Design And Development Of Heat Recovery System For Two-Wheeler

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Abstract:

The engine of the two-wheeler vehicle releases more than 60 percent of its input energy as exhaust heat energy. This heat energy in the exhaust gas increases the atmospheric temperature of the earth's surface. Therefore, this waste heat energy must be recovered, and it should be utilized efficiently. This project is all about recovering the heat energy from the exhaust gas efficiently and utilize it for preserving food items and beverages in warm condition while delivering it to the customers. The project setup consists of an expansion chamber, a ball valve, copper pipes, aluminium pipes, wax, a storage box made up of metal sheets and covered by wooden box. The exhaust gas from the engine of the two- wheeler is diverted to the expansion chamber with the help of ball valve. From the expansion chamber, the hot gas is made to pass through the thick copper pipe and then enters the thin aluminium pipe which is wound between the inner and outer walls of metal sheet box. Over the aluminium pipe winding, the wax is poured which acts as the medium for heat conduction between the aluminum pipe surface and the inner wall of sheet metal box. Thus, the heat energy is recovered and utilized efficiently by the heat recovery system.

Key words: Heat recovery system, two wheeler, design and development

INTRODUCTION

1.1 ENGINE:

An engine is a machine designed to convert one form of energy into mechanical energy. Heat engines burn a fuel to create heat which is then used to do work. Internal combustion engines are heat engines that burn fuel in a combustion chamber to extract work from the pressure of expanding gases. Electric motors convert electrical energy into mechanical motion; pneumatic motorsuse compressed air; and clockwork motors in wind-up toysuse elastic energy.

A heat engine may also serve as a prime mover : a component that transforms the flow or changes in pressure of a fluid into mechanical energy. An automobile powered by an internal combustion engine may make use of various motors and pumps, but ultimately all such devices derive their power from the engine. Another way of looking at it is that a motor receives power from an external source, and then converts it into mechanical energy, while an engine creates power from pressure (derived directly from the explosive force of combustion or other chemical reaction, or secondarily from the action of some such force on other substances such as air, water, or steam).Combustion engines are heat engines driven by the heat of a combustion process.

Particularly notable kinds of engines include:

•Aircraft engine

•Automobile engine

•Model engine

•Motorcycle engine

•Marine propulsion engines such as Outboard motor

•Non-road engine is the term used to define engines that are not used by vehicles on roadways.

•Railway locomotive engine

•Spacecraft propulsion engines such as Rocket engine

•Traction engine

1.2 EXHAUST GAS:

Exhaust gas or flue gas is emitted as a result of the combustion of fuels such as natural gas, gasoline, petrol, biodiesel blends, diesel fuel, fuel oil, or coal. According to the type of engine, it is discharged into the atmosphere through an exhaust pipe, flue gas stack, or propelling nozzle. It often disperses downwind in a pattern called an exhaust plume. The largest part of most combustion gas is nitrogen (N_2), water vapor (H_2O) (except with pure-carbon fuels), and carbon dioxide (CO_2) (except for fuels without carbon); these are not toxic or noxious (although carbon dioxide is a greenhouse gas that contributes to global warming). A relatively small part of combustion gas is undesirable, noxious, or toxic substances, such as carbon monoxide (CO) from incomplete combustion, hydrocarbons (properly indicated as C_xH_y, but typically shown simply as “HC” on emissions-test slips) from unburnt fuel, nitrogen oxides (NO_x) from excessive combustion temperatures, and particulate matter (mostly soot).

1.3 PASSAGE FOR EXHAUST GAS:

The exhaust gas released from the engine goes through the muffler for emission control and goes through silencer and released into the environment. This is the primary cycle. The exhaust gas coming out of the engine is separated and made to flow in another passage and made to join in the primary flow line again.

This passage of the secondary flow is the whole setup of this project. The passage of the secondary flow is made up of various materials at each stage. From the junction of the exhaust pipe where exhaust gas gets separated to the expansion chamber , Galvanized Iron pipe (G.I Pipes) material is used. A brass ball valve setup is used between them. The second stage is the expansion chamber, which is made of mild steel material. The Third stage of the passage of secondary flow is from the expansion chamber to the GI box, which is made up of copper. The fourth stage is the winding inside the GI box, which is made up of aluminium material and finally the fifth stage is to the primary flow again .This stage of the passage is made up of copper.

This is the complete passage of the exhaust gas through the whole system and it is a closed cycle as shown in Fig1.1 , which ensures there is no outlet to the environment from the secondary flow.

Fig 1.1 Passage for Flow of Exhaust Gas **1.4**

EXPANSION CHAMBER:

The part of the passage where the flow pipe diameter is suddenly increased and reduced again to the same level is called expansion chamber. While the exhaust gas passes through the expansion chamber at the entry, the flow volume is increased suddenly and at the exit, the volume is reduced to the normal condition before the exit. So , the entry and the exit velocities of the flow is same. The expansion chamber accumulates the exhaust gas inside it than passing it through directly. The cylinder part of the expansion chamber is shown in Fig 1.2. The engine which emits the exhaust for once in four strokes, make the output of the exhaust gas as intermittent flow. It is not a uniform flow. The main objective of the expansion chamber is to dampen the pulsating flow of exhaust gas into a uniform flow. It cushions the intermittent output flow and make it a continuous flow of gas. These are the needs and importance of the expansion chamber in this system.

