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Fabrication of Mini Jet Engine

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Abstract

Jet engine is motion produced by passing a jet of fluid (e.g. air or water) in the opposite direction to the direction of motion. By conservation of momentum, the moving body is propelled in the opposite direction to the jet. A jet engine is a reaction engine that discharges a fast moving jet of fluid to generate thrust by jet propulsion and in accordance with Newton's laws of motion. This broad definition of jet engines includes turbojets, turbofans, rockets, ramjets, pulse jets and pump-jets. In general, most jet engines are internal combustion engines but non-combusting forms also exist. Before describing the construction of the mini jet engine, some basic Principles should be understood. A mini jet engine can be broken down into five major subassemblies, the inlet duct, compressor, combustion chamber, turbine wheel, and exhaust outlet. When the engine is running, air is drawn into the compressor where it is compressed and the pressure is increased. It is then ducted to the combustion chamber where fuel is added and burned. The heat in the combustion chamber causes the air to expand before it exits through a nozzle and drives the power turbine. The turbine drives the compressor by means of a drive shaft. The remaining hot gasses are expelled out the exhaust nozzle. Forcing the large amount of air taken into the engine and expelling it out the exhaust duct at a much higher velocity creates thrust. This is the principle of operation of the mini jet engine. It is a reaction engine.

Keywords: Jet Engine, Principle of operation

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1. Introduction

A jet engine is a reaction engine discharging a fast-moving jet that generates thrust by jet propulsion. This broad definition includes turbojets, turbofans, rocket engines, ramjets, and pulse jets. In general, jet engines are combustion engines.In common parlance; the term jet engine loosely refers to an internal combustion air breathing jet engine. These typically feature a rotating air compressor powered by a turbine, with the leftover power providing thrust via a propelling nozzle — this process is known as the Brayton thermodynamic cycle. Jet aircraft use such engines for long-distance travel. Early jet aircraft used turbojet engines which were relatively inefficient for subsonic flight. Modern subsonic jet aircraft usually use more complex high-bypass turbofan engines. These engines offer high speed and greater fuel efficiency than piston and propeller aero engines over long distances.

Before describing the construction of the mini jet engine, some basic Principles should be understood. A mini jet engine can be broken down into five major subassemblies, the inlet duct, compressor, combustion chamber, turbine wheel, and exhaust outlet. When the engine is running, air is drawn into the compressor where it is compressed and the pressure is increased. It is then ducted to the combustion chamber where fuel is added and burned. The heat in the combustion chamber causes the air to expand before it exits through a nozzle and drives the power turbine. The turbine drives the compressor by means of a drive shaft. The remaining hot gasses are expelled out the exhaust nozzle. Forcing the large amount of air taken into the engine and expelling it out the exhaust duct at a much higher velocity creates thrust. This is the principle of operation of the mini jet engine. It is a reaction engine

2. Project concept

By the detailed analysis of journals and some publications, we are trying to implement a miniaturized jet engine here we are using LPG instead of aviation fuel, by accounting its weight density and economic friendly characters. Here we are fabricating a mini jet engine, in that there are separate provisions for compressed air and LPG.The combustion process is happening in the combustion chamber and the required thrust is developed when the product of combustion leaves through the nozzle. The below shown is the layout of our design

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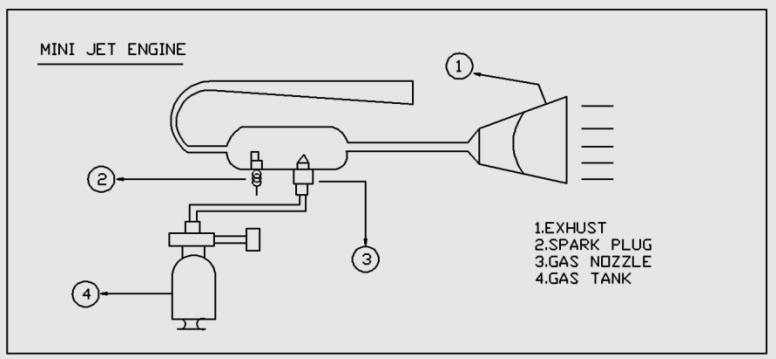

Figure 1 : Schematic 2D diagram of Mini Jet Engine

3. Components and Description

A system consists of four major sub-systems.Gas propulsion system,Nozzle, Fuel, Gas system ,Spark plug.

