Design Of Heat Exchanger And Converting It Into Thermodynamics To Produce Electricity

A Project report submitted

in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

In

MECHANICAL ENGINEERING

By

PADIMI BHAVANI SANKAR	318126520L36
I S K PRANEETH	31716520136
PENKI VINEETH	317126520157
P PAVAN KALYAN REDDY	317126520159
GEDELA ARAVIND	317126520132

Under the esteemed guidance of

Mr. B Ramanjaneyulu

Assistant Professor

DEPARTMENT OF MECHANICAL ENGINEERING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY &

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Sangivalasa, Bheemunipatnam Mandal

Visakhapatnam (District) – 531162

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ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (A)
(Affiliated to Andhra University, Approved by AICTE, Accredited by NBA & NAAC with A grade)
SANGIVALASA, VISAKHAPATNAM (District) – 531162

CERTIFICATE

This is to certify that the Project Report entitled **"DESIGN OF HEAT EXCHANGER AND CONVERTING IT INTO THERMODYNAMICS TO PRODUCE ELECTRICITY"** being submitted by PADIMI BHAVANI SANKAR (318126520L36), INAPUDI SAI KRISHNA PRANEETH (317126520136), PENKI VINEETH (317126520157), PILAKA PAVAN KALYAN REDDY (317126520159), GEDELA ARAVIND (317126520132) in partial fulfillments for the award of degree of **BACHELOR OF TECHNOLOGY** in **MECHANICAL ENGINEERING, ANITS**. It is the work of bona-fide, carried out under the guidance and supervision of **MR.S.RAMANJANEYULU**, Assistant Professor, Department Of Mechanical Engineering, ANITS during the academic year of 2017-2021.

Approved By

PROJECT GUIDE	HEAD OF THE DEPARTMENT
(MR.S.RAMANJANEYULU)	**(Dr. B. Naga Raju)**
Assistant Professor	**Head of the Department**
Mechanical Engineering Department	**Mechanical Engineering Department**
ANITS, Visakhapatnam.	**ANITS, Visakhapatnam.**

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
Sangivalasa-531 162 VISAKHAPATNAM Dist. A.P.

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ABSTRACT

At present the burning issue around the world is the energy crisis due to the lack of non- renewable energy sources , which gives a sound impact on the usage of the energy liberated to the atmosphere (Waste heat) , and all the experiments are going around efficient usage of the available energy into useful work. Huge amount of energy is rejected from industries, manufacturing plants as a waste heat into environment which may lead to increase the environmental global warming.currently it has been identified that there is a lot of unused heat energy which is released into atmosphere from the moulded bars while cooling to room temperature in the Steel Plant.

The aim of this project is to convert the waste heat that is available at the steel plant into useful work. This project works on the principle of seebeck effect and it is one of the direct energy conversion techniques. The Thesis focuses on the design, fabrication of Heat Exchanger in order to produce electricity by using seebeck principle. The analytical work is carried out by using NI lab View Software for calculating temperatures which varies by time to achieve useful work.

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Chapter – 1
Introduction

CHAPTER-1 INTRODUCTION

1.1 Waste heat in the industries – General Overview

As we talk about the waste heat, lots of heat is simply exhausted into the sink i.e., the atmosphere which can be utilized in many ways.

Industrial waste heat refers to energy that is generated in industrial processes without being put to practical use. Sources of waste heat include hot combustion gases discharged to the atmosphere, heated products exiting industrial processes, and heat transfer from hot equipment surfaces. The exact quantity of industrial waste heat is poorly quantified, but various studies have estimated that as much as 20 to 50% of industrial energy consumption is ultimately discharged as waste heat. While some waste heat losses from

Industrial processes are inevitable; facilities can reduce these losses by improving equipment efficiency or installing waste heat recovery technologies. Waste heat recovery entails capturing and reusing the waste heat in industrial processes for heating or for generating mechanical or electrical work. Example uses for waste heat include generating electricity, preheating combustion air, preheating furnace loads, absorption cooling, and space heating.A heat exchanger is a device which is used to transfer heat from a hot body to a cold body.

Heat recovery technologies frequently reduce the operating costs for facilities by increasing their energy productivity. Many recovery technologies are already well developed and technically proven; however, there are numerous applications where heat is not recovered due to a combination of market and technical barriers. As discussed below, various sources indicate that there may be significant opportunities for improving industrial energy efficiency through waste heat recovery. A comprehensive investigation of waste heat losses, recovery practices, and barriers is required in order to better identify heat recovery opportunities and technology needs. Such an analysis can aid decision makers in identifying research priorities for promoting industrial energy efficiency.

1.2 Problem Overview and Approach

As we discussed earlier waste heat is available in the steel plant of Visakhapatnam in the form of the temperature of the molten material which is around 1700^0 c to 1950^0c. So this amount of heat energy is wasted during the process of cooling the molten metal which is drawn into large structures or bars after moulding.

By considering the waste heat that is available in the steel plant which can be best utilized for production of electricity by using the see beck effect. A device named thermoelectric generator is utilized for this purpose. TEC1-12706 Heat sink Thermoelectric Cooler Cooling Peltier Plate Module 12V 60W Features: - Get ice cold in minutes or heat to boiling by simply reversing the polarity. Used for numerous applications from CPU coolers to alternate power sources, or even for your own custom car, drinking water warmer/cooler.

Approach

The temperature at the steel plant is relatively high, in order to represent the high temperature atmosphere that is available at the steel plant I am using an induction spring which produces the heat energy by using electric energy based on the principle of resistance. The heat energy liberated by the ignition coil is equivalent to the heat liberated by the cooling molten metal at steel plant. By using the peltier module and the thermo electric generator we can produce the electricity by the principle of see-beck effect.

1.3Thermoelectric Generators Theory

A Thermoelectric generator (TEG) is a device that converts heat directly into electrical energy through a phenomenon called the Seebeck effect. Thermoelectric generators could be used in power plants in order to convert waste heat into additional electrical power. Another application is radioisotope thermoelectric generators which are used in space probes, which has the same mechanism but use radioisotopes to generate the required heat difference. They are primarily used as remote and off-grid power generators for unmanned sites. They are the most reliable power generator in such situations as they do not have moving parts, work day and night, perform under all weather conditions, and can work without battery backup

Thermoelectric power generators consist of three major components: thermoelectric materials, thermoelectric modules and thermoelectric systems that interface with the heat source.

Thermoelectric materials generate power directly from heat by converting temperature differences into electric voltage. These materials must have both high electrical conductivity (σ) and low thermal conductivity (κ) to be good thermoelectric materials. Having low thermal conductivity ensures that when one side is made hot, the other side stays cold, which helps to generate a large voltage while in a temperature gradient. The measure of the magnitude of electrons flow in response to a temperature difference across that material is given by the Seebeck coefficient (S).

1.4 Objective of the Thesis

The main motto of this thesis is to fabricate a prototype that resembles the heat exchanger which is used for two purposes.

i) To convert the waste heat into electric energy.
ii) To run an electric appliance by using that electricity produced.

Chapter – 2
Literature Review

CHAPTER-2	LITERATURE REVIEW

Summary of Review of Literature:

C.Rameshkumar AnkitSonthalia and **Rahul goel[1]** presented EXPERIMENTAL STUDY ON WASTE HEAT RECOVERY FROM AN INTERNAL COMBUSTION ENGINE USING THERMOELECTRIC TECHNOLOGY has investigated major part of the heat supplied in an internal combustion engine is not realized as work output, but dumped into the atmosphere as waste heat. If this waste heat energy is tapped and converted into usable energy, the overall efficiency of an engine can be improved .The percentage of energy rejected to the environment through exhaust gas which can be potentially recovered is approximately 30-40% of the energy supplied by the fuel depending on engine load.

L.Che F. Meng,F. Sun[2] has done project on Maximum power and efficiency of an irreversible thermo electric generator with a generalized heat transfer law by an advanced model of irreversible thermoelectric generator with a generalized heat transfer law is established based on finite time thermodynamics. The generalized heat transfer law represents a class of heat transfer laws including Newtonian heat transfer law, linear phenomenological heat transfer law, radiative heat transfer law, Dulong-Petit heat transfer law, generalized convective heat transfer law and generalized radiative heat transfer law.

Ajitkumar N. Nikamand Dr. Jitendra[3]has done a Review on use of Peltier Effects by they studied that In recent years, with the increase awareness towards environmental degradation due to the production, use and disposal of Chloro Fluoro Carbons (CFCs) and Hydro Chlorofluorocarbons (HCFCs) as heat carrier fluids in conventional refrigeration and air conditioning systems has become a subject of great concern and resulted in extensive research into development of novel refrigeration and space conditioning technologies.

P.ArunkumarP.Iswarya,S.SuprajaP.RajaRajan and **G.Balajiha[4]**has presented a project on A New Concept of Energy Recovery and Cooling Solution for Integrated Circuit Heat Using Thermoelectric Technology by has done a project on Energy recovered from the waste heat of IC's might be utilized for providing backup electricity in an emergency situation or providing electricity to drive electrical components. Thermoelectric generators are solid-state energy converters that combine thermal and electrical properties to convert heat into electricity or electrical power directly into cooling. Effective energy recovery may improve energy efficiencies and also life of IC and the equipment.

N. Pradeep Kumar S. Suseel Jai Krishnan and**N**. **SakthiThasan's**[5]Effects of fouling in EGR Coolers in Automobiles by 20 per cent of global greenhouse gas emissions such as CO2 NOx and HC which have not been burned completely in the engine. In particular, 55 per cent of globally emitted NOx which is more harmful to the environment than CO2 is produced by the automotive industry alone. Strict emission standards are now in place that set specific limits to the amount of pollutants that can be released into the environment. The widely used measure to reduce NOx emissions in diesel engines is to return part of the exhaust gas to the intake of the engine. This is usually done through via a heat exchanger known as exhaust gas recirculation cooler. However EGR coolers are subject to severe fouling such that their thermal efficiency can drop by as much as 30 per cent within a very short period of time. More importantly, the deposit layer is a blend of particulate matter and sticky heavy hydrocarbons that are very difficult to remove from the heat exchanger surfaces. The present study addresses this problem and provides a review on the effects and R & D activities happening to mitigate fouling of EGR cooler.

Sandeep K. Patel and**Alkesh M. Mavani**[6]SHELL & TUBE HEAT EXCHANGER THERMAL DESIGN WITH PTIMIZATION OF MASS FLOW RATE AND BAFFLE SPACING has investigated a Heat Exchanger is a device which provides a flow of thermal energy between two or more fluids at different temperatures. Heat exchangers are used in a wide variety of engineering applications like power generation, waste heat recovery, manufacturing industry, air-conditioning, refrigeration, space applications, petrochemical industries etc.

Valeri I. Bubnovich, Nina OrlovskayaLuis, A. Henríquez Vargasand **FranciscoEIbacache**[7] done Experimental Thermoelectric Generation in a Porous Media Burner Has done an experimental study on combustion in porous media and thermoelectric generation was performed. The reactor was composed of two types of porous media where flame stabilization was reached at the interface of them. An external thermoelectric module was placed to harvest the thermal energy produced in the system.

Sumeetkumar, Stephen d.heister, Xianfanxuand**James r.salvador and Gregory p.meisner**[8]has studied on Thermoelectric Generators for Automotive Waste Heat Recovery A numerical model has been developed to simulate coupled thermal and electrical energy transfer processes in a thermoelectric generator (TEG) designed for automotive waste heat recovery systems. This model is capable of computing the overall heat transferred, the electrical power output, and the associated pressure drop for given inlet conditions of the exhaust gas and the available TEG volume.