Fig1.2 Mild Steel Pipe

1.5 SILENCER:

Mufflers are installed within the exhaust system of most internal combustion engines. The muffler is engineered as an acoustic device to reduce the loudness of the sound pressure created by the engine by acoustic quieting.

The noise of the burning-hot exhaust gas exiting the engine at high velocity is abated by a series of passages and chambers lined with roving fiberglass insulation and/or resonating chambers harmonically tuned to cause destructive interference, wherein opposite sound waves cancel each other out. An unavoidable side effect of this noise reduction is restriction of the exhaust gas flow, which creates back pressure, which can decrease engine efficiency. This is because the engine exhaust must share the same complex exit pathway built inside the muffler as the sound pressure that the muffler is designed to mitigate. In most motorcycles all or most of the exhaust system is visible and may be chrome plated as a display feature. Aftermarket exhausts may be made from steel, aluminium, titanium, or carbon fiber.

Motorcycle exhausts come in many varieties depending on the type of engine and its intended use.

A twin cylinder bike may have independent exhaust sections, as seen in the Kawasaki EX250 (also known as the Ninja 250 in the US, or the GPX 250), or alternatively a single exhaust section known as a two-into-one (2-1). 4 cylinder machines, super-sport bikes like Kawasaki's ZX series, Honda's CBR series, Yamaha's YZF series, latterly titled R6 and R1, and Suzuki's GSX-R, often have a twin exhaust system. A "full system" may be bought as an aftermarket accessory, also called a 4-2-1 or 4-1, depending on its layout. In the past, these bikes would come as standard with a single exhaust muffler, a practice that lasted until the early 2000's, when EU noise and pollution regulations mostly stopped this practice, forcing companies to use other methods to increase performance of the motorcycle.

A 2-stroke exhaust can be made to be quieter than 70dBa at 6000 rpm without sacrificing any power gains. The latest generations of 4-stroke street motorcycle engines that can come close to a 2T in redline RPM but still having the extra weight and inertia of cams and valves make the differences in being "cleaner burning" negligible, with the decreased engine service life to be expected, while also having the sound of a 4T exhaust carrying for miles in many cases. Additionally, "the nature of the beast" is that a 4T exhaust note above 6000 rpm is unduly harsh to the human ear.

In a two-stroke engine, such as that used on dirt bikes, a bulge in the exhaust pipe known as an expansion chamber uses the pressure of the exhaust to create a pump that squeezes more air and fuel into the cylinder during the intake stroke. This provides greater power and fuel efficiency. This is often fairly expensive as it usually includes replacing the entire exhaust manifold or other large components. These upgrades however can significantly improve engine performance and do this through means of two main principles:

- By reducing the exhaust back pressure, engine power is increased in four-stroke engines
- By reducing the amount of heat from the exhaust being lost into the under-bonnet area. This reduces the under-bonnet temperature and consequently lowers the intake manifold temperature, increasing power. This also has positive side effect of preventing heat-sensitive components from being damaged. Furthermore, keeping the heat in the exhaust gases speeds these up, therefore reducing back pressure as well.

Back pressure is most commonly reduced by replacing exhaust manifolds with headers, which have smoother bends and normally wider pipe diameters.

Exhaust heat management helps in reducing the amount of exhaust heat radiated out from the exhaust pipe and components. One dominant solution to aftermarket upgraders is the use of a ceramic coating applied via thermal spraying. This not only reduces heat loss and lessens back pressure, but also provides an effective way to protect the exhaust system from wear and tear, thermal degradation and corrosion.

LITERATURE SURVEY

In I.C Engines, the heat generated during the combustion of fuel is partially converted into work and remaining is wasted to the atmosphere through exhaust gas and coolant. Out of the total heat supplied to the I.C engine in the form of fuel 30-40% heat is converted into useful work and remaining 60-70 % as a part of waste heat as friction, exhausts gas and engine cooling system. Through the exhaust of engine 30-40 % of heat is lost to the environment. The efficiency of the engines is between 20% and 30%.

Waste heat utilization is the major source of cost saving. If exhaust gases of engines are directly released into atmosphere it will not only waste heat but also causes the environmental problems, so it is required to utilize the waste heat for useful work to increase the efficiency of engine.[1]

Due to growing population, the energy resources are depleting, and pollution levels are increasing day-by-day with the progress of civilization. For the past few years the motorcycles sales in India have been growing at faster rates and recently surpassed approximately one million vehicles a month mark. Viewing from the socioeconomic perspective, as the level of energy consumption is directly proportional to the economic development and total number of populations in a country, the growing rate of population in the world today indicates that the energy demand is likely to increase drastically with the same rate. Substantial thermal energy is available from the exhaust gas in modern automotive engines out of which two-third of the energy from the combustion in a vehicle is lost as waste heat, of which 35-45% is in the form of hot exhaust gas. This exhaust coming from the engine contains two energies, i.e. pressure energy and heat energy.[2]