Gas propulsion system - The gas propulsion system provides the steady supply of clean dry gas used to propel the gas particles. Depending upon the demands of the installation, either an air compressor or bottled gas may be used. If an air compressor is used, proper line filters must be installed to avoid water or oil contamination of the abrasive powders. The least expensive, and thus the most common gasses to use, are nitrogen and carbon-di-oxide. Oxygen should never be used as it presents a fire hazard.

Nozzle - The nozzles are typically made of tungsten carbide, brass or sapphire. Tungsten carbide nozzles with either round or rectangular holes are available and lost for an average of 300 hr but are 3 to 8 times more expensive.

Fuel gas system - When starting the engine, gas flows from the cylinder through solenoid valve, due to vacuum creation inside the crank case and slider being closed, and the coming gas enters directly through the idle passage into the intake tube, thus the engine starts.When acceleration is applied, the slider moves upwards, so the gas enters both through acceleration passage and idle passage into the crankcase thus the vehicle speed is increased**.**

Spark plug - Spark plug is a device to produce electric spark to ignite the compressed air-fuel mixture inside the cylinder. The spark plug is screwed in the top of the cylinder so that its electrodes projects in the combustion chamber.

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Figure 2: Schematic image of spark plug used

Construction: A spark plug consists of mainly three parts:

1. Centre electrode or insulated electrode.
2. Ground electrode or outer electrode.
3. Insulation separating the two electrodes.

The upper end of the centre electrode is connected to the spark plug terminal, where H.T. cable from the ignition coil is connected. It is surrounded by porcelain insulator. The lower half portion of the insulator is fastened with a metal shell. The lower portion of the shell has a short electrode attached to one side and bent in towards the centre electrode, so that there is a gap between the two electrodes. The two electrodes are thus separated by the insulator. The sealing gaskets are provided between the insulator and the shell to prevent the escape of gases under various temperature and pressure conditions. The lower part of the shell has screw threads and the upper part is made in hexagonal shape like a unit, so that the spark plug may be screwed in or unscrewed from the cylinder head.

Flow control valve - The purpose of flow control valve is to control and adjust the flow of LPG in order to maintain the effectiveness of combustion

Working - We are using LPG as fuel because it is very easy to install and there is no need for any injection systems or fuel pumps. LPG is stored in a 2 Kg capacity cylinder. The cylinder is connected to two valves one stop valve and other control valve that regulate the flow of gas. The valve is followed by high pressure flexible tubes used in gas welding. The other end is connected to the fuel nozzle made from mild steel, which is welded to the combustion chamber.

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4. Fabrication process

Manufacturing processes are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the creation of the materials from which the design is made. These materials are then modified through manufacturing processes to become the required part. Manufacturing processes can include treating (such as heat treating or coating), machining, or reshaping the material. The manufacturing process also includes tests and checks for quality assurance during or after the manufacturing, and planning the production process prior to manufacturing.

