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DESIGN AND FABRICATION OF LAND CUTTING AND PIPE LAYING MACHINE

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Abstract:

Within industry, piping is a systems of pipes used convey fluids (liquids and gases) from one location to another. The engineering discipline of piping design studies the efficient transport of fluid. Various piping materials used in industry are Carbon Steel, Mild Steel, Plastic, Stainless Steel, Cupro Nickel, HDPE, LDPE, Tantalum, Tempered Glass, Cement and Asbestos pipes etc., Various areas of piping are refineries, power plants, petrochemicals, hydro power plants, water treatment and distribution, municipalities etc. However in most of the above areas there will be requirement of laying 100's of kilometers of large pipe laying which is one of the most laborious and time taking process. As a part of our project work we are planning to fabricate a land cutting and pipe laying machine which makes the process faster.

Key Words: Land Cutting, Pipe Laying, Motor & Blades

Introduction:

The engineering discipline of piping design studies the efficient transport of fluid. Various piping materials used in industry are Carbon Steel, Mild Steel, Plastic, Stainless Steel, Cupro Nickel, HDPE, LDPE, Tantalum, Tempered Glass, Cement and Asbestos pipes etc., Various areas of piping are refineries, power plants, petrochemicals, hydro power plants, water treatment and distribution, municipalities etc., However in most of the above areas there will be requirement of laying 100's of kilometres of large pipe laying which is one of the most laborious and time taking process. Long length piping is done to transfer water, gases, fuels and sewage. Industrial piping is done from few meters to 100's of Kms (between countries) Conventional Industrial Pipe laying process requires 1. Huge amount of labour force 2. Various equipments 3.Also time consuming.

A pipe laying machine for laying a pipe in a trench, includes a first self-propelled chassis on which a driver's cab and power train are located, a beam connected at a first end to the chassis and which extends laterally, a second moving chassis connected at a second end of the beam and a guiding and supporting element of a pipe, sliding on the beam toward and away from the self-propelled chassis, in which the self-propelled chassis can travel on a track at the edge of the trench, the moving chassis can travel on the bottom of the trench, and the guiding and supporting element can translate to carry the pipe to the trench so that by moving the machine forward along a direction of forward movement the cantilevered portion of pipe is laid on the bottom of the trench

Land cutting and pipe laying machine will be provided with bucket wheel for cutting the land and then lifting and dropping pipe arrangement, pipe transverse movement with trolley, pipe lifting and dropping using winch mechanisms.

Types of Pipelines:

- Gathering Pipelines: Gathering pipelines are used to deliver the oil or gas product from the source to processing plants or storage tanks. These are commonly fed by 'Flow lines', each connected to individual wells in the ground. Additionally, subsea pipes used for collecting product from deep water production platforms are included in this category.
- Transmission pipelines: Transmission pipelines are used to transport crude oil, NGLs, natural gas and refined products for long distances across states, countries and continents. They are used to move the product from the production regions to distribution centers, Transmission pipelines operate at high pressures, ranging from 200 up to 1,200 psi, with each transmission line using compressor stations (for gas lines) and pump stations (for crude oil and liquid products).

- Distribution pipelines: Distribution pipelines are a system made up of 'mains' and 'service' lines, used by distribution companies. Together they deliver natural gas to the neighborhood of homes and businesses.
- Flow lines: Flow lines are prone to methane leakage, and according to EPA (Environmental Protection Agency) in the United States, they are one of the largest sources of emissions in the gas industry. The EPA recommends checking flow lines annually to reduce gas losses. Regular maintenance helps to prevent small leaks from increasing in volume over time

Pipeline Transportation:

Pipeline transport is the long-distance transportation of a liquid or gas through a system of pipes a pipeline typically to a market area for consumption. The latest data from 2014 gives a total of slightly less than 2,175,000 miles (3,500,000 km) of pipeline in 120 countries of the world. The United States had 65%, Russia had 8%, and Canada had 3%, thus 75% of all pipeline were in these three countries.