Alemi.H, Aghanajafi.C and**Kashi.A K.N. Toosi's**[9]OPTIMIZATION AND INVESTIGATION OF MULTI-STAGE THERMOELECTRIC GENERATION SYSTEMS WITH PARTICLE SWARM OPTIMIZATION (PSO)Their aim is to investigate the optimization of some properties of thermoelectric systems in generators systems. The procedures used for the optimization of the system are the particle swarm optimization (PSO). First, the maximum efficiency and power production in multi-stage thermoelectric systems, which are connected in both parallel and series, are computed. Then, the performance of these systems is compared with each other.

José Rui Camargo and **Maria Claudia Costa de Oliveira**[10]has done project on the Seebeck effect was first observed by the physician Thomas Johann Principles of Direct Thermoelectric ConversionSeebeck, in 1821, when he was studying thermoelectric phenomenon. It consists in the production of an electric power between two semiconductors when submitted to a temperature difference. Heat is pumped into one side of the couples and rejected from the opposite side. An electrical current is produced, proportional to the temperature gradient between the hot and cold sides. The temperature differential across the converter produces direct current to a load producing a terminal voltage and a terminal current. There is no intermediate energy conversion process. For this reason, thermoelectric power generation is classified as direct power conversion.

Chapter – 3
Design And Fabrication

3.1 Design Considerations:

The fabricated heat exchanger is of dimensions

14 inches in height

9 inches in length

These dimensions are taken from a heat exchanger that is available at VIZAG STEEL PLANT; the parameters for the design of the heat exchanger are the length, breadth and height.

The most important dimension is the distance between the two heat producing induction coils that plays a vital role in the formation of hot side for the thermo couple. In the fabrication of the prototype two heat exchangers are used in which one of the heat exchanger is placed on the left side and the other one is placed on the right side. The distance between both the coils is 9 inches in which if the distance between the coils is increased then the heat transferred may be low and the required level of temperature is not attained. On the other hand if the length is low then it may lead to spoil the components of the prototype because of the excessive temperature raise within very short span of time. The outer diameter of the heat exchanger is 5.8" inches.

One side of the induction coil holder consists of a peltier module and on the other side, the induction coil which makes one side of the peltier as hot and the other side of the peltier is free to the open atmosphere which acts as a cold junction that can creates the temperature difference in the peltier module which creates the electric power.

At the top of the prototype an integrated cooling fan is fitted whose diameter is 4.8 inches. It is rotated with the energy produced by the peltier`s. A sensor which is used to sense the temperature is placed inside the heat exchanger; it is synchronized with the N.I. Lab View software with the aid of Arduino

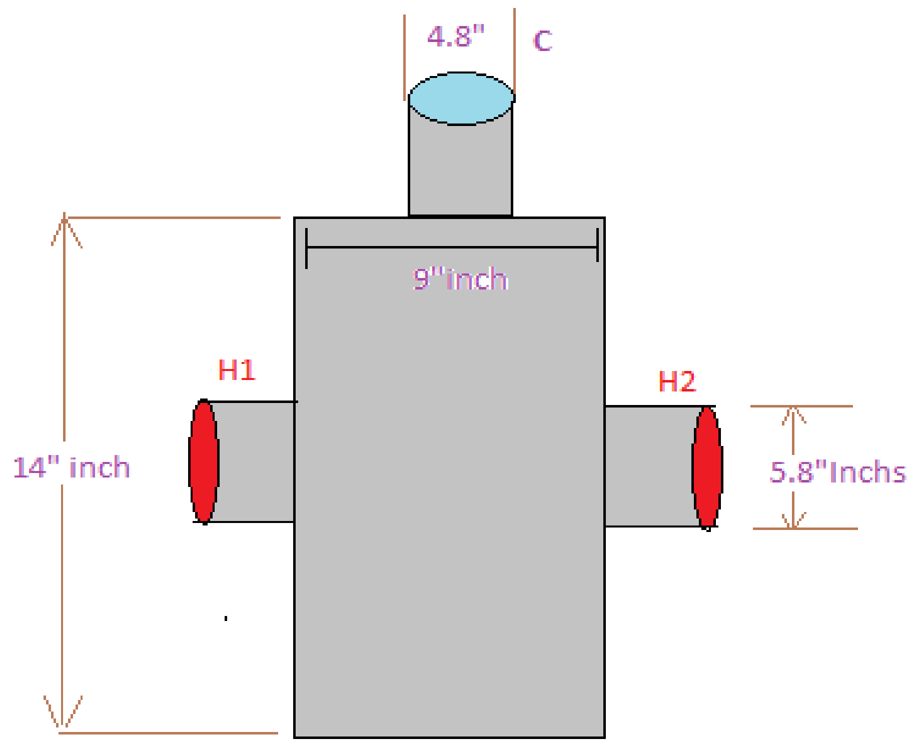


Fig 3.1 Heat Exchanger Prototype

3.2 Fabrication:

The metal taken here is a sheet metal and subjected to perform the following sheet metal operations in order to fabricate the heat exchanger body. The required properties of the sheet metal taken are:

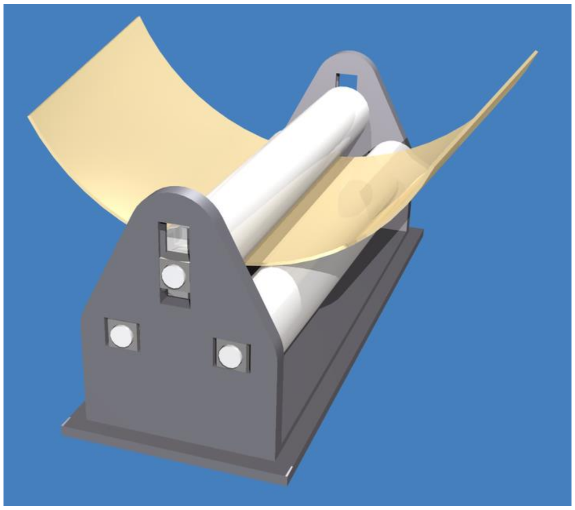
Thickness :

Thermal conductivity :

Thermal expansion coefficient :

The operations performed on the sheet metal are bending, spinning, punching, press brake forming.

Foldable Metal sheet:



Sheet metal is metal formed by an industrial process into thin, flat pieces. It is one of the fundamental forms used in metalworking and it can be cut and bent into a variety of shapes. Countless everyday objects are constructed with sheet metal. Thicknesses can vary significantly; extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered as plate. Sheet metal is available in flat pieces or coiled strips. The coils are formed by running a continuous sheet of metal through a roll slitter. The thickness of sheet metal is commonly specified by a traditional, non-linear measure known as its gauge. The larger the gauge number, the thinner the metal. Commonly used steel sheet metal ranges from 30 gauges to about 7 gauges. Gauge differs between ferrous (iron based) metals and nonferrous metals such as aluminum or copper; for example copper thickness is measured in ounces (and represents the thickness of 1 ounce of copper rolled out to an area of 1 square foot).

Press Brake Forming:

Forming metal on a press brake, this is a form of bending used to produce long, thin sheet metal parts. The machine that bends the metal is called a press brake. The lower part of the press contains a V-shaped groove called the die. The upper part of the press contains a punch that presses the sheet metal down into the v-shaped die, causing it to bend. There are several techniques used, but the most common modern method is "air bending". Here, the die has a sharper angle than the required bend (typically 85 degrees for a 90 degree bend) and the upper tool is precisely controlled in its stroke to push the metal down the required amount to bend it through 90 degrees. Typically, a general purpose machine has an available bending force of around 25 tons per meter of length. The opening width of the lower die is typically 8 to 10 times the thickness of the metal to be bent (for example, 5 mm material could be bent in a 40 mm die). The inner radius of the bend formed in the metal is determined not by the radius of the upper tool, but by the lower die width. Typically, the inner radius is equal to 1/6 of the V-width used in the forming process.

The press usually has some sort of back gauge to position depth of the bend along the work-piece. The back gauge can be computer controlled to allow the operator to make a series of bends in a component to a high degree of accuracy. Simple machines control only the backstop, more advanced machines control the position and angle of the stop, its height and the position of the two reference pegs used to locate the material. The machine can also record the exact position and pressure required for each bending operation to allow the operator to achieve a perfect 90 degree bend across a variety of operations on the part.

Punching:

Punching is performed by placing the sheet of metal stock between a punch and a die mounted in a press. The punch and die are made of hardened steel and are the same shape. The punch just barely fits into the die. The press pushes the punch against and into the die with enough force to cut a hole in the stock. In some cases the punch and die "nest" together to create a depression in the stock. In progressive stamping a coil of stock is fed into a long die/punch set with many stages. Multiple simple shaped holes may be produced in one stage, but complex holes are created in multiple stages. In the final stage, the part is punched free from the "web".

A typical CNC turret punch has a choice of up to 60 tools in a "turret" that can be rotated to bring any tool to the punching position. A simple shape (e.g., a square, circle, or hexagon) is cut directly from the sheet. A complex shape can be cut out by making many square or rounded cuts around the perimeter. A punch is less flexible than a laser for cutting compound shapes, but faster for repetitive shapes (for example, the grille of an air-conditioning unit). A CNC punch can achieve 600 strokes per minute.

A typical component (such as the side of a computer case) can be cut to high precision from a blank sheet in less than 15 seconds by either a press or a laser CNC machine.

Spinning:

Spinning is used to make tubular (axis-symmetric) parts by fixing a piece of sheet stock to a rotating form (mandrel). Rollers or rigid tools press the stock against the form, stretching it until the stock takes the shape of the form. Spinning is used to make rocket motor casings, missile nose cones, satellite dishes and metal kitchen funnels.

Fig 3.2 Fabricated Heat Exchanger

3.3 Components of the prototype

3.3.1 Thermoelectric Generator

A Thermoelectric generator (TEG) is a device that converts heat directly into electrical energy through a phenomenon called the Seebeck effect. Thermoelectric generators could be used in power plants in order to convert waste heat into additional electrical power. Another application is radioisotope thermoelectric generators which are used in space probes, which has the same mechanism but use radioisotopes to generate the required heat difference. They are primarily used as remote and off-grid power generators for unmanned sites. They are the most reliable power generator in such situations as they do not have moving parts, work day and night, perform under all weather conditions, and can work without battery backup

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TEC1-12706 Heat sink Thermoelectric Cooler Cooling Peltier Plate Module 12V 60W Features: - Get ice cold in minutes or heat to boiling by simply reversing the polarity, - Used for numerous applications from CPU coolers toalternate power sources, or even for your own custom car drink warmer/cooler. - Since they consist primarily of semiconductor material sandwiched between ceramic plates and have no moving parts -These devices must be used in conjunction with a heat sink to avoid burned - Each device is full inspected and tested - Fitted with 6-inch insulated leads Technical Specifications: -Model: TEC1-12706 -Size: 40mm x 40mm x 4mm -Operates from 0~15.2V DC and 0~6A -Operates Temperature: -30 to 70 -Max power consumption: 60 Watts -Original box: NO -Net weight: 22g -Package weight: 31g

3.3.2 Heat Exchanger

Heat exchangers are most commonly used to transfer heat from combustion exhaust gases to combustion air entering the furnace. Since preheated combustion air enters the furnace at a higher temperature, less energy must be supplied by the fuel. Typical technologies used for air preheating include recuperators, furnace regenerators, burner regenerators, rotary regenerators, and passive air preheaters.