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. A thermoelectric module is a circuit containing thermoelectric materials that generate electricity from heat directly. Two-thirds of the energy from combustion in a vehicle is lost as waste heat, of which 40% is in the form of hot exhaust gas. The power from vehicle exhaust is used to generate the electricity which can be stored in battery for the later consumption.[3]

The focus of this study is to review the latest developments and technologies on waste heat recovery of exhaust gas from internal combustion engines (ICE). These include thermoelectric generators (TEG), organic Rankine cycle (ORC), six-stroke cycle IC engine and new developments on turbocharger technology. Furthermore, the study investigated the potential energy savings and performances of those technologies. The current worldwide trend of increasing energy demand in transportation sector are one of the many segments that is responsible for the growing share of fossil fuel usage and indirectly contribute to the release of harmful greenhouse gas (GHG) emissions.[4]

It's the fact that almost 70 % of the energy released from the fuel by an engine is lost, mostly in the form of heat. There is approximate 25–30% of the energy engines generate dissipating in the form of exhaust loss energy. Even high efficiency modern engines have only 25 ~ 50% thermal efficiency and the remaining 50 ~ 85% of low heating values of the fuel are dissipating into the environment as a form of heat transfer and exhaust gas enthalpy. If the exhaust gas enters into surroundings directly, it will not only waste energy but also damage the environment.[5]

3 CALCULATION

3.1 HEAT CALCULATION:

The first variable that affect the rate of conductive heat transfer is the temperature difference between the two locations. The second variable of importance is the materials involved in the transfer. Rate of heat transfer depends on the material through which heat is transferred.

The effect of a material upon heat transfer rates is often expressed in terms of a number known as the thermal conductivity. Thermal conductivity values are numerical values that are determined by experiment. The higher that the value is for a particular material, the more rapidly that heat will be transferred through that material. Materials with relatively high thermal conductivities are referred to as thermal conductors. Materials with relatively low thermal conductivity values are referred to as thermal insulators. The table below lists thermal conductivity values (k) for a variety of materials, in units of W/m°C.

Table 3.1 various materials and their Thermal conductivities

Material	k	Material	k
Aluminum (s)	237	Wood (s)	0.13
Brass (s)	110	Cast Iron (s)	55
Copper (s)	398		

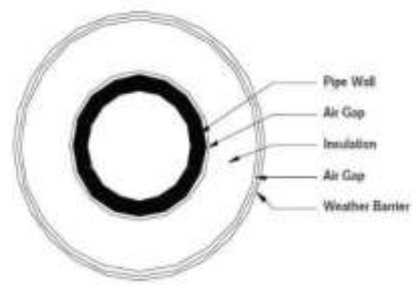

Fig.3.1 Heat Loss in Flow Through Pipes

3.2 HEAT LOSS IN AN INSULATED PIPE:

For pipe insulation, the outer area of insulation is greater than the inner area due to wrapping insulation around the cylindrical shape of a pipe. As a result, consideration must be made for this difference when calculating heat loss for pipes. The diagrammatic representation of the heat loss in flow through pipes is shown in Fig 3.1.

Because pipe heat loss is based on watts per linear foot rather than the entire pipe area, the mean insulation area for one linear foot of pipe is calculated (figure 3). The mean area (A) is the natural logarithm ratio of the outer and inner insulation diameters. To calculate pipe heat loss, the basic heat loss equation (Q) is rewritten as:

$$Q = \frac{2\pi (k)(\Delta T)}{(40.944)\ln(D_o/D_i)} \quad \text{Heat Loss, W/ft-hr}$$

where
2 π is part of the formula for calculating the area of a cylinder
40.944 is 12” of pipe multiplied by the 3.412 conversion factor
D_o is the outer insulation diameter, D_i is the inner insulation diameter
$\ln(D_o/D_i)$ is the mean circumference of insulation

However, that basic equation is the heat loss for pipes due to conduction only. By adding 10 percent for convective and radiant losses, the final form of the basic heat loss formula is:

$$Q = \frac{2\pi (k)(\Delta T)(1.1)}{(40.944)\ln(D_o/D_i)} \quad \text{W/ft-hr}$$

3.3 RATE OF HEAT LOSS:

Rate of Heat loss through the pipe is given by

$Q = 2 \times \prod \times k \times L \times (T_1-T_2)/\ln(r_2/r_1)$ (W/mK)

We know that for this project, temperature at atmosphere T_2 = 30 deg Celsius,

Temperature of the fluid T_1 = 430 deg Celsius

i) For copper ,

L=1.1 m, k= 385 W/mK , r_1 = 0.017m , r_2 = 0.019 m

Substituting the above values, we get,

Q = 9573*10^3 W/mK.

ii) For Aluminium,

Thermal Conductivity k= 205 W/mK,

r_2=0.011m r_1= 0.010m

length L= 3.5 m

Substituting the values, the heat loss rate is obtained as

Q=8060.664 W/mK.

DESIGN

Computer-aided design is the use of computers to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. For this project ,the Design Assembly is modelled and assembled using DASSAULT SYSTEMS “SOLIDWORKS” which is shown in Fig 4.1 ,Fig 4.3 and its exploded View in Fig 4.3.