Pipeline and Gas Journal's worldwide survey figures indicate that 118,623 miles (190,905 km) of pipelines are planned and under construction. Of these, 88,976 miles (143,193 km) represent projects in the planning and design phase; 29,647 miles (47,712 km) reflect pipelines in various stages of construction. Liquids and gases are transported in pipelines and any chemically stable substance can be sent through a pipeline. Pipelines exist for the transport of crude and refined petroleum, fuels such as oil, natural gas and biofuels and other fluids including sewage, slurry, water, beer, hot water or steam for shorter distances. Pipelines are useful for transporting water for drinking or irrigation over long distances when it needs to move over hills, or where canals or channels are poor choices due to considerations of evaporation, pollution, or environmental impact. Oil pipelines are made from steel or plastic tubes which are usually buried. The oil is moved through the pipelines by pump stations along the pipeline. Natural gas (and similar gaseous fuels) are pressurized into liquids known as Natural Gas Liquids (NGLs). Natural gas pipelines are constructed of carbon steel. Hydrogen pipeline transport is the transportation of hydrogen through a pipe. Pipelines are one of the safest ways of transporting materials as compared to road or rail, and hence in war, pipelines are often the target of military attacks.

Pipelines used in the oil and gas industry vary according to many factors, such as the 'product' to be transported, the delivery stage and whether it's part of the upstream, midstream or downstream sector.

Parts:

Bucket Wheel: A bucket-wheel a large heavy equipment machine used in surface mining.A bucket wheel consists of a superstructure to which several more components are fixed. The bucket wheel from which the machines get their name is a large, round wheel with a configuration of scoops which is fixed to a boom and is capable of rotating. Material picked up by the cutting wheel is transferred back along the boom. In early cell-type bucket wheels, the material was transferred through a chute leading from each bucket, while newer cell-less and semi-cell designs use a stationary chute through which all of the buckets discharge. A discharge boom receives material through the superstructure from the cutting boom and carries it away from the machine, frequently to an external conveyor system. The scale of bucket wheel varies significantly and is dependent on the intended application. Compact bucket wheel designed by Thyssen Krupp may have boom lengths as small as six meters (20ft), weigh 50 tons, and move 100 m3 (3,500 cu ft.) of earth per hour. Their larger models reach boom lengths of 80 m (260 ft.), weigh 13,000 tons, and move 12,500 m3 (440,000 cu ft.) per hour.[6] The largest bucket wheel ever constructed is TAKRAF's Bagger 293, which weighs 14,200 tonnes and is capable of moving 240,000 m3 (8,500,000 cu ft) of overburden every day. Excavations of 380,000 m3 (13,000,000 cu ft.) per day have been recorded. The BWEs used in the United States tend to be smaller than those constructed in Germany. Bucket wheel technology is used extensively in bulk materials handling. Bucket wheel recliners are used to pick up material that has been positioned by a stacker for transport to a processing plant. Stacker/recliners, which combine tasks to reduce the number of required machines, also use bucket wheels to carry out their tasks.

Figure 1.1: Bucket Wheel

Grabbing Mechanism: Automatically clamps to pipe when lowered onto it Moveable outriggers stabilize the pipe during lift. No blocking required. Quick and efficient handling of properly balanced pipe.