3.3.2.1 Recuperator

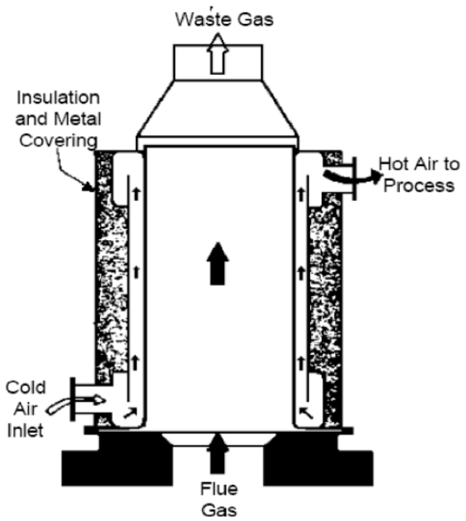
Recuperators recover exhaust gas waste heat in medium to high temperature applications such as soaking or annealing ovens, melting furnaces, afterburners, gas incinerators, radiant tube burners, and reheat furnaces. Recuperators can be based on radiation, convection, or combinations:

• A simple radiation recuperator consists of two concentric lengths of ductwork, as shown in Figure 5. Hot waste gases pass through the inner duct and heat transfer is primarily radiated to the wall and to the cold incoming air in the outer shell. The preheated shell air then travels to the furnace burners.

• The convective or tube type recuperator, Figure 7 (heat exchanger) passes the hot gases through relatively small diameter tubes contained in a larger shell. The incoming combustion air enters the shell and is baffled around the tubes, picking up heat from the waste gas.

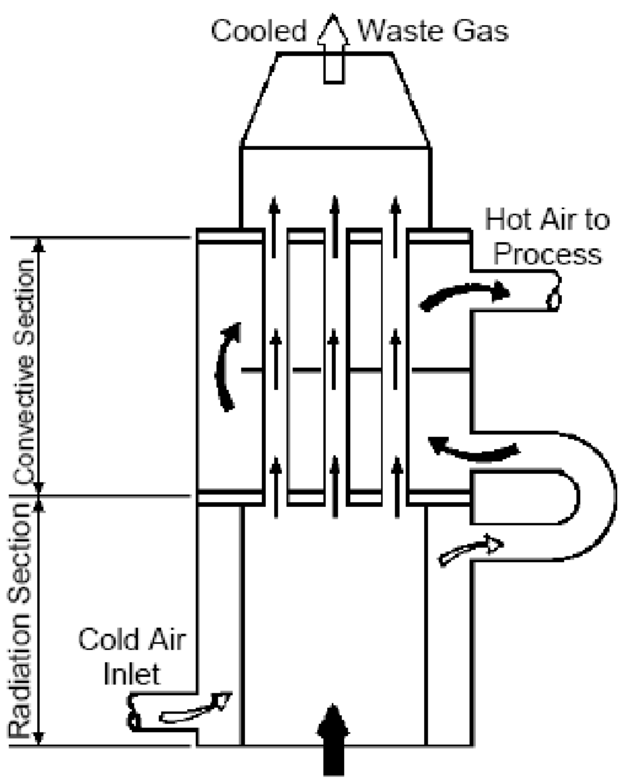
• Another alternative is the combined radiation/convection recuperator. The system includes a radiation section followed by a convection section in order to maximize heat transfer effectiveness.

Recuperators are constructed out of either metallic or ceramic materials. Metallic recuperators are used inapplications with temperatures below 2,000oF [1,093^{0}C], while heat recovery at higher temperatures is better suited to ceramic tube recuperators. These can operate with hot side temperatures as high as 800 ^{0} F [1,538 ^{0}C] and cold side temperatures of about 1,800°F [982 ^{0}C].



(a) Metallic Radiation Recuperator Design

(b) Radiation Recuperator Installed at Glass Melter



(c) Convection Recuperator

Fig 3.3 Recuperators

3.3.2.2 Regenerator

3.3.2.2.1 Furnace Regenerator

Regenerative furnaces consist of two brick “checker work” chambers through which hot and cold airflow alternately (Figure 6). As combustion exhausts pass through one chamber, the bricks absorb heat from the combustion gas and increase in temperature. The flow of air is then adjusted so that the incoming combustion air passes through the hot checker work, which transfers heat to the combustion air entering the furnace. Two chambers are used so that while one is absorbing heat from the exhaust gases, the other is transferring heat to the combustion air. The direction of airflow is altered about every 20 minutes. Regenerators are most frequently used with glass furnaces and coke ovens, and were historically used with steel open hearth furnaces, before these furnaces were replaced by more efficient designs. They are also used to preheat the hot blast provided to blast stoves used in iron making; however, regenerators in blast stoves are not a heat recovery application, but simply the means by which heat released from gas combustion is transferred to the hot blast air (see Section 4.3.1.2 Blast Furnace). Regenerator systems are specially suited for high temperature applications with dirty exhausts. One major disadvantage is the large size and capital costs, which are significantly greater than costs of recuperators.

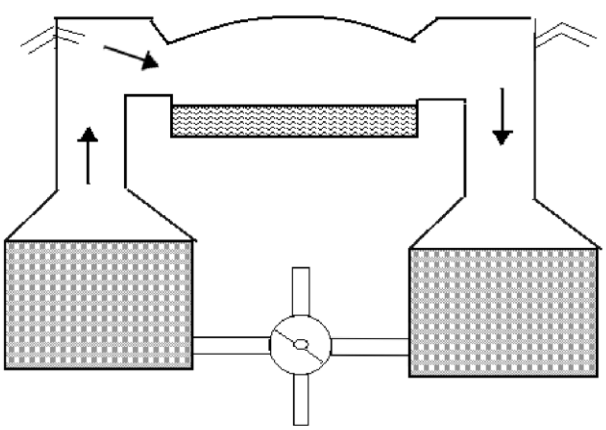


Fig 3.4 Regenerative Furnace Diagram

3.3.2.2.2 Rotary Regenerator/Heat Wheel

Rotary regenerators operate similar to fixed regenerators in that heat transfer is facilitated by storing heat in a porous media, and by alternating the flow of hot and cold gases through the regenerator. Rotary regenerators, sometimes referred to as air preheaters and heat wheels, use a rotating porous disc placed across two parallel ducts, one containing the hot waste gas, the other containing cold gas (Figure 9). The disc, composed of a high heat capacity material, rotates between the two ducts and transfers heat from the hot gas duct to the cold gas duct. Heat wheels are generally restricted to low and medium temperature applications due to the thermal stress created by high temperatures. Large temperature differences between the two ducts can lead to differential expansion and large deformations, compromising the integrity of duct wheel air seals. In some cases, ceramic wheels can be used for higher temperature applications. Another challenge with heat wheels is preventing cross contamination between the two gas streams, as contaminants can be transported in the wheel's porous material.

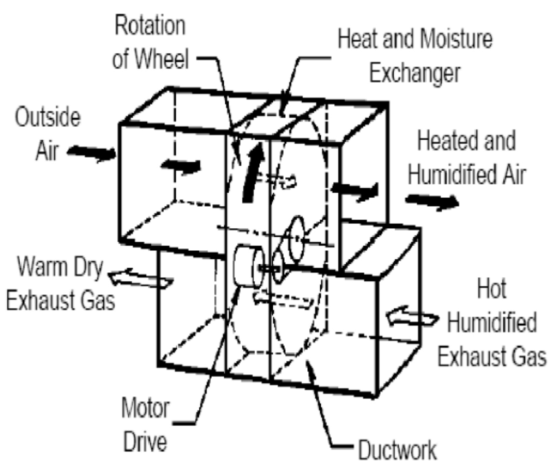


Fig 3.5 Rotary Regenerator

Fig 3.6 Rotary Regenerator on a Melting Furnace

One advantage of the heat wheel is that it can be designed to recover moisture as well as heat from clean gas streams. When designed with hygroscopic materials, moisture can be transferred from one duct to the other. This makes heat wheels particularly useful in air conditioning applications, where incoming hot humid air transfers heat and moisture to cold outgoing air. Besides its main application in space heating and air conditioning systems, heat wheels are also used to a limited extent in medium temperature applications. They have also been developed for high temperature furnace applications such as aluminum furnaces, though they are not widely implemented in the United States due to cost. They are also occasionally used for recovery from boiler exhausts, but more economical recuperators and economizers are usually preferred.

3.3.2.3 Passive Air Preheaters

Passive air preheaters are gas to gas heat recovery devices for low to medium temperature applications where cross contamination between gas streams must be prevented. Applications include ovens, steam boilers, gas turbine exhaust, secondary recovery from furnaces, and recovery from conditioned air. Passive preheaters can be of two types – the plate type and heat pipe. The plate type exchanger (Figure 8) consists of multiple parallel plates that create separate channels for hot and cold gas streams. Hot and cold flows alternate between the plates and allow significant areas for heat transfer. These systems are less susceptible to contamination compared to heat wheels, but they are often bulkier, more costly, and more susceptible to fouling problems. The heat pipe heat exchanger consists of several pipes with sealed ends. Each pipe contains a capillary wick structure that facilitates movement of the working fluid between the hot and cold ends of the pipe. As shown in Figure 9 below, hot gases pass over one end of the heat pipe, causing the working fluid inside the pipe to evaporate. Pressure gradients along the pipe cause the hot vapor to move to the other end of the pipe, where the vapor condenses and transfers heat to the cold gas. The condensate then cycles back to the hot side of the pipe via capillary action.

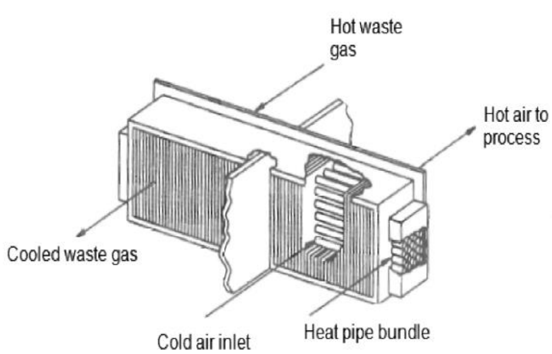


Fig 3.7 Heat Pipe Heat Exchanger

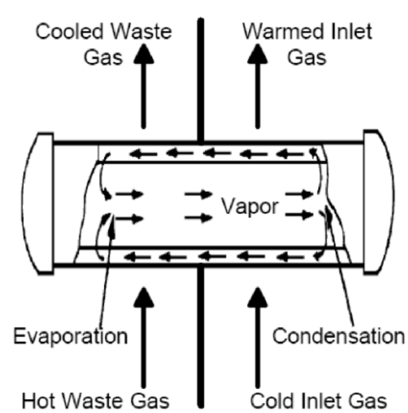


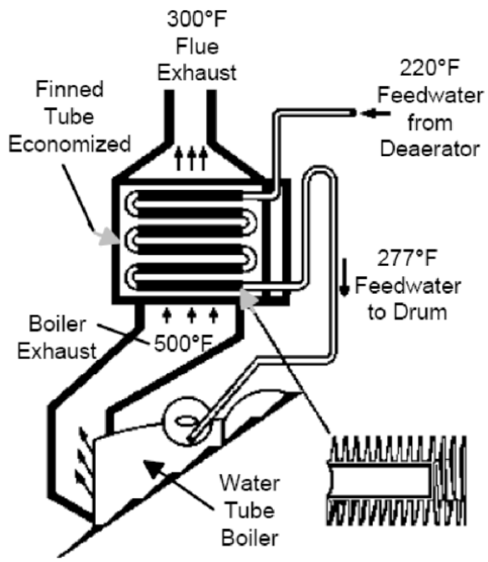
Fig 3.8 Heat Pipe

3.3.2.4 Regenerative/Recuperative Burners

Burners that incorporate regenerative or recuperative systems are commercially available. Simpler and more compact in design and construction than a standalone regenerative furnaces or recuperators these systems provide increased energy efficiency compared to burners operating with ambient air. A self recuperative burner incorporates heat exchange surfaces as part of the burner body design in order to capture energy from the exiting flue gas, which passes back through the body. Self regenerative burners pass exhaust gases through the burner body into a refractory media case and operate in pairs similar in manner to a regenerative furnace. Typically, recuperative burner systems have less heat exchange area and regenerative burner systems lower mass than standalone units. Hence, their energy recovery is lower but their lower costs and ease of retrofitting make them an attractive option for energy recovery.