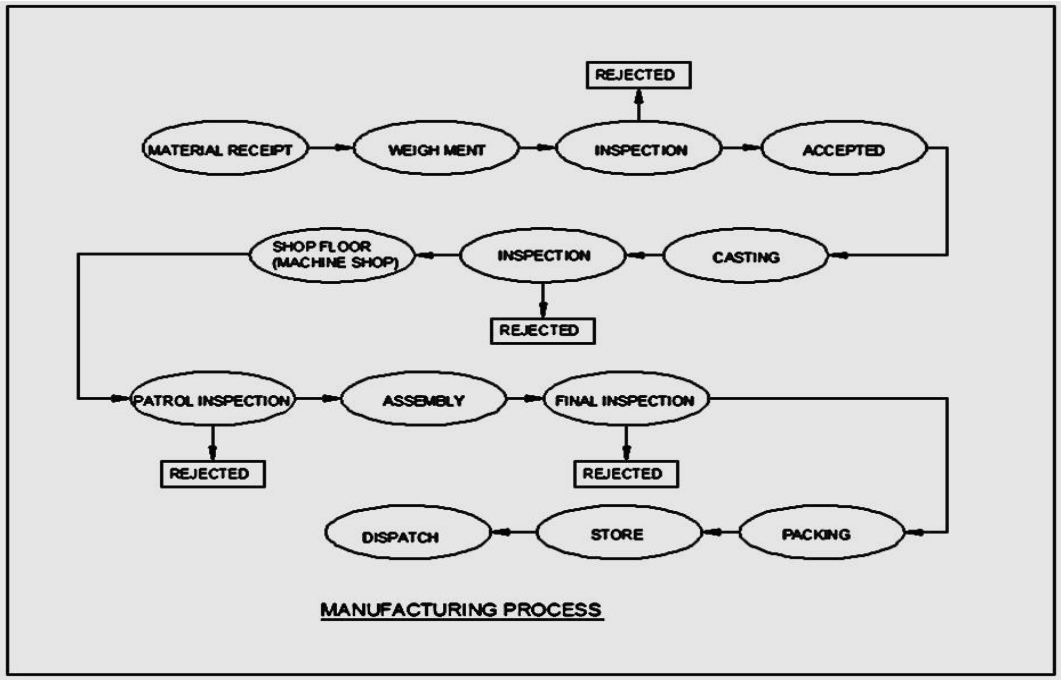

Figure 3: Flow chart of Manufacturing process

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Metal Cutting - Metal cutting or machining is the process of by removing unwanted material from a block of metal in the form of chips

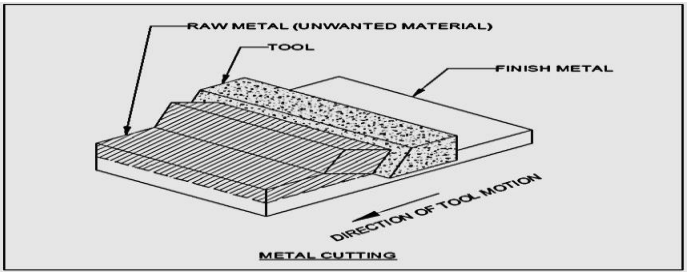

Figure 4: Schematic diagram of Metal Cutting process

Cutting processes work by causing fracture of the material that is processed. Usually, the portion that is fractured away is in small sized pieces, called chips. Common cutting processes includesawing, shaping (or planning), broaching, drilling, grinding, turning and milling. Although the actual machines, tools and processes for cutting look very different from each other, the basic mechanism for causing the fracture can be understood by just a simple model called for orthogonal cutting.

Sawing - Cold saws are saws that make use of a circular saw blade to cut through various types of metal, including sheet metal. The name of the saw has to do with the action that takes place during the cutting process, which manages to keep both the metal and the blade from becoming too hot. A cold saw is powered with electricity and is usually a stationary type of saw machine rather than a portable type of saw.

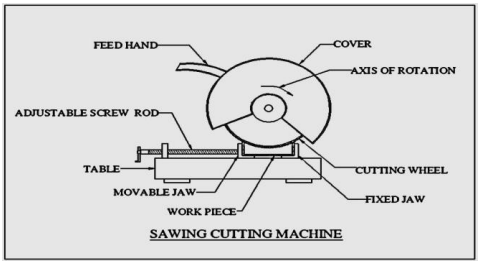

Figure 5: Schematic diagram of Sawing machine used in Metal Cutting process

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The circular saw blades used with a cold saw are often constructed of high speed steel. Steel blades of this type are resistant to wear even under daily usage. The end result is that it is possible to complete a number of cutting projects before there is a need to replace the blade. High speed steel blades are especially useful when the saws are used for cutting through thicker sections of metal.Along with the high speed steel blades, a cold saw may also be equipped with a blade that is tipped with tungsten carbide. This type of blade construction also helps to resist wear and tear. One major difference is that tungsten tipped blades can be re-sharpened from time to time,extending the life of the blade. This type of blade is a good fit for use with sheet metal and other metallic components that are relatively thin in design.