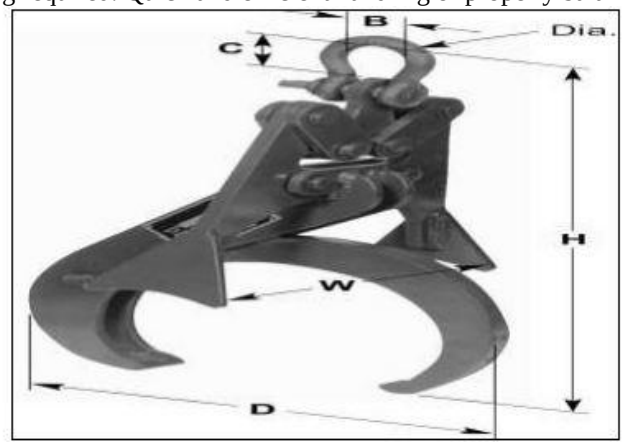

Figure 1.2: Grabbing Mechanism

Trolley Wheel Mechanism: A trolley wheel mechanism has two caster wheel assemblies each having a pair of wheels mounted on a rotatable housing. In a free mode the wheels are free to both rotate and to swivel. This is caused by the user pressing a release pedal. In a unidirectional mode a retainer lock engages a brake disc to prevent swiveling of the housing. This is caused by the user pressing both pedals simultaneously. A brake mode is caused by the user pressing the apply pedal.Frame is main assembly of trolley mounted on axle .Aim to kept material that must be moved. A frame is usually a structural system that supports different parts of a physical construction and/or steel frame that limits the construction's extent. Framing, in construction, is the fitting together of items to give a structure support and shape. Framing materials are usually wood, built wood, or steel. A motor controller designed to convert fixed frequency AC power to available frequency power for AC motor speed control. The system is used in conjunction with a squirrel cage motor to control speed over a relatively wide, constant torque range, by maintaining a constant voltage / frequency ratio. This type of control "leashes" the in-rush current to deliver startup power to the motor as efficiently as possible providing a soft-start feature thereby minimizing load swing.

Figure 1.3: Trolley Mechanism

Literature Review:

In the land cutting Guide, Comprehensive look at the North American THIS MACHINE Industry (2011), Skonberg included a chapter that discusses the benefits and risks of a multitude of environmental factors when utilizing land cutting trenchless technologies.

Skonberg (2011) describes the factors to consider when trying to determine which method of pipe laying installation to use (open-cut), including ground conditions, hydrology, river bed movement, site-specific soil boring, construction impacts at the rig-sites, permit authorities and regulatory requirements, drilling mud properties, frac-out cause and cleanup, and pipe laying wall thickness (thickness of the steel used to fabricate the pipe).

In this Guide, Skonberg (2011) primarily describes the benefits of THIS MACHINE pipe laying installation, with little discussion of the open cut installation method, but he acknowledges the environmental risks involved with This Machine technology during pipe laying installation under watercourses.

This information was helpful to the development of this thesis because he asks questions that are directly pertinent to the study-sites in this thesis, specifically providing well-rounded experiential knowledge regarding This Machine fieldwork and considerations. Bennett and Ariaratnam (2008) wrote another widely utilized guide in the pipe laying and direction drilling industry.

This book is descriptive and practical in explaining the method of land cutting and pipe laying in one machine and trenchless pipe laying installation methods, including the economic, social and environmental footprint caused by the use of this technology in future.

The literature in this book is heavily based on the engineering of land cutting and pipe laying. This was helpful to define and explain the sequence of the work using the appropriate terminology and identifying the steps where unfavourable malfunctions may occur. Unfavourable malfunctions meaning a delay in the work due to unforeseen events, or adverse effects on the surrounding environment. Trenchless methods carry a certain level of risk since there is a dependence on technology and a reliance on the subsurface materials and geotechnical assessment.

According to Benett and Ariaratnam (2008) the information is collected during the planning phase when determining if this is an appropriate method for the crossing. Isolated open-cut is sometimes preferred for that very reason; there is a greater sense of control at the site while working on the surface and watching the material change as equipment cuts through the channel to prepare the ditch for pipe laying installation. In addition, open-cut requires less individual training in order to perform the work.

Land cutting was done by employing a bucket type cutting machine as shown in figure (2.1).

Figure 2.1: Bucket Type Cutting Machine

We have replaced this head with a bucket wheel with several cutting heads at equally distributed angels on single plate, since cutting the land is the basic step for pipe laying. In comparison, the Environmental Handbook for Pipe laying Construction prepared by Alberta Environment (1988) details the requirements and potential impacts of open-cut isolation through watercourses during pipe laying construction. Many factors that impede successful pipe laying installation are explained in the handbook. These include poor construction schedules, inadequate protection measures that damage fish habitat and interfere with recreation activities downstream, alternation of stream substrates and physical or chemical changes in the water quality such as sediment loading and interruption of stream flow or blockage of fish movements

Figure 2.2: Trench Machine

It can be observed that manual or shovel trenching is performed by homeowners to create trenches for various gardening projects. Additionally professional trenching crew resort to hand tools when need of trenching in areas where their trenchers can't fit arises. Digging of trench using digging shovel or spades will be efficient for the first few feet of depth as shown in figure (2.2), but after a certain depth the operation will only lead to backache and frustration as the operation performed is ineffective.