3.3.2.5 Finned Tube Heat

Finned tube heat exchangers are used to recover heat from low to medium temperature exhaust gases for heating liquids. Applications include boiler feed water preheating, hot process liquids, hot water for space heating, or domestic hot water. The finned tube consists of a round tube with attached fins that maximize surface area and heat transfer rates. Liquid flows through the tubes and receive heat from hot gases flowing across the tubes. Figure 10 illustrates a finned tube exchanger where boiler exhaust gases are used for feed water preheating, a setup commonly referred to as a boiler “economizer”.



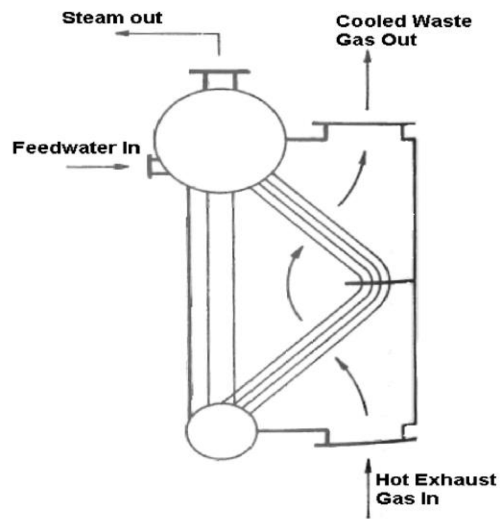


Fig 3.9 Finned Tube Exchanger/ Boiler Economizer　　　Fig 3.10 Waste Heat Boiler

3.3.2.6Waste Heat Boilers

Waste heat boilers, such as the two pass boiler shown in Figure 14, are water tube boilers that use medium to high temperature exhaust gases to generate steam. Waste heat boilers are available in a variety of capacities, allowing for gas intakes from 1000 to1 million ft3/min. In cases where the waste heat is not sufficient for producing desired levels of steam, auxiliary burners or an afterburner can be added to attain higher steam output. The steam can be used for process heating or for power generation. Generation of superheated steam will require addition of an external superheater to the system.

3.3.3 PELTIER MODULE

PELTIER HISTORY

In early 19th century scientists, Thomas Seebeck and Jean Peltier first discovered the phenomena that are the basis for today'sthermoelectric industry. Seebeck found that if you place a temperature gradient across the junctions of two dissimilar conductors,electrical current would flow. Peltier, on the other hand, learned that passing current through two dissimilar electrical conductors,caused heat to be either emitted or absorbed at the junction of the materials. It was only after mid-20th Century advancements insemiconductor technology, however, that practical applications for thermoelectric devices became feasible. With modern techniques,we can now produce thermoelectric “modules” that deliver efficient solid state heat-pumping for both cooling and heating; many ofthese units can also be used to generate DC power at reduced efficiency. New and often elegant uses for thermoelectrics continue tobe developed each day.

PELTIER STRUCTURE

A typical thermoelectric module consists of an array of BismuthTelluride semiconductor pellets that have been “doped” so that onetype of charge carrier– either positive or negative– carries the majority of the current. The pairs of P/N pellets are configured so thatthey are connected electrically in series, but thermally in parallel.Metalized ceramic substrates provide the platform for the pelletsand the small conductive tabs that connect them.

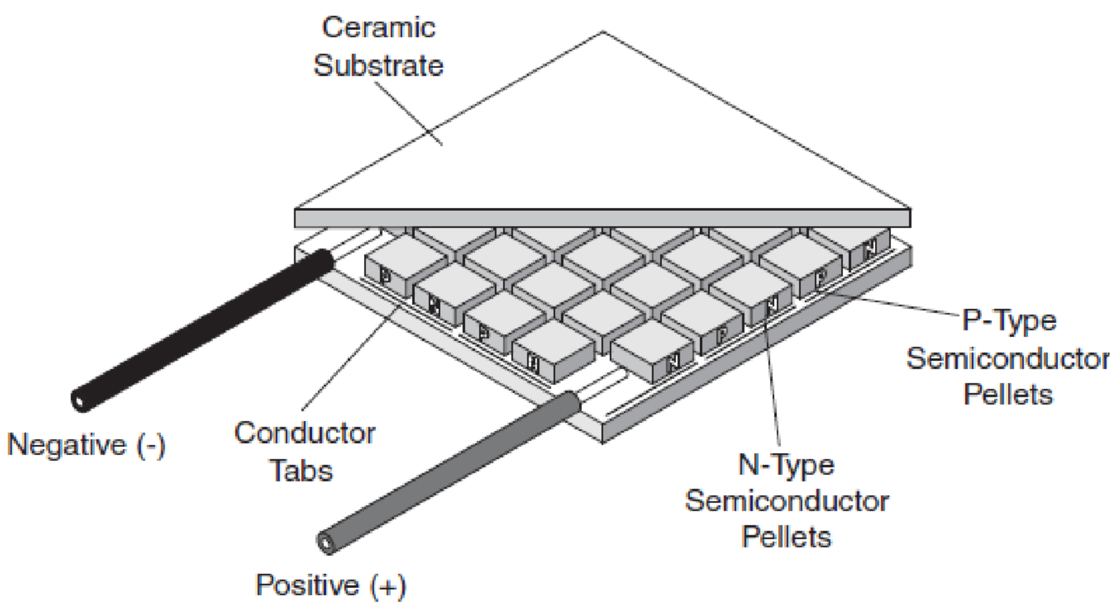


Fig 3.11 Peltier Structure

PELTIER THEORY

When DC voltage is applied to the module, the positive andnegative charge carriers in the pellet array absorb heat energyfrom one substrate surface and release it to the substrate at theopposite side. The surface where heat energy is absorbedbecomes cold; the opposite surface where heat energy isreleased becomes hot. Reversing the polarity will result inreversed hot and cold sides.

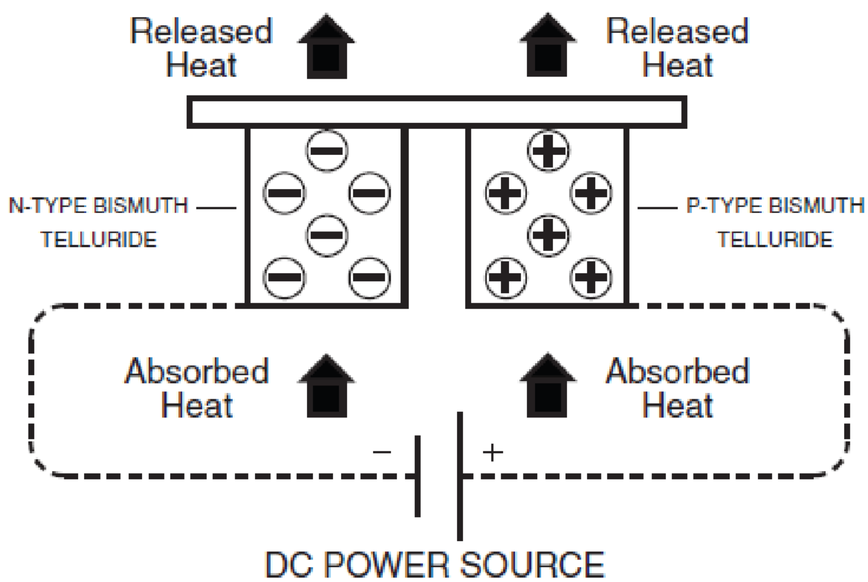


Fig 3.12 Peltier Effect

PELTIER MODULE SPECIFICATIONS

The maximum electric current (I_{max}) and the maximum voltage (V_{max}) values are the absolute rated values. Instead,considering performance coefficients and heat radiation design, it is recommended that products are used to around 70% of the maximumelectric current and voltage values. If products are used with voltages and currents which exceed the maximum values, heatabsorption will decrease and Joule heating will increase. As a result, not only will efficiency be reduced, but the increase intemperature will have an adverse effect on the soldering connecting the semiconductor and could lead to a break down and reversediffusion.

Table 3.1 Temperature Calculation

Hot Side Temperature (ºC)	25ºC	50ºC
Qmax (Watts)	50	57
Delta Tmax (ºC)	66	75
Imax (Amps)	6.4	6.4
Vmax (Volts)	14.4	16.4
Module Resistance (Ohms)	1.98	2.3

This module is selected because of the following operating limits

- Max. Operating Temperature: 138^0C
- Life expectancy: 200,000 hours which is high when compared with other peltier modules
- Failure rate based on long time testing's: 0.2%.

PELTIER MODULE FUNCTION DIAGRAMS

The maximum temperature difference (ΔT_{max}) is the temperature difference between the sides of the semiconductor when the heatabsorption is 0(W). Also, the maximum heat absorption, Q_{max}, is attained when the temperature difference between the sides of thesemiconductor is 0. Even though these are both not actual values but theoretical figures, please use these as a guide for choosingmodules.

3.3.4 TEMPERATURE SENSOR

The temperature sensor used is LM 35. The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly- proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 μA from the supply, it has very low self-heating of less than 0.1°C in still air. TheLM35 device is rated to operate over a −55°C to150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

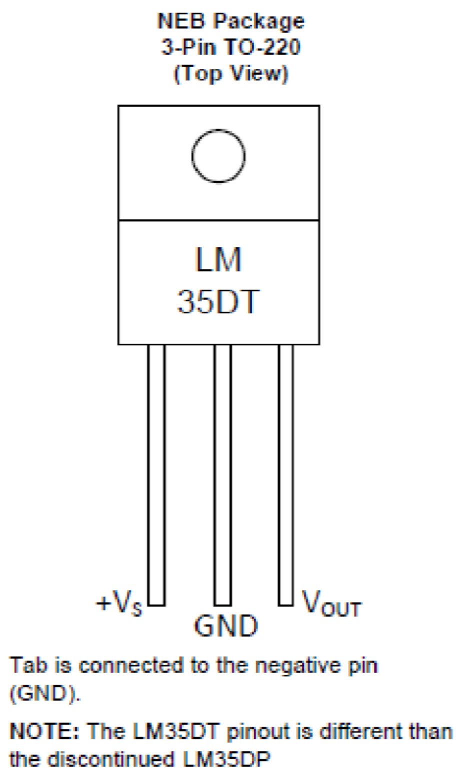


Fig 3.13 LM 35 DT Sensor

It consists of 3 pins. The left pin will carry the voltage in and the right pin will carry the output and center one will be used for grounding.