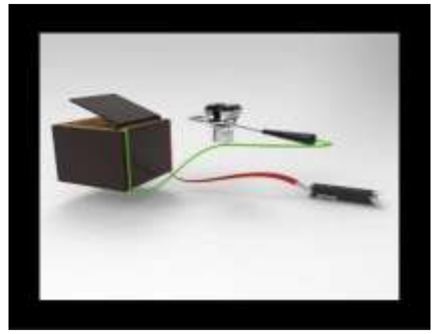

Fig 4.1 Design of the Heat Recovery System for Two-Wheeler (SOLIDWORKS)

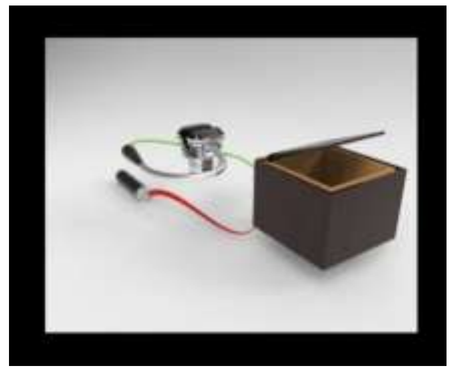

Fig 4.2 Right side view of the 3D model

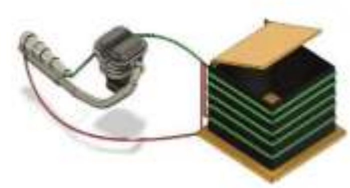

Fig 4.3 Exploded view

5 MATERIALS USED

5.1 MILD STEEL:

Mild steel usually contains 40 points of carbon at most. One carbon point is .01 percent of carbon in the steel. This means that it has at most .4

percent carbon. Most steels have other alloying elements other than carbon to give them certain desirable mechanical properties. Mild steel contains approximately .6 percent to .9 percent manganese, up to .04 percent phosphorus, and up to .05 percent Sulphur. Varying these chemicals affects properties such as corrosion resistance and strength.

Mild steel is very strong due to the low amount of carbon it contains. In materials science, strength is a complicated term. Mild steel has a high resistance to breakage. Mild steel, as opposed to higher carbon steels, is quite malleable, even when cold. This means it has high tensile and impact strength. Higher carbon steels usually shatter or crack under stress, while mild steel bends or deforms.

5.1.1 MS PIPES

MS Pipe and MS Tube refers to Mild Steel Pipe or a Mild Steel Tubes. Mild Steel (MS) pipes are manufactured using low carbon (less than 0.25%) steel. Due to low carbon content the pipes do not harden and are easy to use. As MS Pipes are made from mild steel they can easily be welded and formed in various shapes and sizes for pipelining and tubing purposes. These are generally used for drinking water supply i.e. Plumbing, Firefighting, HVAC but can also be used in various other Industrial and Engineering applications as shown in Fig 5.1.These
pipes are usually coated with other metals/paints/varnish etc. to prevent it from rusting, but extra care should be taken to prevent it under extreme conditions.

Thermal conductivity k= 46 W/mK

Density = 0.287 lbs/cubic inch Melting

point =1220 F

Thermal expansion coefficient (linear) :13.1 *10^-6in/◦C

Fig 5.1 MS PIPES

5.2 COPPER:

Copper is the oldest metal used by man. It's use dates back to prehistoric times. Copper has been mined for more than 10,000 years with a Copper pendant found in current day Iraq being dated to 8700BC. By 5000BC Copper was being smelted from simple Copper Oxides. Copper is found as native metal and in the minerals cuprite, malachite, azurite, chalcopyrite and bornite.

Good strength, conductivity, machinability, durability, ductility properties

Melting point (pure copper) = 1083 degree Celsius.

Both hard work and coldwork is possible.

Tensile strength = 42 ksi or 290mpa.

Density = 0.322 gram per cm cube.

Thermal conductivity k = 385 W/mK.

Linear Thermal expansion coefficient = 16.8 x 10^-6 cm per cm square Celsius.

5.3 ALUMINIUM:

Aluminum pipe is a tubular extruded product with outside diameter (OD) and wall thickness (WT) measurements that must conform to set sizes. The standard measurements follow the format used for steel pipe specifying the OD and WT. For example, pipe noted as 1-1/2" schedule 40 has an OD of 1-1/2" and WT that meets Schedule 40 standards. The higher the schedule number, the thicker the wall.

There Are Two Ways of Extruding Aluminum Pipe:

The Porthole Method: This produces a structural pipe. Because it has an extrusion seam, this pipe should not be used in applications that involve internal pressure. It is commonly used for handrails, flag poles and furniture.

Hollow Extrusion Billet: This method is more costly and produces a product called seamless pipe. Seamless pipe has no seams or weld lines is used in applications where internal pressure and severe forming are required, such as irrigation pipe, process equipment and electrical conductors.

5.4 6061 ALUMINUM PIPES

5.4.1 CHARACTERISTICS

6061 aluminum pipe exhibits moderate strength coupled with good corrosion resistance. It has good workability, making it easy to extrude, weld and coat.