Figure 2.3: Pipe Laying Machine

A pipe laying machine for laying a pipe in a trench, includes a first self-propelled chassis on which a driver's cab and power train are located, a beam connected at a first end to the chassis and which extends laterally, a second moving chassis connected at a second end of the beam and a guiding and supporting element of a pipe, sliding on the beam toward and away from the self-propelled chassis, in which the self-propelled chassis can travel on a track at the edge of the trench, the moving chassis can travel on the bottom of the trench, and the guiding and supporting element can translate to carry the pipe to the trench so that by moving the machine forward along a direction of forward movement the cantilevered portion of pipe is laid on the bottom of the trench as shown in figure (2.3). We are going to combine both the machines and modify it to achieve a high performance land cutting and pipe laying machine.

Figure 2.4: Mild Steel

We have planned to use Mild steel as the major material for the fabrication of the machine because of its high strength and also due to the yield point and easy to manufacturing abilities.

Steel is any alloy of iron, consisting of 0.2% to 2.1% of carbon, as a hardening agent. Besides carbon, many other metals are a part of it. They include chromium, manganese, tungsten and vanadium. Other than a maximum limit of 2% carbon in the manufacture of carbon steel, the proportions of manganese (1.65%), copper (0.6%) and silicon (0.6%) are fixed, while the proportions of cobalt, chromium, niobium, molybdenum, titanium, nickel, tungsten, vanadium and zirconium are not. What is known as mildest grade of carbon steel or mild steel is typically the variety which has a comparatively low amount of carbon (0.05% - 0.26%).

Mild steel as shown in figure (2.4) is overwhelming the market demand makes it the cheapest form of steel available. With such widespread usage, the knowledge of its properties is necessary for anybody who's into the manufacturing business or a student of metallurgy. You will find the most important characteristics of mild steel presented in the following lines.

An alloy is a mixture of metals and non-metals, designed to have specific properties. These metallurgical innovations make it possible to compensate for the shortcomings of a pure metal by adding other elements.

Properties and Uses:

Here is a compilation of mild steel properties and its uses in various fields of technology.

- The calculated average industry grade mild steel density is 7861.093 kg/m3. Its Young's modulus, a measure of its stiffness is around 210,000 MPa.
- A moderate amount of carbon makes this steel different from other types. Carbon atoms get affixed in the interstitial sites of the iron lattice, making it stronger and harder. However, the hardness comes at the price of a decrease in ductility.
- Compared to other types of steel, this type is ideal for welding purposes, as it conducts electric current effectively without tarnishing the metal surface in any way.
- Mild steel has ferromagnetic properties, which make it ideal for manufacture of electrical devices and motors. It yields itself easily to magnetization.
- Unlike other grades of carbon steel, which tend to be brittle, mild steel is hard, yet malleable, making it the ideal choice for the construction of pipelines, construction materials and many other daily use products like cookware.
- Mild steel can be machined and shaped easily due to its inherent flexibility. It can be hardened with carburizing, making it the ideal material for producing a range of consumer products.
- The high amount of carbon also makes it vulnerable to rust. Naturally, people prefer stainless over mild steel, when they want a rust free technology. It is also used in construction as structural steel, besides finding applications in the car manufacturing industry.

So, these are some of the properties and uses of mild steel. It is the cheapest and most versatile form of steel and serves every application which requires a bulk amount of the alloy.

Main materials which we have chosen for making this project includes,

- Hollow square rod
- Plate
- Flat
- Angle

Experimental Procedure:

Designing of Prototype:

This machine cuts land using bucket wheel which is coupled with a high torque low speed motor as low speed geared motor can develop higher torque. Depth of cut is controlled using one more motor mounted on chassis & wire rope and linear motion is controlled by motored powered wheels mounted on chassis.

