# DETAILED PROJECT REPORT
# ON
# CONVENTIONAL CUTTING MACHINE WITH CNC LASER CUTTING MACHINE
# (BANGALORE MACHINE TOOL CLUSTER)











ENERGY IS LIFE
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**Bureau of Energy Efficiency**

*Prepared By*

PCRA

sAsIndiA

*Reviewed By*

ISTSL

# REPLACEMENT OF CONVENTIONAL CUTTING MACHINE
# WITH
# CNC LASER CUTTING MACHINE
# OR
# NEW CNC LASER CUTTING MACHINE

**BANGALORE MACHINE TOOL CLUSTER**

**BEE, 2010**

***Detailed Project Report on Replacement of conventional cutting machine with CNC Laser Cutting Machine or new CNC Laser Cutting Machine***

Bangalore Machine Tool cluster, Karnataka (India)

New Delhi: Bureau of Energy Efficiency;

Detail Project Report No.:

**For more information**

**Bureau of Energy Efficiency (BEE)**

**(Ministry of Power, Government of India)**

4th Floor, Sewa Bhawan

R. K. Puram, New Delhi – 110066

**Telephone** +91-11-26179699

**Fax** +91-11-26178352

**Websites**: www.bee-india.nic.in

**Email:** jsood@beenet.in/ pktiwari@beenet.in

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Shri Dr. Ajay Mathur, Director General

Smt Abha Shukla, Secretary

Shri Jitendra Sood, Energy Economist

Shri Pawan Kumar Tiwari, Advisor, SME

Shri Rajeev Yadav, Project Economist, BEE

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We take this opportunity to express our appreciation for the excellent support provided by Machine Tool Unit Owners, Local Service Providers, and Equipment Suppliers for their active involvement and their valuable inputs in making the program successful and in completion of the cluster manual.

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**Petroleum Conservation Research Association**

**Bangalore**

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| | |
|---|---|
| BEE | Bureau of Energy Efficiency |
| CNC | Computer Numerical Controlled |
| DPR | Detailed Project Report |
| DSCR | Debt Service Coverage Ratio |
| EE | Energy Efficiency |
| GHG | Green House Gas |
| GoI | Government Of India |
| INR | Indian National Rupee |
| IRR | Internal Rate Of Return |
| kWh | kilo Watt Hour |
| NPV | Net Present Values |
| O&M | Operational & Maintenance |
| PAT | Profit After Tax |
| PBT | Profit Before Tax |
| ROI | Return on Investment |
| SIDBI | Small Industries Development Bank of India |
| SME | Small and Medium Enterprises |

## *EXECUTIVE SUMMARY*

Bureau of Energy Efficiency (BEE) appointed Petroleum Conservation Research Association as the executing agency for Machine Tools of Bangalore under BEE's SME programme. Under this project, the executing agency carried out studies in the Machine Tools of Bangalore. Out of a total of 100 machine tools units, study was conducted in 30 units. Preliminary audits were undertaken in all the 30 units whereas detailed energy audits were conducted in 10 of these units.

Bangalore has evolved as one of the most important production centers in the Machine tool sector despite there being nothing favorable for proliferation of a cluster. The place lacks all possible resources, from raw materials to fuels and to skilled man power newer technologies as well which is the most important for processing of Machine tools. Today there are 100 units in Bangalore alone and the production capacity of machine tool units in Bangalore cluster is in the range of 1500 kg per Annum –1050000 kg per Annum.

Energy forms a major chunk of the processing cost with over 30% weight age in the cost basket. As per the preliminary and detailed energy audit findings, there exists potential of saving over 30% electricity and 50% fuel in the applications in power process industries with over all general payback period of less than six year. The payback period in these industries is higher due to their working schedule and lower utilization of facilities.

Based on the energy audits, the executing agency submitted their report to BEE in form of a cluster manual with recommendations for energy conservation & savings potentials in the Machine Tools sector. The recommendations made in the cluster manual are listed below:

Replacement of conventional cutting machine with CNC Laser Cutting Machine or new CNC Laser Cutting Machine

Laser cutting system enables us cut like a 3000W laser at the lower cost of a 2000W laser. Instead of the conventional, variable-length beam of flying optics machines, the Supercharged 2000W CNC Laser Cutting Machine utilizes a custom-length beam which minimizes beam divergence. This results in consistent edge quality, kerf width and accuracy. Paired with a 1500W CNC-controlled laser cutting system, these two machines provide customers with unmatched reliability and productivity in high speed, precision cutting of sheets up to 4' x 8' x 3/4" thick. Whether your requirements are for high-speed cutting of intricate shapes from sheet plate stock as light as .005" or mild steel as thick as 3/4", CNC Laser is equipped to provide you a fast Turnaround in various materials. And under proper maintenance will serve the owner for a period of 18 years.

This bankable DPR also found eligible for subsidy scheme of MoMSME for “Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises” under “National Manufacturing and Competitiveness Programme”. The key indicators of the DPR including the Project cost, debt equity ratio, monetary benefit and other necessary parameters are given in table below:

| S. No | Particular | Unit | Value |
|---|---|---|---|
| 1. | Project cost | `(in lakhs) | 52.76 |
| 2. | Monetary benefit | `(in lakhs) | 41.79 |
| 3. | Debit equity ratio | Ratio | 2.33: 1 |
| 4. | Simple payback period | Year | 1.26 |
| 5. | NPV | `(in lakhs) | 114.59 |
| 6. | IRR | %age | 60.06 |
| 7. | ROI | %age | 27.81 |
| 8. | DSCR | Ratio | 3.25 |
| 9. | Procurement and implementation schedule | week | 11 |

***The projected profitability and financial indicators shows that the project will be able to earn profit from inception and project is financially viable and technically feasible***.