Welding - It is a process for joining similar metals. Welding joins metals by melting and fusing 1,thebase metals being joined and 2,the filler metal applied. Welding employs pinpointed, localized heat input. Most welding involves ferrous-based metals such as steel and stainless steel.Weld joints are usually stronger than or as strong as the base metals being joined.Welding is used for making permanent joints. It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural works, tanks, furniture, boilers, general repair work and ship building.

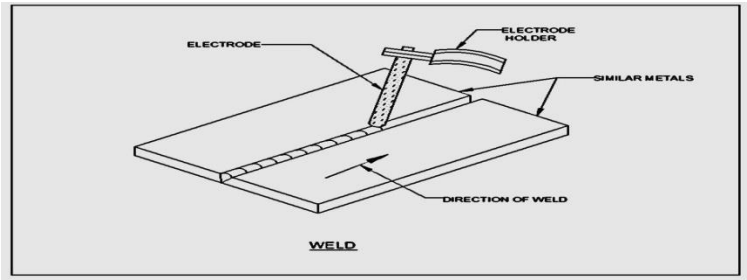

Figure 6: Welding process isometric view

Welding operation-Several welding processes are based on heating with an electric arc, only a few are considered here, starting with the oldest, simple arc welding, also known as shielded metal arc welding (SMAW) or stick welding. In this process an electrical machine (which may be DC or AC, but nowadays is usually AC) supplies current to an electrode holder which carries an electrode which is normally coated with a mixture of chemicals or flux. An earth cable connects the work piece to the welding machine to provide a return path for the current. The

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weld is initiated by tapping ('striking') the tip of the electrode against the work piece which initiates an electric arc. The high temperature generated (about 6000^{o}C) almost instantly produces a molten pool and the end of the electrode continuously melts into this pool and forms the joint.

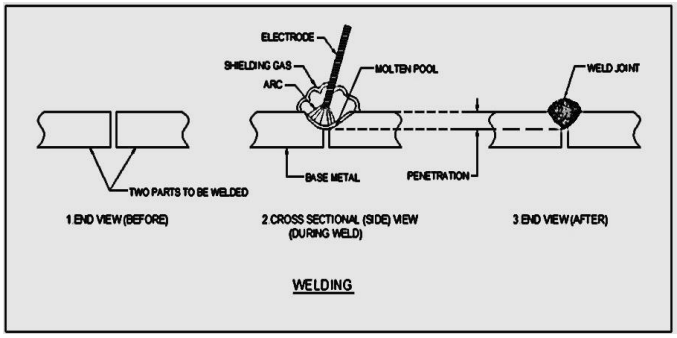

Figure 7: welding process in side view

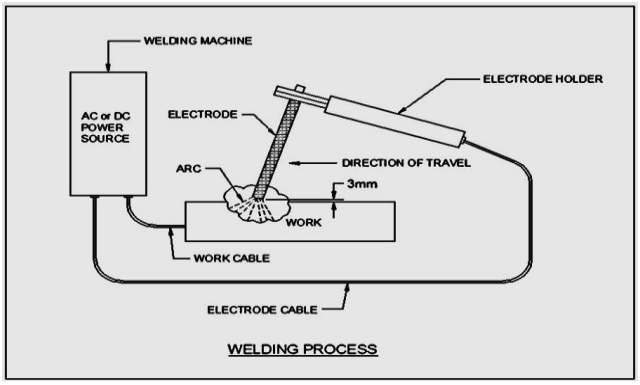

Figure 8: Construction of welding process

In the shielded metal arc welding process (SMAW) the 'stick' electrode is covered with an extruded coating of flux. The heat of the arc melts the flux which generates a gaseous shield to keep air away from the molten pool and also flux ingredients react with unwanted impurities such as surface oxides, creating a slag which floats to the

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surface of the weld pool. This forms a crust which protects the weld while it is cooling. When the weld is cold the slag is chipped off.The SMAW process cannot be used on steel thinner than about 3mm and being a discontinuous process it is only suitable for manual operation. It is very widely used in jobbing shops and for onsite steel construction work. A wide range of electrode materials andcoatings are available enabling the process to be applied to most steels, heat resisting alloys and many types of cast iron.