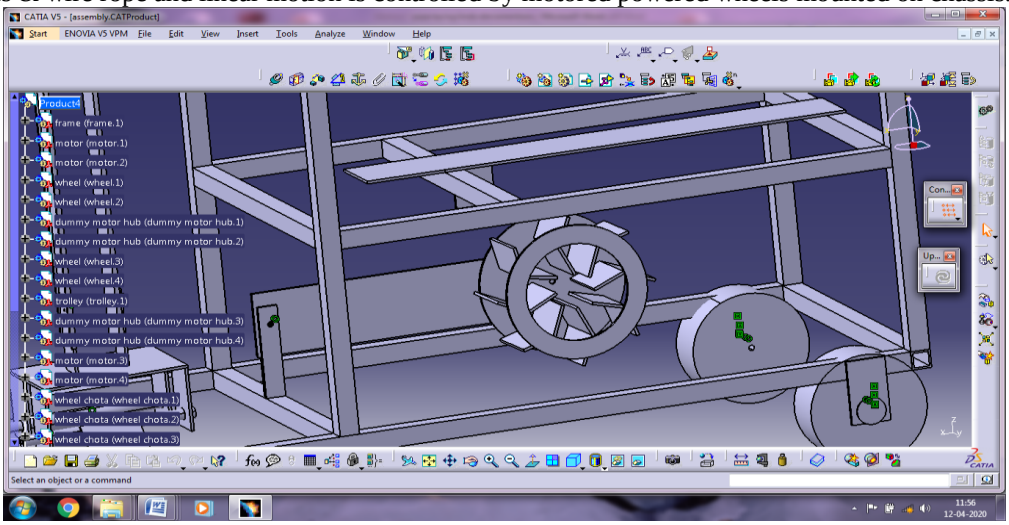

Figure 3.1: Bucket Wheel

Pipe laying operation is carried out by using a grab. Grab rotation is achieved by 3.5rpm high torque motors. This grab is attached to trolley which moves over top rail of chassis. Trolley movement is powered by motors for transport of pipes from storage to rear end. Grab is lifted and lowered by using motors and guides / telescoping channels.

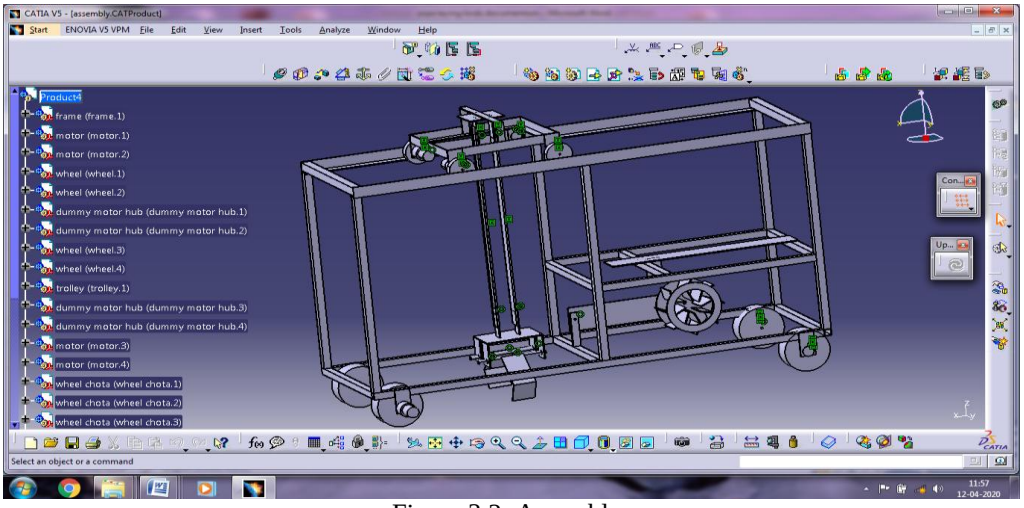

Figure 3.2: Assembly

Selection of Material:

Material selection is a step in the process of designing any physical object. In the context of product design, the main goal of material selection is to minimize cost while meeting product performance goals. Systematic selection of the best material for a given application begins with properties and costs of candidate materials. For example, a thermal blanket must have poor thermal conductivity in order to minimize heat transfer for a given temperature difference. It is essential that a designer should have a thorough knowledge of the properties of the materials and their behavior under working conditions. Some of the important characteristics of materials are: strength, durability, flexibility, weight, resistance to heat and corrosion, ability to cast, welded or hardened, machinability, electrical conductivity, etc.