## *ABOUT BEE'S SME PROGRAM*

Bureau of Energy Efficiency (BEE) is implementing a BEE-SME Programme to improve the energy performance in 25 selected SMEs clusters. Gujarat Dairy Cluster is one of them. The BEE's SME Programme intends to enhance the energy efficiency awareness by funding/subsidizing need based studies in SME clusters and giving energy conservation recommendations. For addressing the specific problems of these SMEs and enhancing energy efficiency in the clusters, BEE will be focusing on energy efficiency, energy conservation and technology up-gradation through studies and pilot projects in these SMEs clusters.

***Major activities in the BEE -SME program are furnished below*:**

***Activity 1: Energy use and technology audit***

The energy use technology studies would provide information on technology status, best operating practices, gaps in skills and knowledge on energy conservation opportunities, energy saving potential and new energy efficient technologies, etc for each of the sub sector in SMEs.

***Activity 2: Capacity building of stake holders in cluster on energy efficiency***

In most of the cases SME entrepreneurs are dependent on the locally available technologies, service providers for various reasons. To address this issue BEE has also undertaken capacity building of local service providers and entrepreneurs/ Managers of SMEs on energy efficiency improvement in their units as well as clusters. The local service providers will be trained in order to be able to provide the local services in setting up of energy efficiency projects in the clusters

***Activity 3: Implementation of energy efficiency measures***

To implement the technology up-gradation project in the clusters, BEE has proposed to prepare the technology based detailed project reports (DPRs) for a minimum of five technologies in three capacities for each technology.

***Activity 4: Facilitation of innovative financing mechanisms for implementation of energy efficiency projects***

The objective of this activity is to facilitate the uptake of energy efficiency measures through innovative financing mechanisms without creating market distortion.

# 1 INTRODUCTION

## 1.1 Brief about the SME cluster

### *About SME cluster*

The Machine Tools Cluster of Bangalore is located in the Bangalore district. Bangalore, also known as Bengaluru is the capital of the Indian state of Karnataka, located on the Deccan Plateau in the south-eastern part of Karnataka. Bangalore was inducted in the list of Global cities and ranked as a "Beta World City" alongside Geneva, Copenhagen, Boston, Cairo, Riyadh, Berlin, to name a few, in the studies performed by the Globalization and World Cities Study Group and Network in 2008. These machine units have been classified into following clusters within the district:

- Abbegere
- Bommasandra
- Peenya

Bangalore is the “HUB” for machine tools in India. The cluster accounts for 60% of the value of production of machine tools in the country. Bangalore is predominantly a metal cutting cluster. The structure of machine tool industry in Bangalore has at its apex 6 large machine tool manufacturers, about 100 small and medium machine tool manufacturers, their suppliers and vendors in large numbers.

### *Product Manufactured*

In SME cluster of Machine Tools at Bangalore, there are varieties of products manufactured that include spindles, centre hobbing machines, ID hobbing machines, Self centering Steady Rests, Bar feeding attachments, Rotary tables, Index tables, Special purpose machines, Co-ordinate Measuring machines, aerospace fixtures, CNC Machine enclosures, Sound proofs, armature rewinding machines etc. There are supporting industries like heat treatment are also located in the cluster. These products/ machines are usually utilized in automobile industry, aerospace industry, CNC Machine industry across the globe. These are products custom made to suit the requirements of ISRO, HAL, BEML, MICO, BHEL, Kirloskar Electric, Bayforge Ltd etc.

### *Production Process*

Typically, process for machine tool units in Bangalore is not the same for all industries involving various activities, as the end products of the industry are different for each industrial unit. Therefore, there is some variation in the flow of activities depending on the customized requirement of the products. However, these activities could be grouped together as shown below, though not in the same order as mentioned.