Drilling –It is a cutting process that uses a drill bit to cut or enlarge a hole of circular cross-section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the workpiece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the workpiece, cutting off chips (swarf) from the hole as it is drilled.

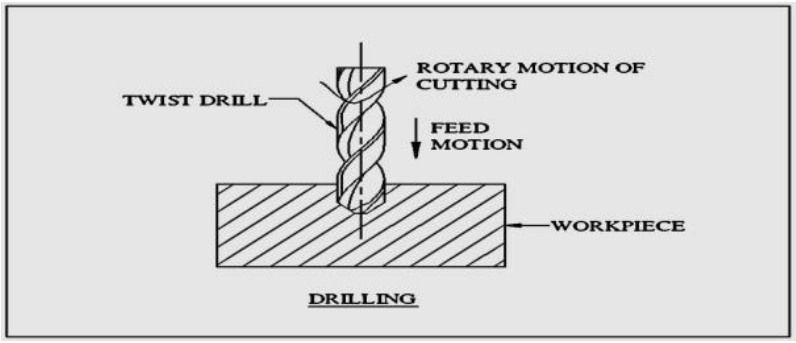

Figure 9: Section view of Drilling

Drilling operation - The geometry of the common twist drill tool (called drill bit) is complex; it has straight cutting teeth at the bottom – these teeth do most of the metal cutting, and it has curved cutting teeth along its cylindrical surface. The grooves created by the helical teeth are called flutes, and are useful in pushing the chips out from the hole as it is being machined. Clearly, the velocity of the tip of the drill is zero, and so this region of the tool cannot do much cutting. Therefore it is common to machine a small hole in the material, called a center-hole, before utilizing the drill. Center-holes are made by special drills called center-drills; they also provide a good way for the drill bit to get aligned with the location of the center of the hole. There are hundreds of different types of drill shapes and sizes; here, we will only restrict ourselves to some general facts about drills.

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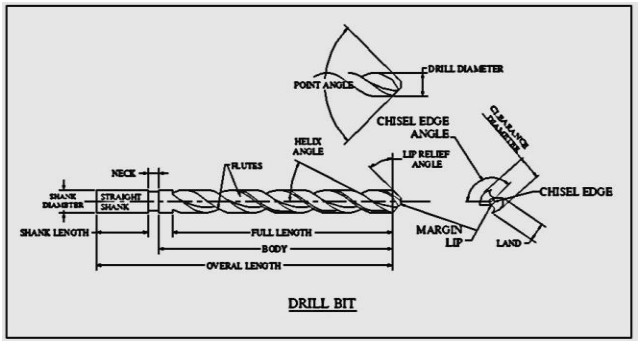

Figure 10: Schematic View of Drill Bit

Common drill bit materials include hardened steel (High Speed Steel, Titanium Nitride coated steel) for cutting harder materials, drills with hard inserts, e.g. carbide or CBN inserts, are used. In general, drills for cutting softer materials have smaller point angle, while those for cutting hard and brittle materials have larger point angle. If the Length/Diameter ratio of the hole to be machined is large, then we need a special guiding support for the drill, which itself has to be very long; such operations are called gun-drilling. This process is used for holes with diameter of few mm or more, and L/D ratio up to 300. These are used for making barrels of guns.

