,3mm/ one hour					
Cable	Red wire - +5VDC, Black(or white)-GND, Blue(or green)-V out					
Connector	1pin-5VDC,2pin-null,3pin-Vout,4pin-GND(Acquiescence type:C2521HF-4P)					
Certificate approving:	ROSH and CE Certificate.					
Remarks:	Special applications request ,can custom by order					

Figure 6.7 datasheet HPT907 series Pressure sensor.

Chapter Seven

Results and Recommendation

7.1 Results

7.1.1 WPTE Hardware System

7.1.2 The targeted plastic

7.1.3 Startup and get tangible results

7.1.4 Final results

7.2 Recommendation

7.1 Results

7.1.1 WPTE Hardware System

After design the system we build it as shown in Fig7.1 which contain the Furnace, Plastic Boiling Tank ,oil burner ,oil tank, oil filter ,oil pipes, pressure sensor, temperature sensor, condensers and fuel tank.

Figure 7.1 The WPTE Pyrolysis system

7.1.2 The targeted plastic

ABS plastic is a Plastic which addressed in this project, for several reasons, including:

* to produce 1kg from this plastic, need 2kg of petrol.

* Does not need catalysts in the pyrolysis system.

* Its waste very present, whether in the form of children's games or in the form of plastic printers, TVs and phones residues, and Plastic waste for cars like front bumpers.

7.1.3 Startup and get tangible results

First step take a sample from ABS plastic like front car bumper as shown in Fig7.2

Figure7.2 plastic front car bumper

Second step, cut it into pieces and put it into Plastic Boiling Tank and Sealing it as shown in Fig7.3.

Figure7.3 Cutting plastic inside Plastic Boiling Tank

Third step starting the process then, after the furnace Up to 400-degree heat, then the Emission flammable gas begins, as shown in Fig 7.4 .

Figure7.4 Flammable gas

Process	Heating rate	Residence time	Temperature (°C)	Target Products
Slow pyrolysis	10-100K/min	10-60 min	450-600	Gas, oil, char
Fast pyrolysis	Up to 1000K/s	0.5-5 s	550-650	Gas, oil, (char)
Flash pyrolysis	Up to 10000K/s	<1 s	450-900	Gas, oil, (char)

Table 7.1 Pyrolysis processes and target products [14].

7.1.4 Final results

1 kg ABS plastic sample gives 0.75 liter of fuel per 1 hour, and this is a mixture of fuel and can be separated. Also each hour the system consumes 2.5 liter of used motor oil.

Figure7.5 Produced fuel

After this operation and at the end of process the plastic became a fully char as shown in Fig7.6 and this char can benefit from it to making a pencils, for example.

Figure7.6 plastic char

7.2 Recommendations

1-To facilitate the operation and get away from the smoke occurs in the first minutes of the operating system ,prefer to work on diesel for the first minutes

2- Use a special condenser ”special design “ instead of using traditional gas condenser

3-Work pyrolysis system for output fuel, but under lower temperatures to get pure fuel.

References

1- Plastic waste management by:JaveriyaSiddiquiM.Tech(Env. Engg.)

http://www.slideshare.net/030889/plastic-waste-management-16667588

2- Recycling of Plasticsby: By Salman Zafar | April 7, 2014

http://www.ecomena.org/tag/plastic-waste-management/

3- Waste management:

http://en.wikipedia.org/wiki/Waste_management

4- Landfill :

http://en.wikipedia.org/wiki/

5- plastic biodegradiation in landfills by: Galen Killam

http://green-plastics.net/posts/45/plastic-biodegradation-in-landfills/

6- Plastic recycling :

http://en.wikipedia.org/wiki/Plastic_recycling

7- Plastic :

http://en.wikipedia.org/wiki/Plastic

8- Acrylonitrile butadiene styrene:

http://en.wikipedia.org/wiki/Acrylonitrile_butadiene_styrene

9- http://toplowridersites.com/sporty-dynamic-front-bumper-from-pain-capable-abs-plastic-shock/

10- http://homeguides.sfgate.com/transition-abs-pvc-sink-drain-66285.html

11- http://en.wikipedia.org/wiki/Pyrolysis

12-Synthesis of Petroleum-Based Fuel from Waste Plastics and

Performance Analysis in a CI Engine by:

Christine Cleetus, ShijoThomas,andSoney Varghese ,Feb 2013

13-Pyrolysis of Acrylonitrile-Butadiene-Styrene (ABS)
Under High Heat Flux Conditions by :
James R. Wilson , Utah State University ,12/1/2013
14- Pyrolysis of Waste Plastics into Fuels By :
FengGao , University of Canterbury , 2010

15-Thermofuel – " Pyrolysis of waste plastic to produce Liquid Hydroocarbons" By:
Dr. P.V. Thorata, Miss. SandhyaWarulkara ,Miss.HarshalSathonea11 January 2013