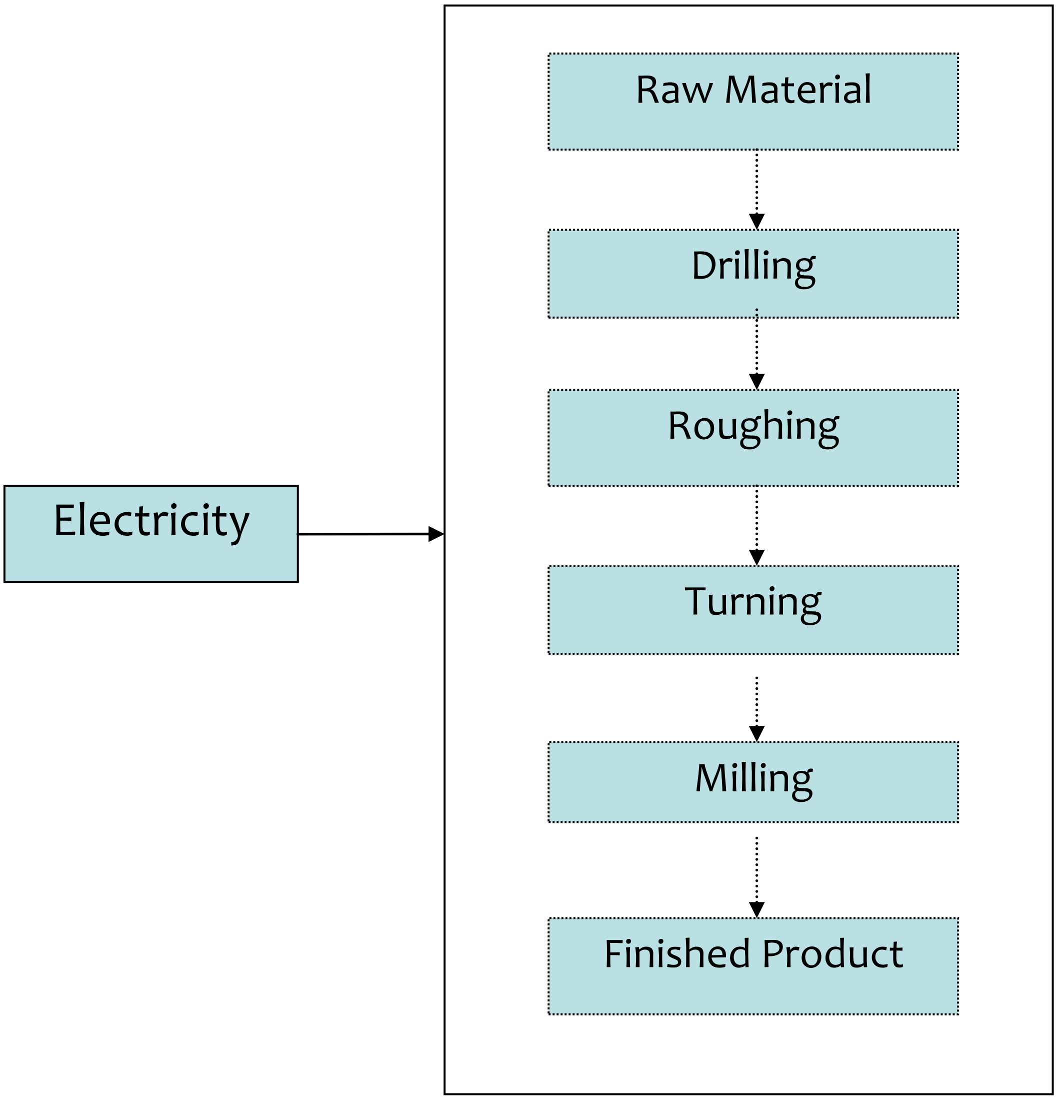
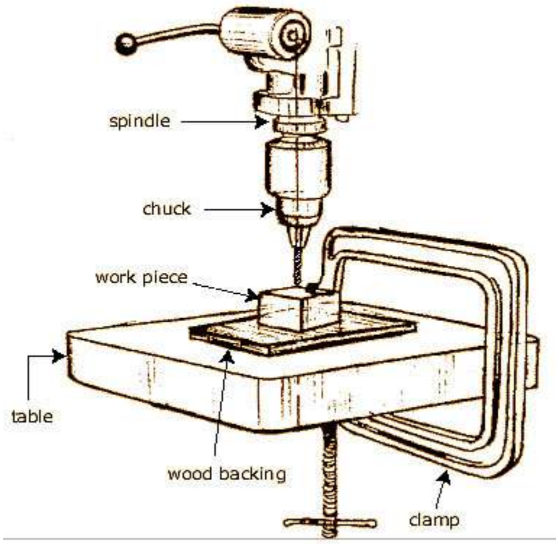



**Figure 1.1 Process flow chart of typical Machine Tools Unit**

***Drilling Process***

Drilling is the most common machining process whereby the operation involves making round holes in metallic and nonmetallic materials. Approximately 75% of all metal- cutting process is of the drilling operation. Drills usually have a high length to diameter ratio that is capable of producing deep hole, however due to its flexibility, necessary precaution need to be taken to maintain accuracy and prevent drill from breaking.

Drilled holes can be either through holes or blind holes. A through holes is made when a drill exits the opposite side of the work; in blind hole the drill does not exit the workpiece. Drilled holes are characterized by their sharp edge on the entrance side and the presence of burrs on the exit side (unless they have been removed). Also, the inside of the hole usually has helical feed marks.

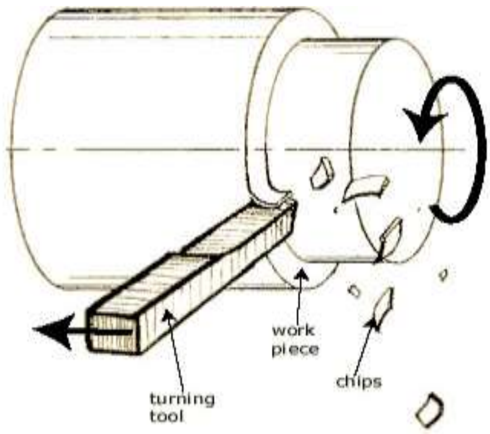



Drilling may affect the mechanical properties of the work piece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the work piece to become more susceptible to corrosion at the stressed surface.

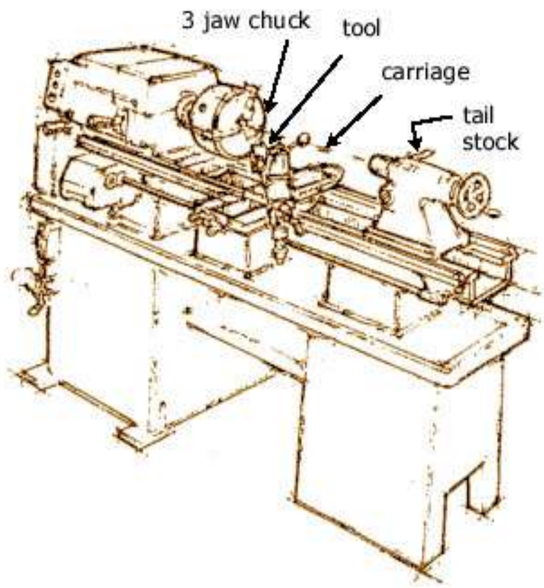
For fluted drill bits, any chips are removed via the flutes. Chips may be long spirals or small flakes, depending on the material, and process parameters. The type of chips formed can be an indicator of the machinability of the material, with long gummy chips reducing machinability.

When possible drilled holes should be located perpendicular to the work piece surface. This minimizes the drill bit's tendency to "walk", that is, to be deflected, which causes the hole to be misplaced. The higher the length-to-diameter ratio of the drill bit, the higher the tendency to walk.