5.4.2 APPLICATIONS

6061 aluminum pipe is used in both structural and seamless pipe applications. Some structural products it is used for including fence posts, sign structures, and highway and bridge rails. Note that after anodizing a structural product, the seam will be visible. Seamless pipe products from 6061 include processing equipment pipe, drainage pipe and electrical raceways as shown in 5.2.

5.4.3 TYPICAL CHEMICAL PROPERTIES

Table 5.1 Typical Chemical Properties of 6061 Aluminium Pipe

Name of the Constituent	Max %
Silicon	0.8
Iron	0.7
Copper	0.4
Manganese	0.15
Magnesium	1.2
Chromium	0.35
Zinc	0.25
Titanium	0.15

Fig 5.2 Aluminium Pipes

5.4.4 TYPICAL MECHANICAL PROPERTIES

Table 5.2 Typical Mechanical Properties of Aluminium 6061

PROPERTIES [unit]	Value
Tensile Strength [ksi]	180
Yield 0.2% Offset [ksi]	110
Elongation	14
Density [g/cubic cm]	2.7
Thermal conductivity [W/ mK]	205.0
Linear thermal expansion coefficient [*10^-6/deg Celsius]	23.5

FABRICATION

6.1 BENDING OF PIPES:

A beam deforms and stresses develop inside it when a transverse load is applied on it. In the quasi-static case, the amount of bending deflection and the stresses that develop are assumed not to change over time. In a horizontal beam supported at the ends and loaded downwards in the middle, the material at the over-side of the beam is compressed while the material at the underside is stretched. There are two forms of internal stresses caused by lateral loads:

•Shear stress parallel to the lateral loading plus complementary shear stress on planes perpendicular to the load direction;

•Direct compressive stress in the upper region of the beam, and direct tensile stress in the lower region of the beam. These last two forces form a couple or moment as they are equal in magnitude and opposite in direction. This bending moment resists the sagging deformation characteristic of a beam experiencing bending. The stress distribution in a beam can be predicted quite accurately when some simplifying assumptions are used.

In the Euler–Bernoulli theory of slender beams, a major assumption is that 'plane sections remain plane'. In other words, any deformation due to shear across the section is not accounted for (no shear deformation). Also, this linear distribution is only applicable if the maximum stress is less than the yield stress of the material. For stresses that exceed yield, refer to article plastic bending. At yield, the maximum stress experienced in the section (at the furthest points from the neutral axis of the beam) is defined as the flexural strength.

Fig 6.1 Bending of Copper Pipe

Tube bending is the umbrella term for metal forming processes used to permanently form pipes or tubing. One must differentiate between form-bound and freeform-bending procedures, as well as between heat supported and cold forming procedures. A tube can be bent in multiple directions and angles. Common simple bends consist of forming elbows, which are bends that range from 2 to 90°, and U-bends, which are 180° bends. More complex geometries include multiple two-dimensional (2D) bends and three-dimensional (3D) bends. A 2D tube has the openings on the same plane; a 3D has openings on different planes. A two-plane bend or compound bend is defined as a compound bend that has a bend in the plan view and a bend in the elevation. When calculating a two-plane bend, one must know the bend angle and rotation (dihedral angle).

6.1.1 Press bending

Press bending is probably the first bending process used on cold pipes and tubing.[clarification needed] In this process a die in the shape of the bend is pressed against the pipe forcing the pipe to fit the shape of the bend. Because the pipe is not supported internally there is some deformation of the shape of the pipe, resulting in an oval cross section. This process is used where a consistent cross section of the pipe is not required. Although a single die can produce various shapes, it only works for one size tube and radius.

6.1.2 Rotary draw bending

Rotary draw bending (RDB) is a precise technology, since it bends using tooling or "die sets" which have a constant center line radius (CLR), alternatively indicated as mean bending radius (Rm). Rotary draw benders can be programmable to store multiple bend jobs with varying degrees of bending. Often a positioning index table (IDX) is attached to the bender allowing the operator to reproduce complex bends which can have multiple bends and differing planes.

The aluminum and copper pipes of required dimensions are purchased. They are cut into separate pieces according to the calculated length. The main part of the fabrication process is the bending of aluminum and copper pipes in the required shape. The aluminum pipe should be bend as a square formation consisting of number of windings . The bend should not have a small radius as well as not so large radius of curvature. The bend of the pipe may hinder the flow of exhaust gas but should not block the passage of flow.

The design of the bend is made, such that the setup is compact, and it is assuring that it does not affect the driver's comfort while driving.

Fig 6.2 Bending of Aluminium Pipe

The bending is done in a workshop with the help of pipe bending apparatus , which consists of various removable pulleys which determines the radius of curvature of the bend as shown in Fig 6.2.There is a square shaped lever for the handle for the pipe .The length of the lever determines the torque with which the pipe is made to bend. More the length of the lever, more is the torque of bending, since

Torque = Force applied * Length

6.2 LATHE OPERATIONS:A lathe is a machine that rotates a workpiece about an axis of rotation to perform various operations such as cutting, sanding, knurling, drilling, deformation, facing, and turning, with tools that are applied to the workpiece to create an object with symmetry about that axis. Lathes are used in woodturning, metalworking, metal spinning, thermal spraying, parts reclamation, and glass-working. Lathes can be used to shape pottery, the best-known design being the Potter's wheel. Most suitably equipped metalworking lathes can also be used to produce most solids of revolution, plane surfaces and screw threads or helices. Ornamental lathes can produce three-dimensional solids of incredible complexity.Theworkpiece is usually held in place by either one or two centers, at least one of which can typically be moved horizontally to accommodate varying workpiece lengths. Other work-holding methods include clamping the work about the axis of rotation using a chuck or collet, or to a faceplate, using clamps or dogs. Examples of objects that can be produced on a lathe include screws, candlesticks, gun barrels, cue sticks, table legs, bowls, baseball bats, musical instruments (especially woodwind instruments), crankshafts and much more.