Features:

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Operates from 4 V to 30 V
- Less than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

Absolute Maximum Ratings of LM-35

Table 3.2 Over operating free-air temperature range (unless otherwise noted)

		Min	Max	unit
Supply voltage		-0.2	35	V
Output voltage		-1	6	V
Output current			10	mA
Maximum Junction Temperature, TJmax			150	°C
Storage Temperature, Tstg°C	TO-CAN, TO-92 package	-60	150	°C
	TO-220, SOIC Package	-65	150	

Response of the sensor is drawn between voltage output and time and is as below:

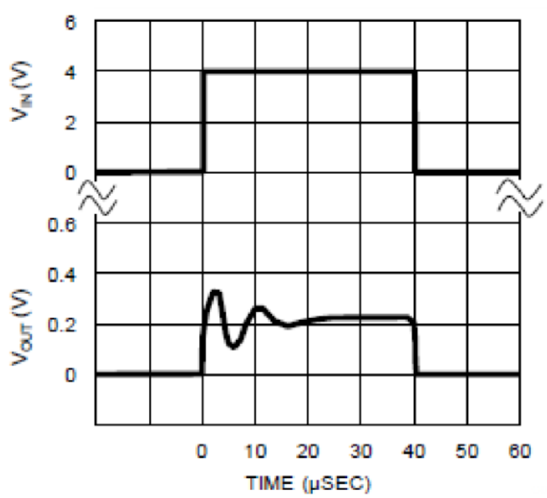


Fig 3.14 Voltage Output Vs Time Graph

Chapter – 4
ANALYSIS

4.1 Introduction to NI LAB VIEW

Lab view is a System Design Software which originated from the inception of an idea to the commercialization of a widget. It is a development environment designed specifically to accelerate the productivity of engineers and scientists. With a graphical programming syntax that makes it simple to visualize, create, and code engineering systems, Lab view is unmatched in helping engineers translate their ideas into reality, reduce test times, and deliver business insights based on collected data. From building smart machines to ensuring the quality of connected devices, Lab view has been the preferred solution to create, deploy, and test the Internet of Things for decades.

Lab view is utilized here because of its following characteristic features:

i. **Reduce Test Development Time with Intuitive Graphical Programming**

The NI Lab view graphical programming language is intuitive in nature, allowing you to spend less time addressing text-based syntax and more time solving complex test system challenges. Lab view is easier to quickly understand because it is implemented through icons that closely resemble visual models, such as flowcharts, that test engineers already use for problem solving.

ii. **Automate Any Instrument Using Free Instrument Drivers**

The Save time and money by automating all of your test equipment in one environment. Lab view can connect to a wide variety of instruments ranging from traditional boxes to software-defined PXI modular instruments, so you can acquire nearly any measurement.

iii. **Integrate With Test Management Software Like NI Test Stand**

Instead of building your own test executive from scratch, you can use test management software to sequence your code, generate reports, and log results to databases. NI Test Stand, the most popular test management software ,has best-in-class integration with Lab view so you can easily debug Lab view code, create code templates to develop tests faster, and increase execution performance through low-level control of the Lab view run-time engine.

iv. **Decrease Maintenance Costs Using Commercial Off-the-Shelf Software**

By building your application with Lab view, you can take advantage of the continuing NI pledge to support new OSs and technologies. Instead of worrying about how to support advances such as multi core processors and 64-bit processors, Lab view, as a commercial off-the-shelf software tool, helps you focus on testing your product.

v. **Secure Your Investment with Long-Term Support and Legacy Code Integration**

As a Lab view developer, you have access to world-class phone support and discussion forums in your local language .National Instruments is dedicated to the long-term support of Lab view, which means that NI helps you keep your application running for years to come. Lab view also helps you reuse legacy code in the form of DLLs, .NET assemblies, or .m files as you migrate to the Lab view platform.

vi. **Stay Ahead With the Latest PC Technologies**

With Lab view you can take advantage of the latest technologies, such as multi core processors and high-performance field-programmable gate arrays (FPGAs), helping to improve your test system performance inside the same software environment. Lab view evolves over time to integrate cutting-edge technologies for better system performance while saving you time and money

vii. **Quickly Understand Your Data**

With Lab view, you can quickly and easily analyze your data using more than 850 built-in signal processing, analysis, and mathematics functions. Choose how you implement analysis in your Lab view application, whether inline or offline, to fully customize your algorithms, make better measurements, or get results faster.

viii. **Easily Create Professional User Interfaces**

With Lab view, you get more than just acquisition and analysis; you can also easily create user interfaces that display measurement-specific data and test results within the same environment. Lab view contains a full collection of test-specific drag-and-drop controls and indicators that intuitively describe your system to engineers, technicians, or operators.

ix. **Interact With Source Code Control, Validation, and Requirements Management Tools**

When you develop large-scale test applications, you probably follow standard software engineering practices. Lab view helps you integrate with standard software engineering process systems such as requirements management and source code control. In addition, you can use Lab view tools for validation and software quality assurance.

x. **Collaborate and Develop With a Worldwide Community of Engineers**

Because millions of users have successfully adopted Lab view for a wide range of applications, you lower your risk by tapping into an extensive technical support network. You can find a wealth of example programs, white papers and Knowledge Base articles. You also can participate in an extensive network of Lab view user groups, product partners, and select integrators around the world.

4.2ANALYSIS

4.2.1INTRODUCTION TO AURDINO:

Hardware:

An Arduino board consists of an Atmel 8-bit microcontroller with complementary components to facilitate programming and incorporation into other circuits. Official Arduino have used the mega AVR series of chips, specifically the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560. Most boards include a 5 volt linear regulator and a 16 MHz crystal oscillator or ceramic resonator in some variants.

An Arduino microcontroller is also pre-programmed with a boot loader that simplifies uploading of programs to the on-chipflash memory, compared with other devices that typically need an external programmer. This allows an Arduino to be used by novices and experts alike without having to go through the difficulties first faced by many when using electronics by allowing the use of an ordinary computer as the programmer. At a conceptual level, when using the Arduino software stack, all boards are programmed over an RS-232 serial connection, but the way this is implemented varies by hardware version.

Current Arduino boards are programmed via USB, implemented using USB-to-serial adapter chips such as the FTDI FT232. When used with traditional microcontroller tools instead of the Arduino IDE, standard AVR ISP programming is used. Arduino board provides 14 digital I/O pins, six of which can produce pulse-width modulated signals, and other six analog inputs. The output or inputs can be taken from the boards or given to the board using convenient connectors. Both digital and analog inputs and outputs are available in all Arduino boards. The arduino boards can also communicate with other devices using standard communication ports like USART, IIC, and USB etc.

Fig 4.1 Arduino Board

Pin Description:

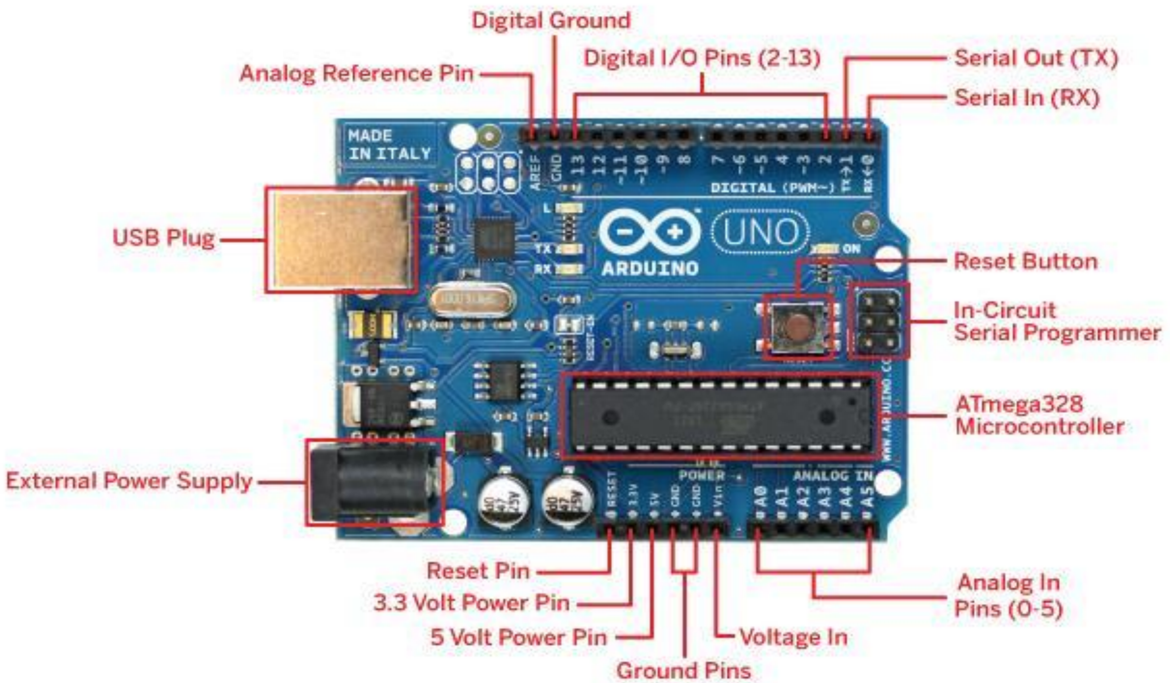


Fig4.2 Arduino Board representing all Components

Serial: 0 (RX) and 1 (TX):

Used to receive (RX) and transmit (TX) TTL serial data. On the Arduino Diecimila, these pins are connected to the corresponding pins of the FTDI USB-to-TTL Serial chip. On the Arduino BT, they are connected to the corresponding pins of the WT11 Bluetooth module. On the Arduino Mini and LilyPad Arduino, they are intended for use with an external TTL serial module.

Digital pins:

In addition to the specific functions listed below, the digital pins on an Arduino board can be used for general purpose input and output via the pin Mode (),digital Read () and digital Write () commands. Each pin has an internal pull-up resistor which can be turned on and off using digital Write (). When the pin is configured as an input. The maximum current per pin is 40 mA.

External Interrupts: 2 and 3:

These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.

PWM: 3, 5, 6, 9, 10, and 11:

Provide 8-bit PWM output with the analog Write()function. On boards with an ATmega8, PWM output is available only on pins 9, 10, and 11.

BT Reset: 7:

(Arduino BT-only) Connected to the reset line of the Bluetooth module.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK):

These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

LED 13:

On the Diecimila and LilyPad, there is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

Power:

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External power can come either from an AC-to-DC adapter or battery. The adapter can be connected by plugging a 2.1mm centre-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and V_{in} pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

Memory:

The ATmega328 has 32 KB with 0.5 KB used for the boot loader. It also has 2 KB of SRAM and 1 KB of EEPROM which can be read and written with the EEPROM library.

Features:

Table 4.1 Micro Controller Specifications

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 Ma
DC Current for 3.3V Pin	50 Ma
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

4.2.2ATmega Microcontroller:

It consists of an open source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Pre-programmed into the on-board microcontroller chip is a boot-loader that allows uploading programs into the microcontroller memory without needing a chip /device programmer.

Arduino started in 2005 as a project for students at the Interaction Design Institute Ivrea in Italy. The core Arduino developer team is composed of Massimo Banzi, David Cuartielles, and David Mellis. Arduino family consists of UNO, LILYPAD, DIECIMILA, NANO, and DUEMILANOVE.