***Turning Process***




Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or Gear Hobbing, work piece, fixture, and cutting tool. The work piece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speeds. The cutter is typically a single-point cutting tool that is also secured in the machine, although some operations make use of multi-point tools. The cutting tool feeds into the rotating work piece and cuts away material in the form of small chips to create the desired shape. Turning is used to produce rotational, typically axi-symmetric, parts that have many features, such as holes, grooves, threads, tapers, various diameter steps, and even contoured surfaces. Parts that are fabricated completely through turning often include components that are used in limited quantities, perhaps for prototypes, such as custom designed shafts and fasteners. Turning is also commonly used as a secondary process to add or refine features on parts that were manufactured




using a different process. Due to the high tolerances and surface finishes that turning can offer, it is ideal for adding precision rotational features to a part whose basic shape has already been formed.

Turning is the process whereby a single point cutting tool is parallel to the surface. It can be done manually, in a traditional form of Gear Hobbing, which frequently requires continuous supervision by the operator, or by using a computer controlled and automated CNC machine which does not. This type of machine tool is referred to as having computer numerical control, better known as CNC, and is commonly used with many other types of machine tool besides the Turning machines.

When turning, a piece of material (wood, metal, plastic, or stone) is rotated and a cutting tool is traversed along 2 axes of motion to produce precise diameters and depths. Turning can be either on the outside of the cylinder or on the inside (also known as boring) to produce tubular components to various geometries. Although now quite rare, early Gear Hobbings could even be used to produce complex geometric figures, even the platonic solids; although until the advent of CNC it had become unusual to use one for this purpose for the last three quarters of the twentieth century. It is said that the Lathes is the only machine tool that can reproduce itself.

The turning processes are typically carried out on a Turning machine, considered to be the oldest machine tools, and can be of four different types such as straight turning, taper turning, profiling or external grooving. Those types of turning processes can produce various shapes of materials such as straight, conical, curved, or grooved work piece. In general, turning uses simple single-point cutting tools. Each group of work piece materials has an optimum set of tools angles, which have been developed through the years.

The bits of waste metal from turning operations are known as chips (North America), or swarf (Britain). In some areas they may be known as turnings.

Turning specific operations include:

- ***Hard turning***

Hard turning is a turning done on materials with Rockwell C hardness greater than 45. It is typically performed after the work piece is heat treated.

The process is intended to replace or limit traditional hobbing operations. Hard turning, when applied for purely stock removal purposes, competes favorably with rough hobbing. However, when it is applied for finishing where form and dimension are critical, hobbing is superior. Hobbing produces higher dimensional accuracy of roundness and cylindricity. In addition, polished surface finishes of Rz=0.3-0.8z cannot be achieved with hard turning alone. Hard turning is appropriate for parts requiring roundness accuracy of 0.5-12 microns, and/or surface roughness of Rz 0.8–7.0 microns. It is used for gears, injection pump components, hydraulic components, among other applications.

➢ ***Facing***

It is part of the turning process. It involves moving the cutting tool at right angles to the axis of rotation of the rotating workpiece. This can be performed by the operation of the cross-slide, if one is fitted, as distinct from the longitudinal feed (turning). It is frequently the first operation performed in the production of the work piece, and often the last- hence the phrase "ending up".

➢ ***Parting***

This process is used to create deep grooves which will remove a completed or part-complete component from its parent stock.

➢ ***Grooving***

Grooving is like parting, except that grooves are cut to a specific depth by a form tool instead of severing a completed/part-complete component from the stock. Grooving can be performed on internal and external surfaces, as well as on the face of the part (face grooving or trepanning).

Non-specific operations include:

➢ ***Boring***

Machining of internal cylindrical forms (generating) a) by mounting work piece to the spindle via a chuck or faceplate b) by mounting work piece onto the cross slide and placing cutting tool into the chuck. This work is suitable for castings that are to awkward to mount in the face plate. On long bed lathes large work piece can be bolted to a fixture on the bed and a shaft passed between two lugs on the work piece and these lugs can be bored out to size. A limited application, but one that is available to the skilled turner/machinist. In machining, boring is the process of enlarging a hole that has already been drilled (or cast), by means of a single-point cutting tool (or of a boring head containing several such tools), for example as in boring a cannon barrel. Boring is used to achieve greater accuracy of the diameter of a hole, and can be used to cut a tapered hole.

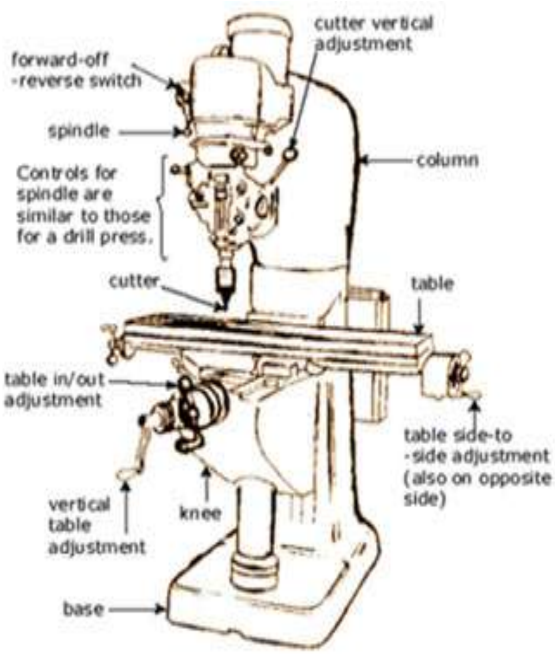
There are various types of boring. The boring bar may be supported on both ends (which only works if the existing hole is a through hole), or it may be supported at one end. Line boring (line boring, line-boring) implies the former. Back boring (back boring, back-boring) is the process of reaching through an existing hole and then boring on the "back" side of the workpiece (relative to the machine headstock).