6.2.1 FACING:

Facing on a milling machine is the process of cutting a flat surface perpendicular to the axes of the milling cutter. This process removes the material by rotating the facing tool in the counterclockwise direction as the table feeds the work piece across the cutter. Face milling can be achieved with an end mill, but is often done with a face mill, shell mill or a fly cutter. Face milling can be done in both manual machining and CNC machining. To obtain a smoother surface finish it is best to let the machine feed the table. Newer manual milling machines and CNC machines will have this option, but older milling machines will not. When available, use the machine feed instead of manually feeding the part. This will provide an optimal surface finish due to the constant feed maintained by the mill. Hand feeding the table will allow human error into the process. Machinists also have the option to take roughing cuts and finish cuts. Factors that affect the quality and effectiveness of facing operations on the mill are speeds and feeds, material hardness, cutter size, and how the part is being clamped down.

6.2.2 TURNING:

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helix toolpath by moving more or less linearly while the workpiece rotates. The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear. Usually the term "turning" is reserved for the generation of external surfaces by this cutting action, whereas this same essential cutting action when applied to internal surfaces is called "boring". Thus, the phrase "turning and boring" categorizes the larger family of processes known as lathing. The cutting of faces on the workpiece, whether with a turning or boring tool, is called "facing", and may be lumped into either category as a subset.

6.2.3 BORING:

In machining, boring is the process of enlarging a hole that has already been drilled by means of a single-point cutting tool, such as in boring a gun barrel or an engine cylinder. Boring is used to achieve greater accuracy of the diameter of a hole and can be used to cut a tapered hole. Boring can be viewed as the internal-diameter counterpart to turning, which cuts external diameters. The boring process can be executed on various machine tools, including (1) general-purpose or universal machines, such as lathes (/turning centers) or milling machines (/machining centers), and machines designed to specialize in boring as a primary function, such as jig borers and boring machines or boring mills, which include vertical boring mills (workpiece rotates around a vertical axis while boring bar/head moves linearly; essentially a vertical lathe) and horizontal boring mills (workpiece sits on a table while the boring bar rotates around a horizontal axis; essentially a specialized horizontal milling machine).Lathe boring is a cutting operation that uses a single-point cutting tool or a boring head to produce conical or cylindrical surfaces by enlarging an existing opening in a workpiece. For non-tapered holes, the cutting tool moves parallel to the axis of rotation. For tapered holes, the cutting tool moves at an angle to the axis of rotation. Geometries ranging from simple to extremely complex in a variety of diameters can be produced using boring applications. Boring is one of the most basic lathe operations next to turning and drilling. Lathe boring usually requires that the workpiece be held in the chuck and rotated.

As the workpiece is rotated, a boring bar with an insert attached to the tip of the bar is fed into an existing hole. When the cutting tool engages the workpiece, a chip is formed. Depending on the type of tool used, the material, and the feed rate, the chip may be continuous or segmented. The surface produced is called a bore.

The pipes made up of different materials , in this case copper and aluminium cannot be welded , which is not suitable for removing the joints when needed.so, instead of welding , metal connectors can be used for joining two dissimilar metals of various diameter. The material used for fabricating this connector is aluminium. A round aluminium blank is faced, turned throughout the length and bored on both sides suitable for the diameter of the copper and aluminium pipes.

6.3 GAS WELDING:

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool causing fusion. Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. Gas metal arc welding, sometimes referred to by its subtypes metal inert gas welding or metal active gas welding, is a welding process in which an electric arc form between a consumable MIG wire electrode and the workpiece metal(s), which heats the workpiece metal(s), causing them to melt and join. Along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from contaminants in the air. The typical GMAW welding gun has several key parts—a control switch, a contact tip, a power cable, a gas nozzle, an electrode conduit and liner, and a gas hose. The control switch, or trigger, when pressed by the operator, initiates the wire feed, electric power, and the shielding gas flow, causing an electric arc to be struck. The contact tip, normally made of copper and sometimes chemically treated to reduce spatter, is connected to the welding power source through the power cable and transmits the electrical energy to the electrode while directing it to the weld area. It must be firmly secured and properly sized, since it must allow the electrode to pass while maintaining electrical contact. On the way to the contact tip, the wire is protected and guided by the electrode conduit and liner, which help prevent buckling and maintain an uninterrupted wire feed. The gas nozzle directs the shielding gas evenly into the welding zone.