Mild Steel:

Mild steel (iron containing a small percentage of carbon, strong and tough but not readily tempered), also known as plain-carbon steel and low-carbon steel, is now the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. Mild steel contains approximately 0.05–0.30% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing.

In applications where large cross-sections are used to minimize deflection, failure by yield is not a risk so low-carbon steels are the best choice, for example as structural steel. The density of mild steel is approximately 7.85 g/cm3 (7850 kg/m3 or 0.284 lb/in3) and the Young's modulus is 200 GPa (29,000 ksi).

Low-carbon steels display yield-point runout where the material has two yield points. The first yield point (or upper yield point) is higher than the second and the yield drops dramatically after the upper yield point. If a low-carbon steel is only stressed to some point between the upper and lower yield point then the surface develops slip bands. Low-carbon steels contain less carbon than other steels and are easier to cold-form, making them easier to handle.

Operations Performed:

Cutting Operation:


Figure 3.4: Cutting Operation

In the context of machining, a cutting tool or cutter is any tool that is used to remove some material from the work piece by means of shear deformation. Cutting may be accomplished by single-point or multipoint tools.

Single-point tools are used in turning, shaping, planning and similar operations, and remove material by means of one cutting edge. Milling and drilling tools are often multipoint tools. It is a body having teeth or cutting edges on it. Grinding tools are also multipoint tools. Each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip. Cutting tool materials must be harder than the material which is to be cut, and the tool must be able to withstand the heat and force generated in the metal-cutting process. Also, the tool must have a specific geometry, with clearance angles designed so that the cutting edge can contact the work piece without the rest of the tool dragging on the work piece surface. The angle of the cutting face is also important, as is the flute width, number of flutes or teeth, and margin size. In order to have a long working life, all of the above must be optimized, plus the speeds and feeds at which the tool is run.

Grinding Operation: Grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material. In grinding, an abrasive material rubs against the metal part and removes tiny pieces of material**.** Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool. To grind means to abrade, to war away by friction or to sharpen. In manufacturing it refers to the removal of metal by an abrasive wheel rotating at high speeds and working on the external or internal surface of a metallic or other part hard enough to be abraded, rather than indented by the grinding wheel. The action of the grinding wheel is similar to that of a milling cutter. The grinding wheel is composed of many small abrasive particles bounded together, each one acting as a miniature cutting point. Grinding removes metal from the work piece in the form of small chips by the mechanical action of abrasive particles bonded together in a grinding wheel.

Figure 3.5: Grinding Operation

Grinding Machine Specification:

Welding Operation: 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. In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that, based on weld configuration (butt, full penetration, fillet, etc.), can be stronger than the base material (parent metal). Pressure may also be used in conjunction with heat or by itself to produce a weld. Welding also requires a form of shield to protect the filler metals or melted metals from being contaminatedor oxidized.

Welding Machine Specifications: Shielded metal arc welding (SMAW), also known as manual metal arc welding (MMA or MMAW), flux shielded arc welding or informally as stick welding, is a manual arc welding process that uses a consumable electrode covered with a flux to lay the weld.To strike the electric arc, the electrode is brought into contact with the work piece by a very light touch of the electrode to the base metal. The electrode is then pulled back slightly. This initiates the arc and thus the melting of the work piece and the consumable electrode, and causes droplets of the electrode to be passed from the electrode to the weld pool. Striking an arc, which varies widely based upon electrode and work piece composition, can be the hardest skill for beginners. The orientation of the electrode to work piece is where most stumble, if the electrode is held at a perpendicular angle to the work piece the tip will likely stick to the metal which will fuse the electrode to the work piece which will cause it to heat up very rapidly. The tip of the electrode needs to be at a lower angle to the work piece, which allows the weld pool to flow out of the arc. As the electrode melts, the flux covering disintegrates, giving off shielding gases that protect the weld area from oxygen and other atmospheric gases. In addition, the flux provides molten slag which covers the filler as it travels from electrode to the weld pool. The slag floats to the surface and protects the weld from contamination as it solidifies. Once hardened, it must be