- ***Knurling***

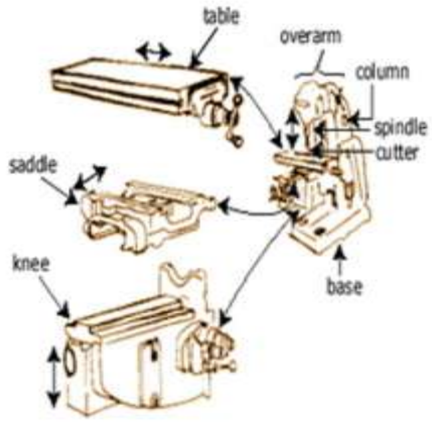
The cutting of a serrated pattern onto the surface of a part to use as a hand grip using a special purpose knurling tool. Threading both standard and non-standard screw threads can be turned on a hobbing machines using an appropriate cutting tool. (Usually having a 60, or 55° nose angle) Either externally, or within a bore. [Generally referred to as single-point threading. tapping of threaded nuts and holes a) using hand taps and tailstock centre b) using a tapping device with a slipping clutch to reduce risk of breakage of the tap threading operations include a) all types of external and internal thread forms using a single point tool also taper threads, double start threads, multi start threads, worms as used in worm wheel reduction boxes, lead screw with single or multi start threads. b) by the use of threading boxes fitted with 4 form tools, up to 2" diameter threads but it is possible to find larger boxes than this.

***Milling Process***

Milling is the most common form of machining, a material removal process, which can create a variety of features on a part by cutting away the unwanted material. The milling process requires a milling machine, work piece, fixture, and cutter. The work piece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to a platform inside the milling machine. The cutter is a cutting tool with sharp teeth, which is also secured in the milling machine and rotates at high speeds. By feeding the workpiece into the rotating cutter, material is cut away from this work piece in the form of small chips to create the desired shape.



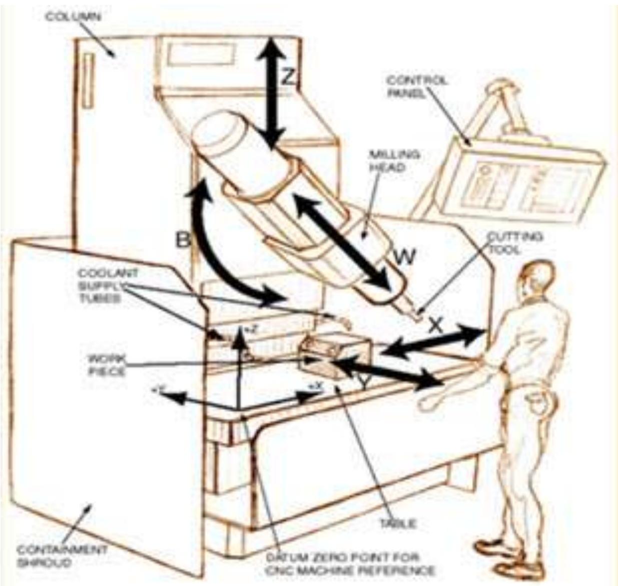
Milling is typically used to produce parts that are not axially symmetric and have many features, such as holes, slots, pockets, and even three-dimensional surface contours. Parts that are fabricated completely through milling often include components that are used in limited quantities, perhaps for prototypes, such as custom designed fasteners or brackets. Another application of milling is the fabrication of tooling for other processes. For example, three-dimensional molds are typically milled. Milling is also commonly used as a secondary process to add or refine features on parts that were manufactured using a different process. Due to the high tolerances and surface finishes that milling can offer, it is ideal for adding precision features to a part whose basic shape has already been formed.




Milling is as fundamental as drilling among powered metal cutting processes. Milling is versatile for a basic machining process, but because the milling set up has so many degrees of freedom, milling is usually less accurate than turning or hobbing unless especially rigid fixturing is implemented. For manual machining, milling is essential to fabricate any object that is not axially symmetric. Below is illustrated the process at the cutting area. A typical column-and-knee type manual mill is shown. Such manual mills are common in job shops that specialize in parts that are low volume and quickly fabricated. Such job shops are often termed 'model shops' because of the prototyping nature of the work.

The parts of the manual mill are separated below. The knee moves up and down the column on guide ways in the column. The table can move in x and y on the knee, and the milling head can move up and down.

CNC Milling: Computer Numerical Control (CNC) Milling is the most common form of CNC. CNC mills can perform the functions of drilling and often turning. CNC Mills are classified according to the number of axes that they possess. Axes are labeled as x and y for milling movement, and z for vertical movement, as shown in this view of a manual mill table. A standard manual light-duty mill is



typically assumed to have four axes: Table X, Table Y, Table Z and milling head Z.

A five-axis CNC milling machine has an extra axis in the form of a turning pivot for the milling head. This allows extra flexibility for machining with the end mill at an angle with respect to the table. A six-axis CNC milling machine would have another milling pivot for the milling head, this time perpendicular to the fifth axis.

CNC milling machines are traditionally programmed using a set of commands known as G-codes. G-codes represent specific CNC functions in alphanumeric format.

## 1.2 Energy performance in existing situation

### 1.2.1 Fuel and electricity consumption

The machine tool industries in this cluster use electricity from grid to meet their electrical energy requirement. Some of the industrial units having the backup power generator (Diesel Based) to meet the demand in case of grip power supply failure or scheduled power cut from the grid. The main and primary energy for machine tool industries is the electricity for operation of production and utility services. In manufacturing of some category of products, heat treatment process required to achieve the desired material properties. In heat treatment units of the clusters, which are very few in numbers (only 14 %) are using electricity as the main source of energy even in the process of heat treatment, which is usually outsourced. The percentage segregation of used energy in the cluster is given in figure 1.2, which reveals that the 95.9% of energy used in the cluster is drawn from the Bangalore Electricity Supply Company Limited (BESCOM) grid whereas only 4.1% of total energy required is being generated by thermal energy (High Speed Diesel) using DG sets.