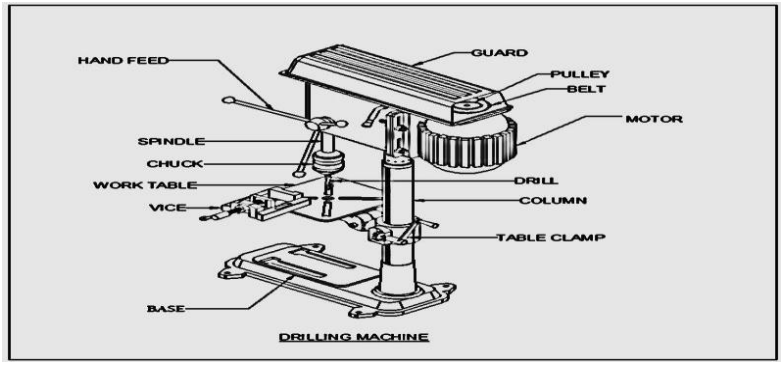

Figure 11: Schematic diagram of Electric Motor Drilling Machine

Drilling is not useful for very small diameter holes (e.g. < 0.5 mm), since the tool may break and get stuck in the work piece; - Usually, the size of the hole made by a drill is slightly larger than the measured diameter of the drill – this is mainly because of vibration of the tool spindle as it rotates, possible misalignment of the drill with the spindle

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axis, and some other factors.For tight dimension control on hole diameter, we first drill a hole that is slightly smaller than required size (e.g. 0.25 mm smaller), and then use a special type of drill tight dimension control on hole diameter, we first drill a hole that is slightly smaller than required size (e.g. 0.25 mm smaller), and then use a special type of drill.called a reamer. Reaming has very low material removal rate, low depth of cut, but gives good dimension accuracy.

5. Inspection

Critical appraisalinvolvingexamination, measurement, testing, gauging, and comparison of materials or items. An inspection determines if the material or item is in proper quantity and condition, and if it conforms to the applicable or specified requirements. Inspection is generally divided into three categories: (1) Receiving inspection, (2) In-process inspection, and (3) Final inspection. In quality control (which is guided by the principle that "Quality cannot be inspected into a product") the role of inspection is to verify and validate the variancedata; it does not involve separating the good from the bad.

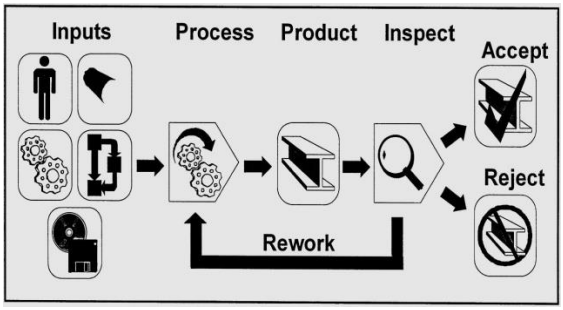

Fig .12 Schematic layout of Inspection method

Assembly-An assembly line is a manufacturing process (most of the time called a progressive assembly) in which parts (usually interchangeable parts) are added as the semi-finished assembly moves from work station to work station where the parts are added in sequence until the final assembly is produced. By mechanically moving the parts to the assembly work and moving the semi-finished assembly from work station to work station, a finished product can be assembled much faster and with much less labor than by having workers carry parts to a stationary piece for assembly.

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6. Metal fabrication process

Metal fabrication is the building of metal structures by cutting, bending, and assembling processes. It is a value added process that involves the construction of machines and structures from various raw materials.

Processes

- *Cutting* is done by sawing, shearing, or chiseling (all with manual and powered variants); torching with hand-held torches (such as oxy-fuel torches or plasma torches); and via numerical control (CNC) cutters (using a laser, mill bits, torch, or water jet).
- *Bending* is done by hammering (manual or powered) or via press brakes and similar tools. Modern metal fabricators use press brakes to either coin or air-bend metal sheet into form. CNC-controlled back gauges use hard stops to position cut parts in order to place bend lines in the correct position. Off-line programming software now makes programming the CNC-controlled press brakes seamless and very efficient.
- *Assembling* (joining of the pieces) is done by welding, binding with adhesives, riveting, threaded fasteners, or even yet more bending in the form of a crimped seam. Structural steel and sheet metal are the usual starting materials for fabrication, along with the welding wire, flux, and fasteners that will join the cut pieces. As with other manufacturing processes, both human labor and automation are commonly used. The product resulting from fabrication may be called a fabrication. Shops that specialize in this type of metal work are called *fab shops*. The end products of other common types of metalworking, such as machining, metal stamping, forging, and casting, may be similar in shape and function, but those processes are not classified as fabrication.