The most common electrode holder is a semiautomatic air-cooled holder. Compressed air circulates through it to maintain moderate temperatures. It is used with lower current levels for welding lap or butt joints. The second most common type of electrode holder is semiautomatic water-cooled, where the only difference is that water takes the place of air. It uses higher current levels for welding T or corner joints. The third typical holder type is a water-cooled automatic electrode holder— which is typically used with automated equipment.

Shielding gases are necessary for gas metal arc welding to protect the welding area from atmospheric gases such as nitrogen and oxygen, which can cause fusion defects, porosity, and weld metal embrittlement if they come in contact with the electrode, the arc, or the welding metal. This problem is common to all arc welding processes; for example, in the older Shielded-Metal Arc Welding process (SMAW), the electrode is coated with a solid flux which evolves a protective cloud of carbon dioxide when melted by the arc. In GMAW, however, the electrode wire does not have a flux coating, and a separate shielding gas is employed to protect the weld. This eliminates slag, the hard residue from the flux that builds up after welding and must be chipped off to reveal the completed weld. The choice of a shielding gas depends on several factors, most

important GMAW's basic technique is uncomplicated, with most individuals able to achieve reasonable proficiency in a few weeks, assuming proper training and sufficient practice. As much of the process is automated, GMAW relieves the welder (operator) of the burden of maintaining a precise arc length, as well as feeding filler metal into the weld puddle, coordinated operations that are required in other manual welding processes, such as shielded metal arc. GMAW requires only that the welder guide the gun with proper position and orientation along the area being welded, as well as periodically clean the gun's gas nozzle to remove spatter buildup. Additional skill includes knowing how to adjust the welder so the voltage, wire feed rate and gas flow rate are correct for the materials being welded and the wire size being employed.

6.4 SHEET METAL WORKING:

Sheet metal is metal formed by an industrial process into thin, flat pieces. Sheet metal 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 fabricated from sheet metal. Thicknesses can vary significantly; extremely thin sheets are considered foil or leaf, and pieces thicker than 6 mm are considered plate steel or "structural steel."

Fasteners that are commonly used on sheet metal include:

•Clecos

•Rivets

•Sheet metal screws

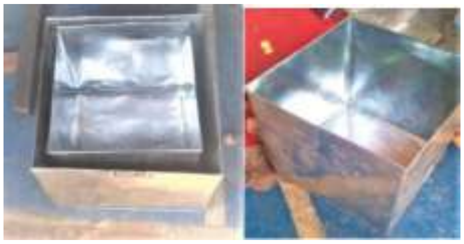

Fig 6.3 Sheet Metal Working

In this project GI sheets are used to make the inner and outer cover boxes as shown in Fig 6.3 which handles the heat transfer from the exhaust gas to the food.

6.5 CARPENTRY:

Carpentry is a skilled trade and a craft in which the primary work for performed is the cutting, shaping and installation of building materials during the construction of buildings, ships, timber bridges, concrete formwork, etc. Carpenters traditionally worked with natural wood and did the rougher work such as framing, but today many other materials are also used and sometimes the finer trades of cabinet making and furniture building are considered carpentry.

In this project , the wooden box as shown in Fig 6.4 is used to carry the whole setup of GI box and weight of the food. Since, wood is a bad conductor of heat ,the heat flowing through the GI metal box will not escape out into the environment.

Fig 6.4 Wooden Box

6.6 INSULATION OF PIPE:

Pipe Insulation is thermal or acoustic insulation used on pipework.

The relative performance of different pipe insulation on any given application can be influenced by many factors.

The principal factors are:

•Thermal conductivity ("k" or "λ" value)

•Surface emissivity ("ε" value)

•Water-vapor resistance ("μ" value)

•Insulation thickness

•Density

Pipe insulation materials come in a large variety of forms, but most materials fall into one of the following categories.

6.6.1 MINERAL WOOL:

Mineral wools, including rock and slag wools, are inorganic strands of mineral fiber bonded together using organic binders. Mineral wools are capable of operating at high temperatures and exhibit good fire performance ratings when tested. Mineral wools are used on all types of pipework, particularly industrial pipework operating at higher temperatures.

6.6.2 GLASS WOOL:

Glass wool is a high-temperature fibrous insulation material, similar to mineral wool, where inorganic strands of glass fiber are bound together using a binder. As with other forms of mineral wool, glass-wool insulation can be used for thermal and acoustic applications.

6.6.3 FLEXIBLE ELASTOMERIC FOAMS:

These are flexible, closed-cell, rubber foams based on NBR or EPDM rubber. Flexible elastomeric foams exhibit such a high resistance to the passage of water vapor that they do not generally require additional water-vapor barriers. Such high vapor resistance, combined with the high surface emissivity of rubber, allows flexible elastomeric foams to prevent surface condensation formation with comparatively small thicknesses. As a result, flexible elastomeric foams are widely used on refrigeration and air-conditioning pipework. Flexible elastomeric foams are also used on heating and hot-water systems.

6.6.4 RIGID FOAM:

Pipe insulation made from rigid Phenolic, PIR, or PUR foam insulation is common in some countries. Rigid-foam insulation has minimal acoustic performance but can exhibit low thermal-conductivity values of 0.021 W/(m·K) or lower, allowing energy-saving legislation to be met whilst using reduced insulation thicknesses.