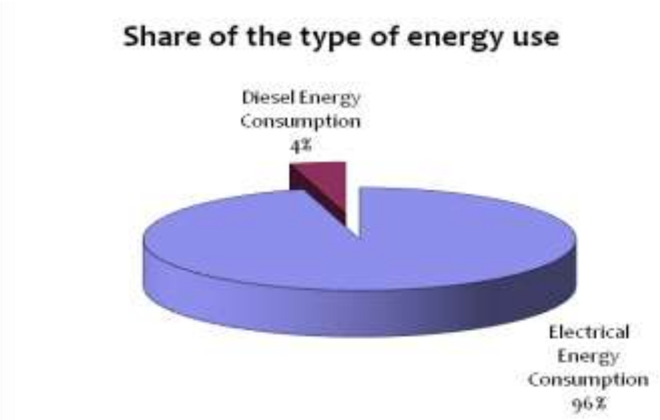



**Figure 1.2: Share of Energy Type used in the Machine Tool Units**

### 1.2.2 Average production

Production capacity of machine tool units in Bangalore cluster depends on the type of product being produced in unit. Production capacity of machine tool units in Bangalore cluster is in the range of 1500 kg per Annum –1050000 kg per Annum. The following figure shows the classification of machine tool units in Bangalore cluster based on production capacity. The production capacity as the weight of the metal removed in case of components, accessories and SPM making industries. In case of Heat treatment, weight of the material treated has been considered as the production capacity. The above methodology is adopted as major energy is spent towards removing the metal, as per the specifications of the product, while carrying out jobs such as milling, turning, hobbing and drilling. In case of heat treatment units, major energy is spent in the heat treatment furnaces. Hence, the weight of material processed is taken as production capacity.

### 1.2.3 Specific energy consumption

The specific energy consumption depends on the final product being manufactured by the machine tool units; therefore SEC has been classified according to the types of products produced in the cluster. Details of the SEC depending on the type of products is shown in the following table

**Table 1.1 Energy Consumption Pattern of Machine Tools Cluster**

| Type of units | Specific Energy Consumption, GJ/Tonne | Specific Energy Consumption, kWh/Tonne |
|---|---|---|
| Components | 24.8 | 6472 |
| Accessories | 19.7 | 5118 |
| Machines | 2.2 | 600 |
| Heat Treatment | 64.2 | 15057 |
| Average | 27.7 | 6811.8 |

## 1.3 Identification of technology/equipment

The existing process or technology used in the cluster is mixed type. Some units are using conventional cutting machines and performing cutting jobs in two or three steps for cutting which are completely depends on operator’s skills Projects whereas some units also using the CNC cutting machines. The existing technologies required two or three times setup of the job machine and result in higher energy consumption and lower production rate. The error in product and material rejections also increased due the multiple setup requirements for a job.

### 1.3.1 Description of technology/equipment

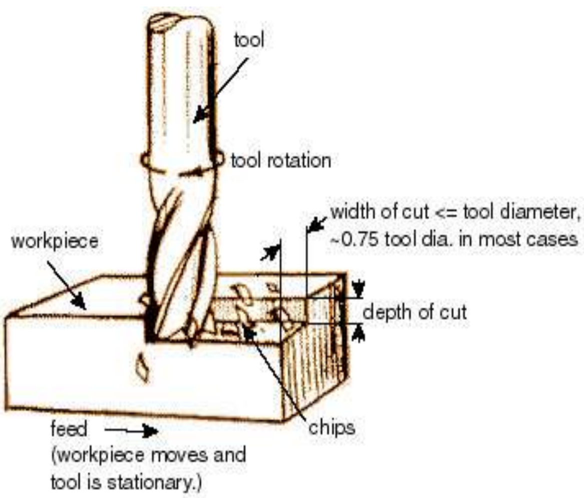
The machine tools industry can be divided into metal cutting and metal forming sectors. The metal cutting sector can be further classified into conventional and computer numerically controlled (CNC) machines, while the metal forming sector can be segregated into conventional and numerically controlled (NC) machines. Some commonly used metal cutting machines include electrical discharge machining systems (EDMS), machining centers, Turret CNC Machines and automats, boring, milling, drilling, hobbing, honing and polishing machines, total NC machines and so on. Metal forming machines include bending, folding, straightening, flattening machines, punching and/or shearing machines, die casting machines and others.

The NC machines developed in the 1950s and 1960s did not possess CPU's. The CNC machine tools are essentially NC machines with microprocessors as the CPU.

The first American machine tools with a CNC system was developed in 1972 and the first Japanese machine tools with a CNC system was developed in 1976. CNC systems made it possible for microprocessors and programmable logic controllers to work in parallel. This allowed simultaneous servo position and velocity control of several axes of a machine, monitoring of the controller and machine tools performance, and monitoring of the cutting process. For a basic three axes milling machine, with the CNC systems, there could be coordination of feeding velocity and position control of all the three axes. The spindle speed could also be controlled simultaneously. These features enhanced the versatility of a traditional milling machine. Moreover, by employing multiple CPU's, the versatility of the machine tools was increased manifold.

As with CNC turning centers, the Indian machine tools industry produces a range of CNC machining centers covering small to very large sizes. These machines are technologically more complex than turning machines. Typically, a CNC machining center has 3 linear movements, one rotary movement, apart from features such as tool changers, pallet changers etc. Indian machine tools meet the basic requirement of machining center operations, and a number of models are produced with both Horizontal and vertical spindle configurations. Machines with spindle speeds of upto 10000 rpm, traverse rates of upto 60 mpm are produced by the Indian industry.

The current trend in machining centers is to have additional axes of movements to take on complex machining requirements (sometimes as many as 6 or 7), high traverse rates of 100 to 120 mpm, spindle speeds of 10000 to 50000 rpm, some turning and even hobbing capabilities on the machining center. Internationally, machining centers are mostly built with at least 5 axes. Modern machines incorporate linear motors for high traverse rates, and integral motor spindles are universally used. At the simpler end of the product spectrum, machines are configured to occupy very



small floor space suitable for line integration for mass production of auto components.

### 1.3.2 Role in process

Machining is a critical process in machine tools manufacturing industries. Design standards in all application areas are becoming increasingly more demanding. Expectations in terms of ergonomics, the air drag coefficient (CW value) or simply aesthetic appeal are creating a need for more complex surface geometries to be achieved in less time and with greater precision. The design primarily comes from CAD systems, the machining programs from CAM stations.