4.2.2.1Overview of AT mega:

The ATmega48A/PA/88A/PA/168A/PA/328/P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, theATmega48A/PA/88A/PA/168A/PA/328/P achieves throughputs approaching 1 MIPS per MHz allowing the systemdesigner to optimize power consumption versus processing speed.

4.2.2.2 Specifications of AT mega:

The high-performance Atmel 8-bit AVR RISC-based microcontroller combines 32 KB ISP flash memory with read-while-write capabilities, 1 KB EEPROM, 2 KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter programmable watchdog timer with internal oscillator, and five software selectable0 power saving modes. The device operates between 1.8-5.5 volts.

4.2.2.3 AT mega 328P Parameters:

Table 4.2 Key Parameters of ATMEGA 328P Microcontroller

PARAMETERS	VALUE
Flash	32 Kbytes
RAM	2 Kbytes
Pin Count	28
Max. Operating Frequency	20 MHz
CPU	8-bit AVR

# of Touch Channels	16
Hardware QTouch Acquisition	No
Max I/O Pins	26
Ext Interrupts	24
USB Interface	No
USB Speed	No

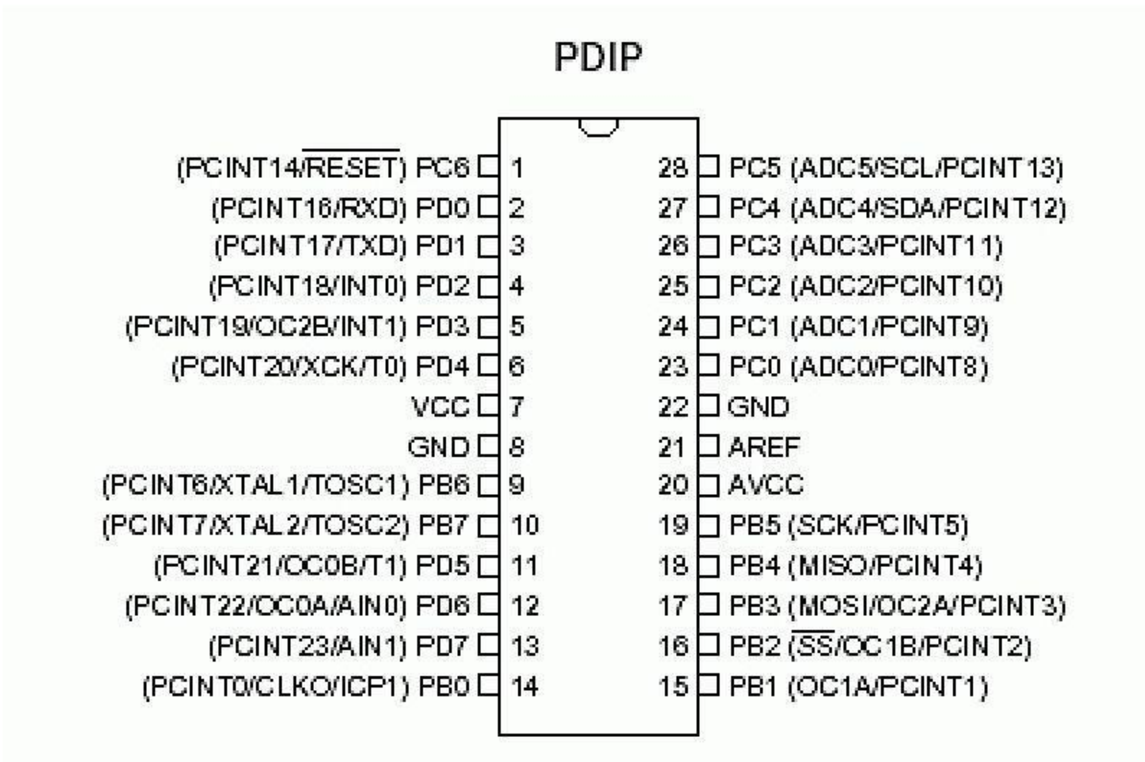


Fig 4.3 Pin Details of ATMEGA 328P Microcontroller

VCC:

Digital supply voltage.

GND:

Ground.

Port B (PB7:0) XTAL1/XTAL2/TOSC1/TOSC2:

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors selected for each bit. The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when are set condition becomes active, even if the clock is not running. Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit. Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier. If the Internal Calibrated RC Oscillator is used as chip clock source, PB7...6 is used as TOSC2...1 input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

Port C (PC5:0):

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors selected for each bit. The PC5...0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when are set condition becomes active, even if the clock is not running.

PC6/RESET:

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C. If the RSTDISBL Fuse is un programmed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a Reset.

Port D (PD7:0):

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when are set condition becomes active, even if the clock is not running.

AVCC:

AVCC is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6. It should be externally connected to VCC ,even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.

AREF:

AREF is the analog reference pin for the A/D Converter

ADC7:6 (TQFP and QFN/MLF Package Only):

In the TQFP and QFN/MLF package, ADC7:6 serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

4.2.2.4 ATmega328P Typical Characteristics

The following charts show typical behavior. These figures are not tested during manufacturing. All current consumption measurements are performed with all I/O pins configured as inputs and with internal pull-ups enabled. A sine wave generator with rail-to-rail output is used as clock source. The power consumption in Power-down mode is independent of clock selection. The current consumption is a function of several factors such as: operating voltage, operating frequency, loading of I/O pins, switching rate of I/O pins, code executed and ambient temperature.The dominating factors are operating voltage and frequency. The current drawn from capacitive loaded pins may be estimated as CL*VCC*f

where CL = load capacitance, VCC = operating voltage and f = average switching frequency of I/O pin.

The parts are characterized at frequencies higher than test limits. Parts are not guaranteed to function properly at frequencies higher than the ordering code indicates. The difference between current consumption in Power-down mode with Watchdog Timer enabled and Power-down mode with Watchdog Timer disabled represents the differential current drawn by the Watchdog Timer.

4.2.2.5 ATmega328P Active Supply Current

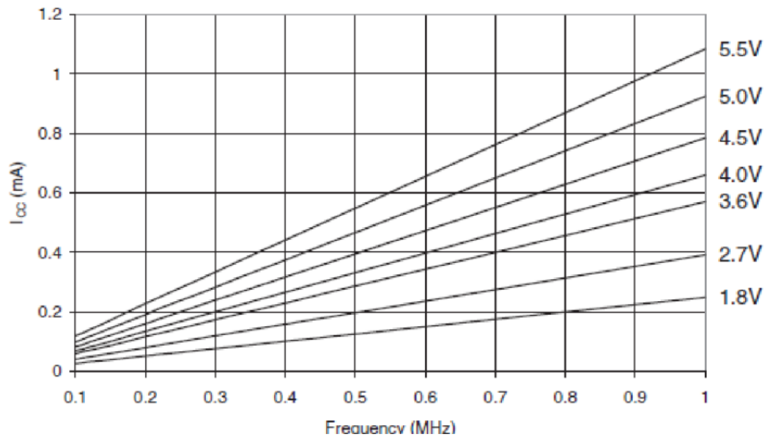


Fig 4.4: Active Supply Current vs. Low Frequency (0.1MHz - 1.0MHz)

4.2.2.5 Description:

Any microcontroller based board which follows the standard Arduino schematic and is flashed with the Arduino boot loader can be called an Arduino board. The Arduino is referred to as open source hardware, since the standard schematic is open to everyone and anybody can make their own version of Arduino board following the standard schematic.

Arduino is a single board microcontroller, intended to make the application of interactive objects or environments more accessible.

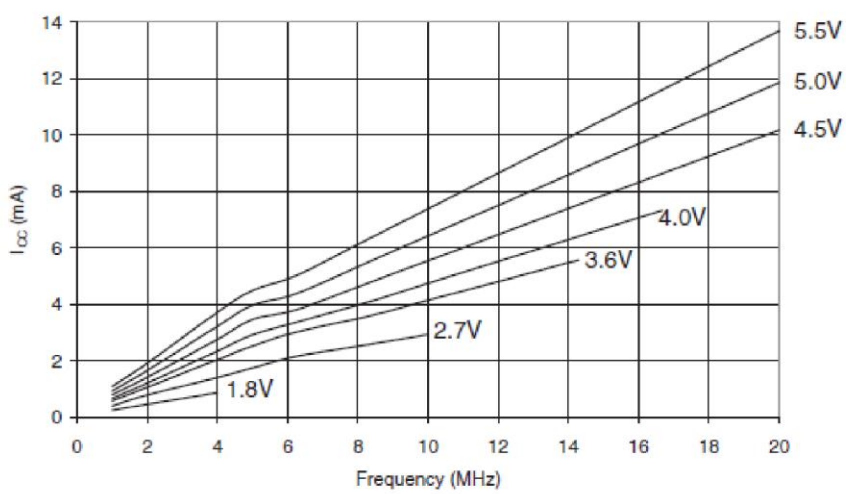


Fig 4.5 Frequency Vs Current Graph

Idle Supply Current:

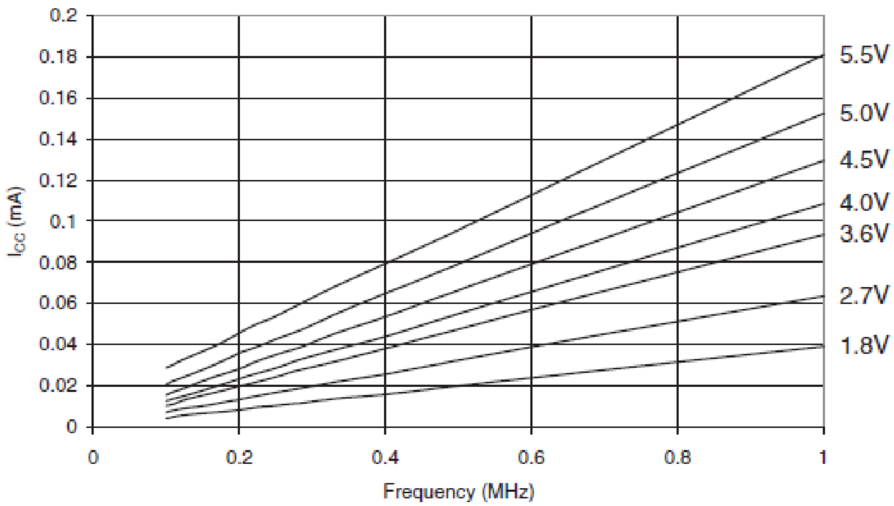


Fig 4.6 Frequency Vs Current Graph at Idle Supply

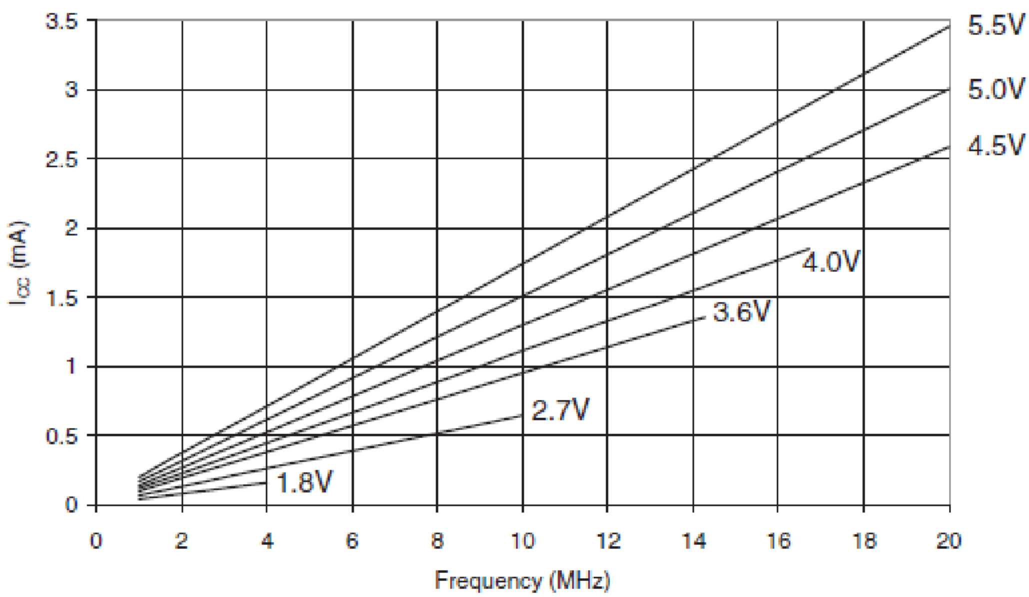


Fig 4.7 Frequency Vs Current Graph

4.3.2.6Advantages:

Some advantage of Arduino over other systems:

i. **Inexpensive:**

Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50

ii. Cross-platform:

The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

iii. Simple, clear programming environment:

The Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with the look and feel of Arduino

iv. Open source and extensible software:

The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.

v. **Open source and extensible hardware:**

The Arduino is based on Atmel's ATMEGA8 and ATMEGA168 microcontrollers. The plans for the modules are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

4.3.3Interfacing sensor with the microcontroller:

The interfacing of the temperature sensor with the microcontroller is done by drawing the Arduino Paraaduisicion in lab view as follows. This is how a microcontroller can be programmed in lab view. The main advantage of the lab view is that we can give the required programming by either c program or by drawing the Para aduisicion, with that it can prepare its own program as a background work.

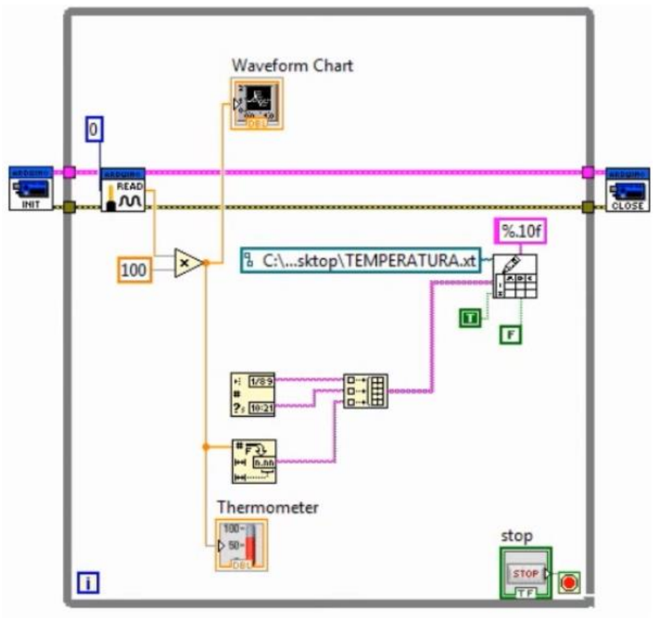


Fig 4.8 Circuit of the temperature sensor for acquiring the interface

The output of the system can be observed on running the program in the solution part as it is interfaced with the lab view as follows:

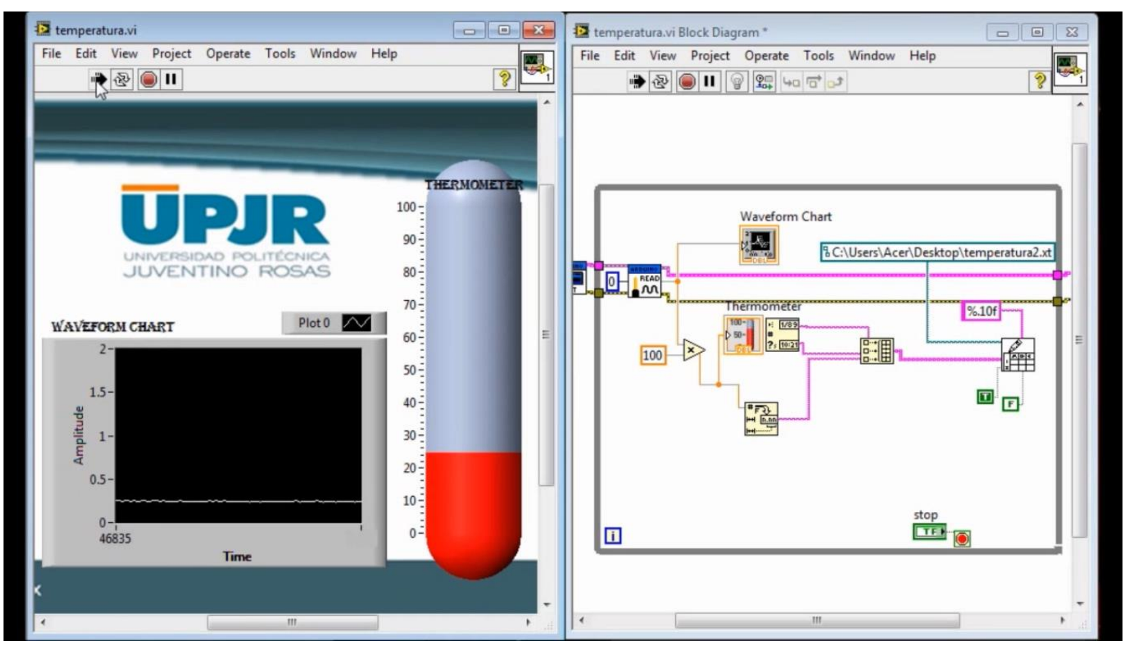


Fig 4.9 NI Lab View Temperature Indicator

As the sensor is connected and interfaced with the Arduino the result can vary as shown below.

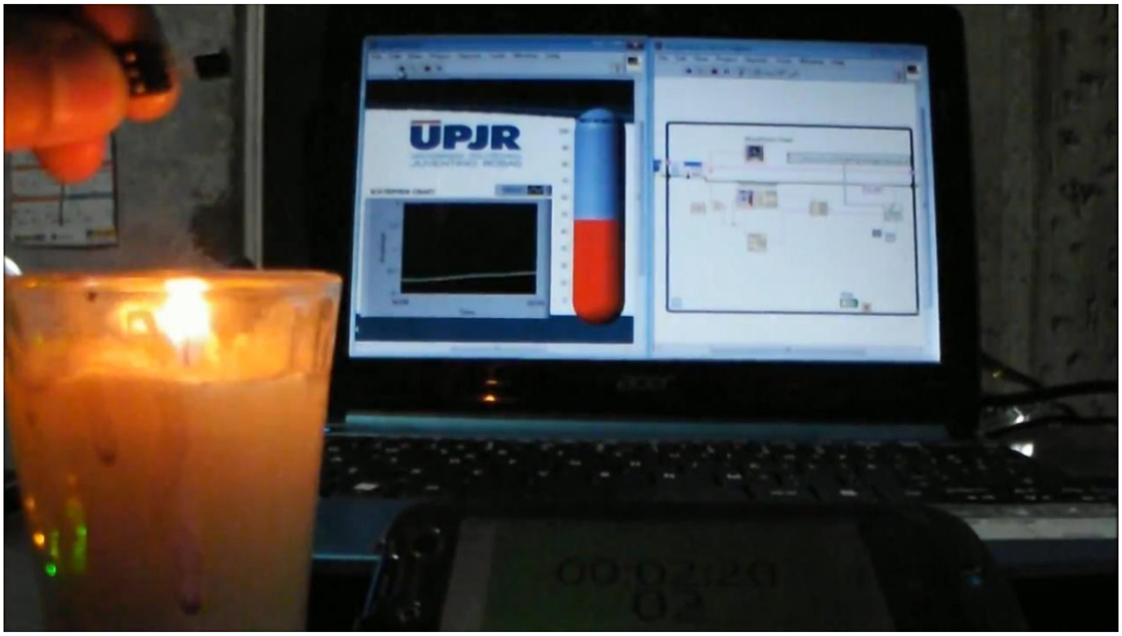


Fig 4.10 Varying Temperature

Chapter – 5

Results and Discussions

Thermodynamics of open systems has been developed which provides an entirely new theoretical framework based on novel concepts without any recourse to statistical mechanics. The standard chemical potential is replaced by a convective potential itself derived from a new concept referred to as the “thermo baric potential”. Entropy convicted by addition of masses into an open system is obtained using only classical concepts without leading to Gibb's paradox. A generalized Gibbs-Duhem theorem is derived. Application to chemical systems leads to new expressions for the affinity and an “intrinsic” heat of reaction which excludes the heat of mixing and is more representative of the true chemical energy. These expressions involve only mechanical and calorimetric concepts. They are much more general than the standard formulas which are restricted to temperature variations. The van't Hoff-le Chatelier principle is extended to open systems in terms of the new convective potential.

Readings Obtained from Software:

National Instruments offers a wide variety of temperature measurement solutions ranging from low-cost single-channel USB devices to modular and scalable systems that are ideal for the challenges of large-channel-count sensor measurements. Whether you are measuring temperature in a lab or rugged remote location, NI has the right measurement platform for your application. National Instruments has software options for quickly logging data to disk as well as for full programming environments for complex system architectures. From NI modular hardware and flexible software, we can easily measure temperature as part of a complete measurement system that meets the specific and unique needs of our application.

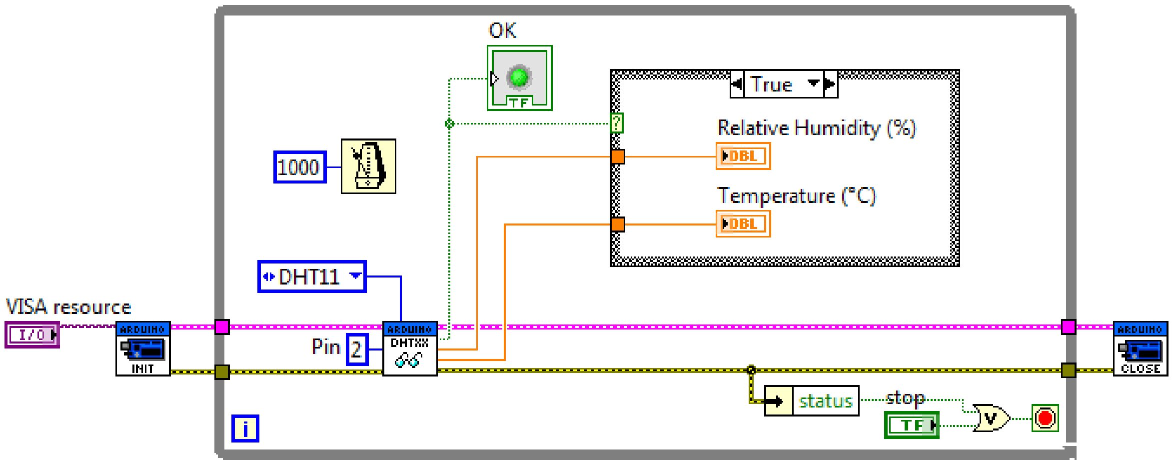


Fig 5.1 Model Diagram for Temperature sensor

Figure 5.1 explains about the temperature sensor circuits that are available to measure the temperature in the atmosphere.