chipped away to reveal the finished weld. As welding progresses and the electrode melts, the welder must periodically stop welding to remove the remaining electrode stub and insert a new electrode into the electrode holder. This activity, combined with chipping away the slag, reduces the amount of time that the welder can spend laying the weld, making SMAW one of the least efficient welding processes. In general, the operator factor, or the percentage of operator's time spent laying weld, is approximately 25%.

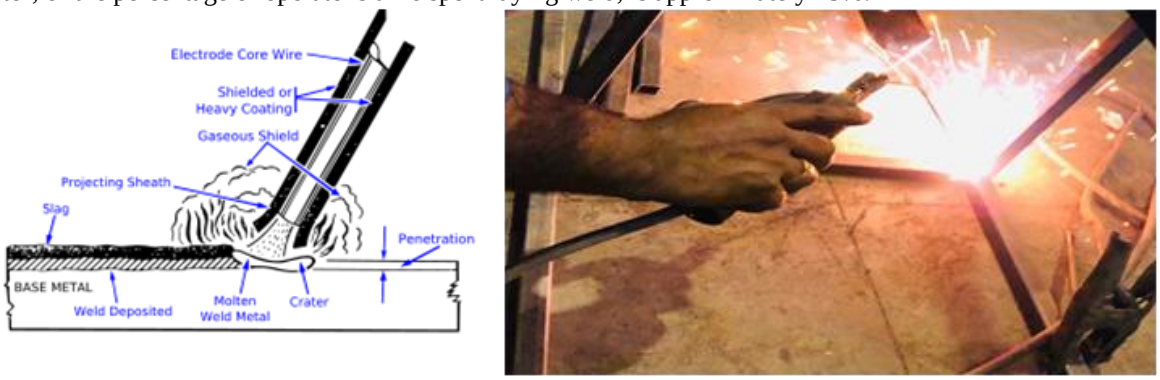

Figure 3.6: Arc Welding

Drilling Operation: Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, cutting off chips from the hole as it is drilled.The purpose of spot drilling is to drill a hole that will act as a guide for drilling the final hole. The hole is only drilled part way into the work piece because it is only used to guide the beginning of the next drilling process.

Figure 3.7: Drilling Machine

It is one of the main parts of a drilling machine, it carries the entire weight of the machine, and transfer the weight to the ground. The base of a drilling machine is generally made of cast iron or steel, and it is very rigid. At the top of the base, there are some slots provided to support the big jobs.

Figure 3.8: Drilled Plate

Result:

Figure 4.1: Final Model of Land Cutting and Pipe Laying

In this project with this machine we can perform land cutting and pipe line laying simultaneously .The machine will reduce man power requirement to maximum extent for large pipe laying and digging process. This machine can cut 700mm length of land to a depth of 70mm per hour and lay pipe of 50mm diameter. However we can scale the machine and enable it to cut land to higher depths and lay large pipes .If there are larger stones in digging path we can use conventional methods like blasting as per requirement. For higher torque we can use hydraulic drives for various components.

Conclusions:

With this machine we can perform land cutting and pipe line laying simultaneously .The machine will reduce man power requirement to maximum extent for large pipe laying and digging process. This machine can cut 700mm length of land to a depth of 70mm per hour and lay pipe of 50mm diameter. However we can scale the machine and enable it to cut land to higher depths and lay large pipes .If there are larger stones in digging path we can use conventional methods like blasting as per requirement. For higher torque we can use hydraulic drives for various components. Therefore this machine helps to reduce time and man power work in laying pipe lines which are of long distances like between countries. This helps manpower not to work in severe weather conditions like in high or low temperatures

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