Nevertheless, the skilled machine tool operator still has overall responsibility (in terms of technology) for the quality of the mold and the complete tool. Conventional machining, one of the most important material removal methods, is a collection of material-working processes in which power-driven machine tools, such as Lathes, milling machines, and drill presses, are used with a sharp cutting tool to mechanically cut the material to achieve the desired geometry. Machining is a part of the manufacture of almost all metal products, and it is common for other materials, such as wood and plastic, to be machined. A person who specializes in machining is called a machinist. A room, building, or company where machining is done is called a machine shop. Much of modern day machining is controlled by computers using computer numerical control (CNC) machining. Machining can be a business, a hobby, or both.

## 1.4 Benchmarking for existing specific energy consumption

The baseline data has been established based in the energy audits conducted in a total number of 30 machine units out of which 20 were preliminary audits and 10 were detailed audits. The average production cost estimated based on the various technology dependent cost of production of these units. It can be onserved that the total production cost is about ` 49359913 anually and ` 902375 per tonne.

**Table 1.2 Energy Consumption Pattern of Existing Technology**

| Particular | | | | | |
|---|---|---|---|---|---|
| **Name of cluster unit studied** | **Unit** | **Unit 1** | **Unit 2** | **Unit 3** | **Value** |
| Specific Energy Consumption | kWh/Tonne | 975 | 868 | 11585 | 4476 |
| Average Energy Cost | `/Tonne | 4874 | 4342 | 57925 | 22380 |
| Raw material cost | `/Tonne | 500000 | 500000 | 500000 | 500000 |
| Other Cost (Utility) | `/Tonne | 334515 | 212370 | 203123 | 250000 |
| Average Production cost | `/Tonne | 797659 | 905605 | 1003861 | 772380 |
| Annual Production | Tonne | 130.5 | 21.6 | 12 | 54.7 |
| Annual Production Cost | `/annum | 104094503 | 19561061 | 12046332 | 42249186 |

### 1.4.1 Design and operating parameters

In present scenarion of the machine tools industries, machine cannot afford to breakdown, frequent change of the job settings and dependency on manpower since the investment cost of the machine is high. Each downtime is a lost for the investor. From economic point of view, in order to produce part at effective cost is by producing at high volume. Machine components become expensive which requires new type of maintenance to cater this problem.

### 1.4.2 Operating efficiency analysis

To determine the Energy use and technical study, individual units were identified within different locations of the Bangalore Machine Tools clusters in Bangalore district. It is integral to target different units in the clusters as it accounts for deviations in type of prudcts, job properties, sourcing of raw materials, and variations in manufacturing and housekeeping operations. The overall step by step methodology followed for Energy use and technical study is as below:


**Figure 1.3 Energy auditing methodology**

***Preliminary energy study***

The preliminary study is the first stage in conducting an energy and technology assessment of the machine tools manufacturing units in the cluster. The aim of the preliminary study is collecting information relating to production, machinery and energy use to get an overview of energy sources, raw materials, processes involved, etc of the units within the cluster. Preliminary energy studies were conducted at 30 machine tools manufacturing units in the Bangalore cluster and the time taken for each study was 1 – 2 days.

***Detailed energy study***

Detailed energy studies are conducted to get an in depth break up of energy usage of each of the associated processes in the machine tools manufacturing. It covers the quintessential steps in preliminary study and provides a thorough analysis of the functioning of units. Since electricity is the main source of energy used, there are some guidelines which need to be maintained while analyzing and measuring the electricity consumption pattern of the individual unit.

### 1.4.3 Specific fuel and electricity consumption

The main and basic energy used in the manufacturing process of machine tools is electricity in this unit. The liquid fuel (HSD) energy is mainly using to operate the diesel power generators during the power cut/non-availability of the electrical power from state electricity board.

## 1.5 Barriers for adoption of proposed technology/equipments

### 1.5.1 Technological Barrier

Technology obsolescence in the machine tool business is extremely rapid. Product lifecycles are declining and currently average life cycle is no more than 3 years! Thus, in a globalized India, SMEs have been and will continue to face challenges they have not seen before. In the past, most of the products have been a result of ‘Reverse Engineering’. Unlike the Japanese and Koreans, the Indian manufacturers have not graduated to the next level of ‘Improving’ the technology of reverse engineered products. Thus, product technology obsolescence is a major issue facing the Bangalore machine tools industry today. There is a definitive void in development and existing facilities for Research and Development in this sector. Institutes in the past have been integral in facilitating technology transfers and improvement in the machine tools manufacturing cluster all over India, However there is need for continuous Research and Development associated processes.

### 1.5.2 Financial Barrier

The restricted availability and the inability to raise resources are common to all types of small businesses. However, the machine tools sector, by its very nature, is a high financial outlay driven business. Average product costs are greater, gestation period of investments – longer, time to market – higher and a purchasing system – not yet fully matured. All this means greater, than most other businesses, financial resource requirement. This, in turn, puts the machine tool SMEs in a particular disadvantage.

### 1.5.3 Manpower Skill

Machine downtime ranged from 1 percent to as high as 20 percent in some cases. Labour efficiency ranged between 60 percent to 95 percent. Lower labour efficiency and labour utilization has manifested in lower employee productivity. Labour utilization has been lower as compared to other sectors because of surplus labour since only 26 percent of the companies have undergone downsizing and lack of awareness of productivity methodologies.

Only 65 percent of the companies used CNC or NC machines because most of the smaller players get almost 95 percent of their products outsourced and they only do assembling. In fact, as high as 17 percent of the companies get 100 percent of the manufacturing activities subcontracted. However, on an average 75 percent of the companies subcontracted some amount of their manufacturing. The subcontracting was mainly done due to capacity constraints followed by cost considerations.