6.6.5 POLYETHYLENE:

Polyethylene is a flexible plastic foamed insulation that is widely used to prevent freezing of domestic water supply pipes and to reduce heat loss from domestic heating pipes. The fire performance of Polyethylene is typically 25/50 E84 compliant up to 1" thickness.

6.6.6 CELLULAR GLASS:

100% Glass manufactured primarily from sand, limestone & soda ash.

6.6.7 AEROGEL:

Silica Aerogel insulation has the lowest thermal conductivity of any commercially produced insulation. Although no manufacturer currently manufactures Aerogel pipe sections, it is possible to wrap Aerogel blanket around pipework, allowing it to function as pipe insulation. The usage of Aerogel for pipe insulation is currently limited.

6.7 PAINTING:

Painting is the practice of applying paint, pigment, color or other medium to a solid surface. The medium is commonly applied to the base with a brush, but other implements, such as knives, sponges, and airbrushes, can be used. The final work is also called a painting.

6.7.1 SPRAY PAINTING:

Aerosol paint (also called spray paint) is a type of paint that comes in a sealed pressurized container and is released in a fine spray mist when depressing a valve button. A form of spray painting, aerosol paint leaves a smooth, evenly coated surface. Standard sized cans are portable, inexpensive and easy to store. Aerosol primer can be applied directly to bare metal and many plastics. Speed, portability and permanence also make aerosol paint a common graffiti medium. In the late 1970s, street graffiti writers' signatures and murals became more elaborate and a unique style developed as a factor of the aerosol medium and the speed required for illicit work. Many now recognize graffiti and street art as a unique art form and specifically manufactured aerosol paints are made for the graffiti artist. A stencil protects a surface, except the specific shape to be painted. Stencils can be purchased as movable letters, ordered as professionally cut logos or hand-cut by artists.

WORKING

❖ The engine releases the exhaust gas at very high temperature and high pressure. The temperature of the exhaust gas is from 400^{o}C to 600^{o} C. The hot exhaust gas with high pressure and high velocity from the engine is made to enter the expansion chamber through a vent. The material used for the Vent pipe from the exhaust tube is G.I (Galvanized Iron). A ball valve is kept before the Expansion chamber in the project setup for controlling the flow of the exhaust gas.

❖ The part of the passage where the flow pipe diameter is suddenly increased and reduced again to the same level is called expansion chamber. While the exhaust gas passes through the expansion chamber at the entry, the flow volume is increased suddenly and at the exit , the volume is reduced to the normal condition before the exit . So , the entry and the exit velocities of the flow is same. The expansion chamber accumulates the exhaust gas inside it than passing through directly. The engine which emits the exhaust for once in four strokes, make the output of the exhaust gas as pulsating flow. It is not a uniform flow. The main objective of the expansion chamber is to dampen the pulsating flow of exhaust gas into a uniform flow. It cushions the intermittent output flow and make it a continuous flow of gases. The aluminium pipe is bent and wound around a rectangular box made up of GI sheet metal and its output is given to the expansion pipe, where it started.

❖ From the expansion chamber , the exhaust gas is made to pass through the copper pipe. Since , copper pipe has higher thermal conductivity and it been insulated on the surface ,the heat energy is efficiently transferred to the end of the pipe.

❖ A heat conducting fluid is needed to transfer the heat from the outer surface of the aluminium pipe to the Box made up of GI sheet metal. In this project GI sheets are used to make the inner and outer cover boxes which handles the heat transfer from the exhaust gas to the food.

❖ For the above-mentioned purpose, white paraffin wax which has the high thermal conductivity and low melting point property. The wax is filled between the coil windings. When the engine is running, the heat is continuously transferred to the food through the wax medium which will be at liquid state. If the engine is turned off, the heat will be gradually decreased, and the wax undergoes phase change from liquid state to solid state.

❖ The expansion chamber and coils are insulated tightly to avoid heat dissipation outside the box. Thus, the heat energy of the exhaust gas is recovered and used for useful application.

This is the working and experimental procedure of Heat Recovery System for Two-wheeler.

CONCLUSION

- This method proves to be efficient and useful to utilize the waste heat energy liberated from the exhaust gas of the two wheelers.
- It utilizes half of the liberated heat energy and conserve it for the heating process. In actual scenario thermo insulated bag can be replaced by our heat recovery setup.
- This also reduces the amount of heat energy emitted into the atmosphere and reduces the global warming.
- It provides a real time product for food delivery two wheelers with greater economic significance.

FUTURE SCOPE

The scope of project work presented in this project was defined as the design and development of heat recovery system in two wheelers using waste heat of engine exhaust without much effect on engine performance, essentially the fuel efficiency. As discussed in the abstract, the basic idea behind this research work is to use the available heat energy in engine exhaust for producing heating effect. The literature review and evaluated various technologies for heat generated heating systems, was found to be most promising alternative solution for the research problem at hand.

The end result of this project work is an innovative design of heat recovery system, which is directly superior to the existing design in terms of heating effect, thermal conductivity, heating time and overall efficiency of the system. In future purpose thermal electric generators (TEG) can also be implemented to the system for generating electricity.

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