Overlap -Fabrication comprises or overlaps with various metalworking specialties

- Fabrication shops and machine shops have overlapping capabilities, but fabrication shops generally concentrate on metal preparation and assembly as described above. By comparison, machine shops also cut metal, but they are more concerned with the machining of parts on machine tools. Firms that encompass both fab work and machining are also common.

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- Blacksmithing has always involved fabrication, although it was not always called by that name.
- The products produced by welders, which are often referred to as weldments, are an example of fabrication.
- Boilermakers originally specialized in boilers, leading to their trade's name, but the term as used today has a broader meaning.
- Similarly, millwrights originally specialized in setting up grain mills and saw mills, but today they may be called upon for a broad range of fabrication work.
- Ironworkers, also known as steel erectors, also engage in fabrication. Often the fabrications for structural work begin as prefabricated segments in a fab shop, then are moved to the site by truck, rail, or barge, and finally are installed by erectors.

Raw materials - Standard raw materials used by metal fabricators are;

- plate metal
- formed and expanded metal
- tube stock,
- welding wire/welding rod
- casting

Cutting and burning -The raw material has to be cut to size. This is done with a variety of tools.The most common way to cut material is by Shearing (metalworking). Special band saws designed for cutting metal have hardened blades and a feed mechanism for even cutting. Abrasive cut-off saws, also known as chop saws, are similar to miter saws but with a steel cutting abrasive disk. Cutting torches can cut very large sections of steel with little effort.Burn tables are CNC cutting torches, usually natural gas powered. Plasma and laser cutting tables, and Water jet cutters, are also common. Plate steel is loaded on a table and the parts are cut out as programmed. The support table is made of a grid of bars that can be replaced. Some very expensive burn tables also include CNC punch capability, with a carousel of different punches and taps. Fabrication of structural steel by plasma and laser cutting introduces robots to move the cutting head in three dimensions around the material to be cut.

Forming- Forming is a process of material deformation. Forming is typically applied to metals. To define the process, a raw material piece is formed by applying force to an object. The force must be great enough to change the

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shape of the object from its initial shape. The process of forming can be controlled with the use of tools such as punches or dies. Machinery can also be used to regulate force magnitude and direction. An example of machine based forming can also combine forming and welding to produce lengths of fabricated sheeting, most commonly seen in the form of linear grating. Proper design and use of tools with machinery creates a repeatable form which can be used to create products for many industries, including jewelry, aerospace, automotive, construction, civil and architectural, etc.

Machining is the process of removing unwanted material from the block of metal to get the desire shape. Machining is a trade, in and of itself, although Fab shops will generally entail a limited machining capability including; metal lathes, mills, magnetic based drills, along with other portable metal working tools.Welding is the main focus of steel fabrication. The formed and machined parts will be assembled and tack welded into place then re-checked for accuracy. A fixture may be used to locate parts for welding if multiple weldments have been ordered.The welder then completes welding as per the engineering drawings if welding is detailed, or as per his/her own judgment if no welding details are provided.Special precautions may be needed to prevent warping of the weldment due to heat. These may include re-designing the weldment to use less weld, welding in a staggered fashion, using a stout fixture, covering the weldment in sand during cooling, and straightening operations after welding.Steel weldments are occasionally annealed in a low temperature oven to relieve residual stresses. Such weldments, particularly those employed for engine blocks, may be line-bored after heat treatment.

7. Working principle

We are using LPG as fuel because it is very easy to install and there is no need for any injection systems or fuel pumps. LPG is stored in a 2 Kg capacity cylinder. The cylinder is connected to two valves one stop valve and other control valve that regulate the flow of gas. The valve is followed by high pressure flexible tubes used in gas welding. The other end is connected to the fuel nozzle made from mild steel, which is welded to the combustion chamber.Here we are using a blower to blow the air through the inlet .It mixes with LPG in the combustion chamber and get ignited by the aid of a spark plug.The mixing proportion can be controlled by a flow control valve. The amount of thrust is getting experienced in the exit of the nozzle.