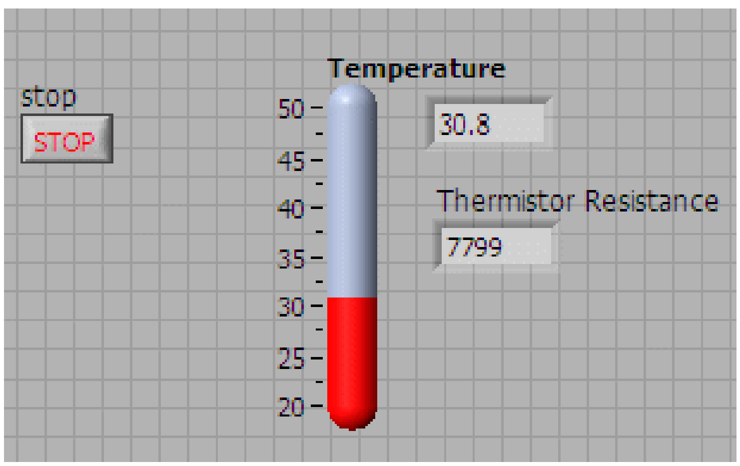


Fig 5.2 Varying Temperature resistance

On interfacing temperature sensor and the Aurdino which includes micro controller that gives the temperature variation at every second. The temperature variation at an instant is obtained by the temperature sensor. The figure 5.2 shows the room temperature when it is interfaced with the Aurdino.

Readings Obtained from Practical calculations

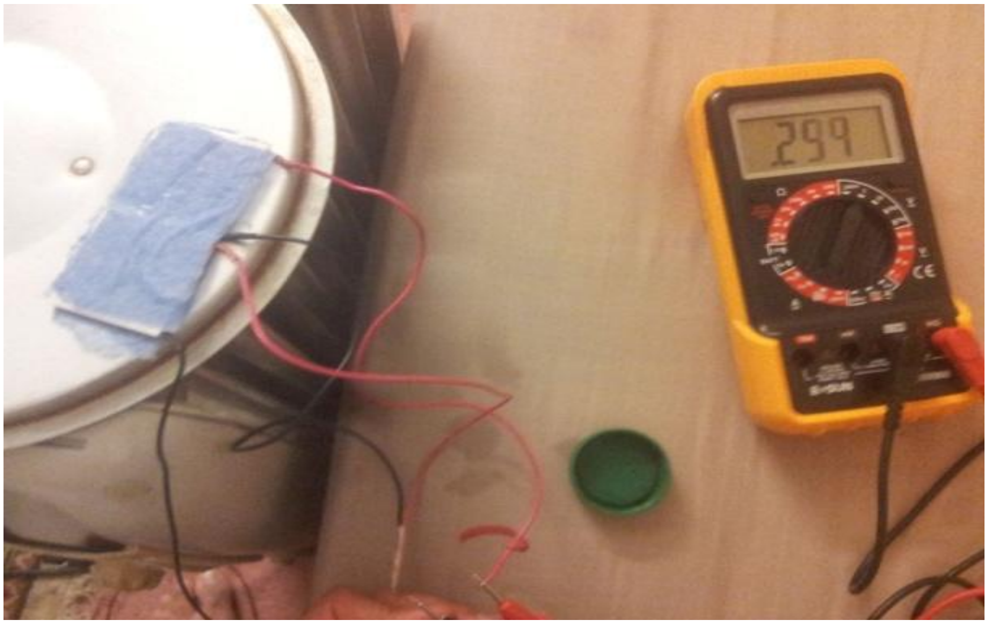


Fig 5.3 Ammeter Reading

Fig 5.4 Testing and Placing on Heat Exchanger

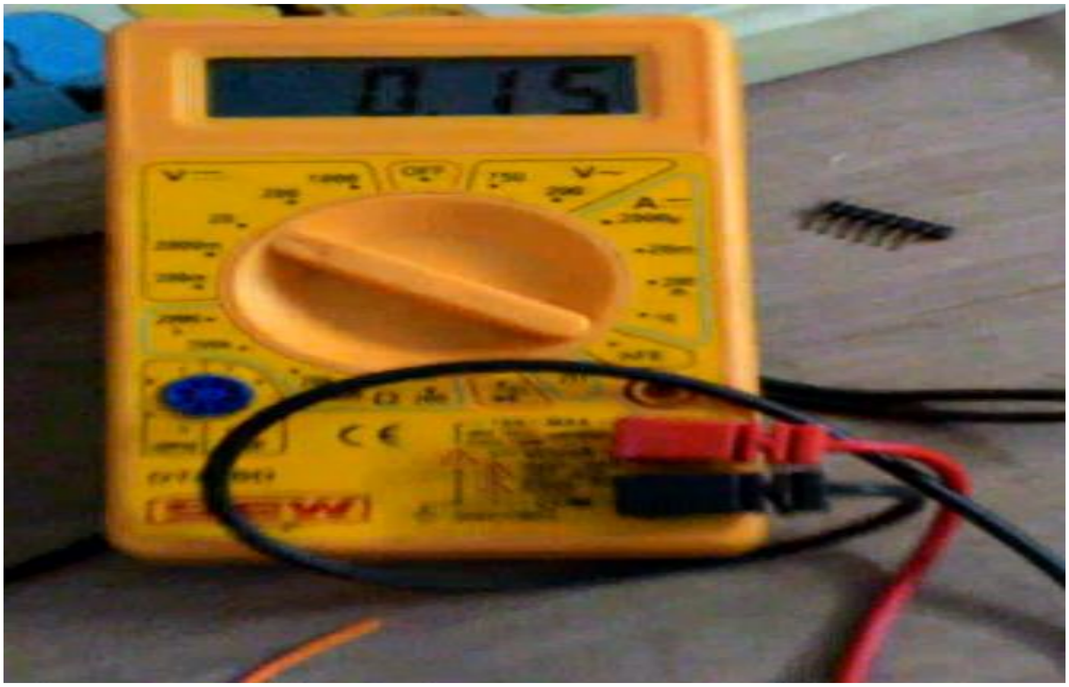


Fig 5.5 Voltage Reading from Multimeter

Inspection is done on the peltier module by preparing the hot and cold junctions. It is shown in Figure 5.3 the ammeter reading and the figure 5.4 explains to you the testing of the induction coil while connected. The figure 5.5 indicates the voltage reading in the multimeter.

S.No	Time	Temperature
1	0	32
2	1	33
3	2	34
4	3	36
5	4	38
6	5	40
7	6	42

Table: Analytical Results of Prototype

The above table explains about the time to time temperature values that are sensed by the sensor. Those values are taken from the NI LabView software.

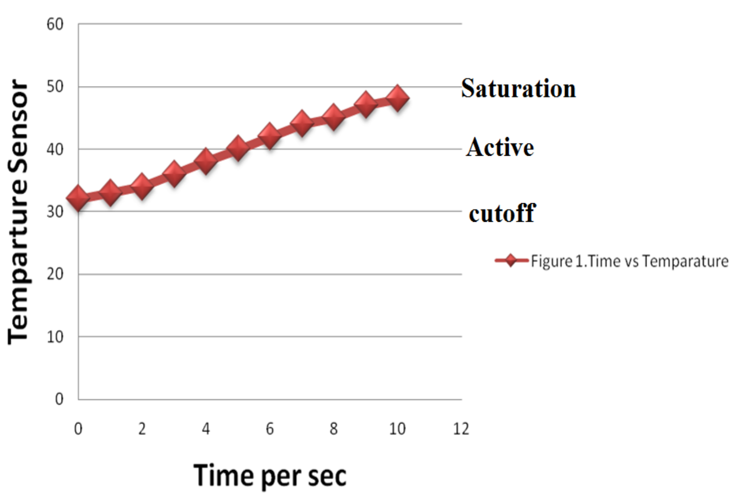
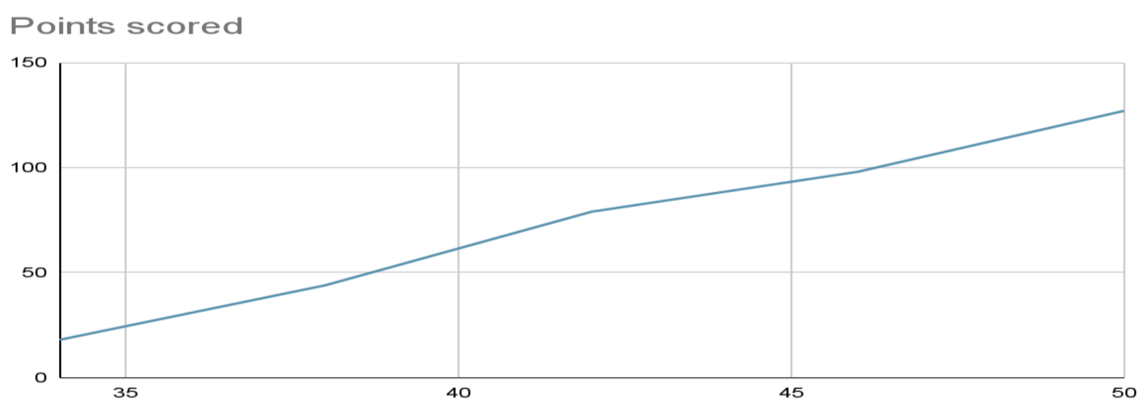


Fig 5.6 Temperature Vs Time Graph

The temperature values that are available time to time are drawn in a graph in which time in seconds along the x-axis and temperature along the y-axis. On studying the graph it is noted that the minimum temperature that is noticed is 30^0c is called as the cutoff temperature. The temperature 40^0c is called as the active temperature and 50^0c is called as the saturation temperature.

s.no	Temperature	voltage
1	34	18
2	38	44
3	42	79
4	46	98
5	50	127

temperature and voltage readings



Graph between temperature(X axis) and voltage(Y axis)

So as the temperature increases voltage also increases

s.no	Tempatreture ($^{\circ}$**C)**	Current(mA)	voltage (mV)	P=V*I(mW)
1.	34	75	18	1350
2.	38	75	44	3300
3.	41	75	75	5625
4.	45	75	93	6975

calculations

P=V*I

p=power in milli watts
v=volts
i=current

75*18=1350mw
75*44=3300mw
75*75=5625mw
75*93=6975mw

so with increase in voltage we get more power

Conclusion

It has been identified that there are large potentials of energy savings through the use of waste heat recovery technologies. In this work the electricity of 10v is produced and is utilized to run a computer integrated cooling fan which is the main motto of this work. From the above work it may be considered that peltier and seebeck effects are the one of the most promising concepts to achieve effective use of waste heat recovery from industries, plants etc.

The aim of this project is achieved by conversion of waste heat that is available at the steel plant into useful work. It is also observed that the voltage produced by the peltiers in the multimeter and that energy is either stored or it can be directly utilized. Apart from the utilization of heat, this project also deals with the continuous representation of the temperature available at any point of time by using a temperature sensor. This validates the project practically.

Future scope

Above work shows the utilization of the waste heat into generating electricity. At present the work was done up to 10V only by using a small prototype. By studying the proper design and arrangements it can also be employed for all industries, plants & etc. But it is based on temperature limits & ranges.

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