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Figure 13: Fabricated Min Jet Engine

8. Merits & demerits

The Advantages of LPG include

- Because LPG vaporizes when released from the tank and is not water soluble, LPG does not pollute underground water sources.
- Power, acceleration, payload and cruise speed are comparable to those of an equivalent vehicle fueled on gasoline. Propane has a high octane rating of 104, in-between Compressed Natural Gas (CNG) (130) and regular unleaded gasoline (87).
- Refueling a propane vehicle is similar to filling a gas grill tank; the time it takes is comparable with that needed to fill a CNG, gasoline or diesel fuel tank.
- Its high octane rating enables it to mix better with air and to burn more completely than does gasoline, generating less carbon. With less carbon buildup, spark plugs often last longer and oil changes are needed less frequently.
- Because it burns in the engine in the gaseous phase, propane results in less corrosion and engine wear than does gasoline.

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- Power to the weight ratio of a turbojet is about four times that of a propeller system having reciprocating engine.
- It is simple, easy to maintain and requires lower lubricating oil consumptions. Further more liquid cooling results in reduced frontal area.
- LPG is clean, high octane, abundant and eco-friendly fuel. Higher energy content, lower CO_2 emission. It can be easily condensed packaged, stored and utilized
- There is no limit to power output which can be obtained from a turbojet while the piston engines have reached almost their peak power and further increased will be at the cost of complexity and greater engine weight and frontal area of aircraft.
- The speed of turbo jet is not limited by the propeller and it can attain higher flight speeds than engine propeller aircrafts.
- Simplicity of design, efficient at supersonic speed Mach

The Drawbacks of LPG include

- In cold conditions, below 32 degrees Fahrenheit, starting could be a problem because of the low vapor pressure of propane at low temperatures.
- One gallon of LPG contains less energy than a gallon of gasoline. The driving range of a propane vehicle is about 14 percent lower than a comparable gasoline-powered vehicle.
- LPG is generally higher priced than other fuel alternatives such as CNG and gasoline.
- There are over 4,000 LPG refueling sites in the US, more than all of the other alternative fuels combined. Most of these stations, however, are not readily available to consumers on a 24/7 basis. This is one of the reasons why most on-road applications are bi-fuel vehicles, which burn LPG and gasoline.

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Special Features of LPG System

- LPG is cheaper than gasoline in cost as well availability.
- It gives better manifold distribution and mixes easily with air.
- It is highly knock resistant.
- Residue and oil contamination is small as it burns early.
- Crank case dilution is small thereby resulting in increased engine life
- Due to uniform distribution thermal efficiency is higher.
- LPG has a higher octane rating making it useful in engines having compression ratio above 10:1.
- It leaves little or no carbon deposits in the cylinder when it burns. It is a clean gas.
- Easy cold starting is possible due to thermal motion.
- It has a low strain on lubricants.
- Lesser exhaust emission and hence lesser air pollution.
- High durability of exhaust system. Spark plug and upper cylinder.
- Since it enters as a gas it cannot wash down the cylinder walls. Thus not remove lubricant and so cylinder wall wear, piston rings wear is decreased.

Table 1: Specification of properties of LPG

BOILING POINT	$176^{O}C$	$410^{0}C$
FREEZING POINT	−47 °C (−53 °F)	$-42^{0}C$
WEIGHT DENSITY	$.78g/cm^3$	$.5g/cm^3$
CALORIFIC VALUE	11,250 *kcal/kg*	12034 KCAL/KG
COST	46/lit	42/lit
EXHUST	HARMFUL	ECO FRIENDLY

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9. Conclusion

The mini jet engine was assembled and placed on a suitable base. The engine was run at a suitable speed by using LPG as a fuel. It worked satisfactorily and provided a unique opportunity to witness the working of a jet engine at close range. This study enabled a deeper study and better understanding of the designs used in the construction of such engines.

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