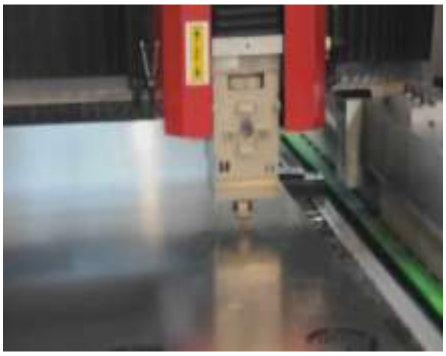
### 1.5.4 Vendor Linkages:

No other business requires such complex level of vendor linkages as the machine tools. For materials, electrical, electronics, hydraulics, pneumatics, metallurgy, tribology, measurement controls – the list of myriad technology linkages is endless. This requires exceptional networking capabilities and plenty of time to be spent by owner of accompany/CEO himself.

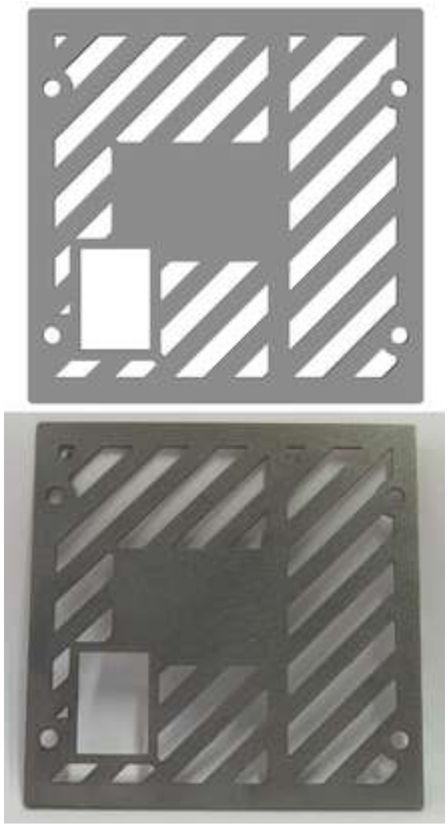
# 2 TECHNOLOGY OPTION FOR ENERGY EFFICIENCY IMPROVEMENTS

## 2.1 Detailed description of technology selected

### 2.1.1 Description of technology



**Laser cutting on a sheet of steel**.



CAD (top) and stainless steel laser-cut part (bottom)

Laser cutting is a technology that uses a laser to cut materials, and is typically used for industrial manufacturing applications, but is also starting to be used by schools, small businesses and hobbyists. Laser cutting works by directing the output of a high-power laser, by computer, at the material to be cut. The material then either melts or burns or vaporizes away, or is blown away by a jet of gas, leaving an edge with a high-quality surface finish. Industrial laser cutters are used to cut flat-sheet material as well as structural and piping materials. There are three main types of lasers used in laser cutting. The $CO_2$ laser is suited for cutting, boring, and engraving. The neodymium (Nd) and neodymium yttrium-aluminum-garnet (Nd-YAG) lasers are identical in style and differ only in application. Nd is used for boring and where high energy but low repetitions are required. The Nd-YAG laser is used where very high power is needed and for boring and engraving. Both $CO_2$ and Nd/ Nd-YAG lasers can be used for welding. Common variants of $CO_2$ lasers include fast axial flow, slow axial flow, transverse flow, and slab. $CO_2$ lasers are commonly "pumped" by passing a current through the gas mix (DC-excited) or using radio frequency energy (RF-excited). The RF method is newer and has become more popular. Since DC designs require electrodes inside the cavity, they can encounter electrode erosion and plating of electrode material on glassware and optics. Since RF resonators have external electrodes they are not prone to those problems.$CO_2$ lasers are used for industrial cutting of many materials including mild steel, aluminum, stainless steel, titanium, paper, wax, plastics, wood, and fabrics. YAG lasers are primarily used for cutting and scribing metals and ceramics. In addition to the power source, the type of gas flow can affect performance as well. In a fast axial flow resonator, the mixture of carbon dioxide, helium and nitrogen is circulated at high velocity by a turbine or blower. Transverse flow lasers circulate the gas mix at a lower velocity, requiring a simpler blower. Slab or diffusion cooled resonators have a static gas field that requires no pressurization or glassware, leading to savings on replacement turbines and glassware. The laser generator and external optics (including the focus lens) require cooling. Depending on system size and configuration, waste heat may be transferred by a coolant or directly to air. Water is a commonly used coolant, usually circulated through a chiller or heat transfer system.

A ***laser micro jet*** is a water-jet guided laser in which a pulsed laser beam is coupled into a low-pressure water jet. This is used to perform laser cutting functions while using the water jet to guide the laser beam, much like an optical fiber, through total internal reflection. The advantages of this are that the water also removes debris and cools the material. Additional advantages over traditional "dry" laser cutting are high dicing speeds, parallel kerfs and omnidirectional cutting.

***Application suited for Variants avail in the Market***

| Lasing Materials | Applications |
|---|---|
| $CO_2$ | Boring<br><br>Cutting/Scribing Engraving |
| Nd | High-energy pulses<br><br>Low repetition speed (1 kHz)<br><br>Boring |
| Nd-YAG | Very high energy pulses<br><br>Boring Engraving Trimming |

Laser cutting is a technology that uses a laser to cut materials, and is typically used for industrial manufacturing applications, but is also starting to be used by schools, small businesses and hobbyists. Laser cutting works by directing the output of a high-power laser, by computer, at the material to be cut. The material then either melts or burns or vaporizes away, or is blown away by a jet of gas, leaving an edge with a high-quality surface finish. Industrial laser cutters are used to cut flat-sheet material as well as structural and piping materials.

### 2.1.2 CNC LASER Cutting Machine operations

Generation of the laser beam involves stimulating a lasing material by electrical discharges or lamps within a closed container. As the lasing material is stimulated, the beam is reflected internally by means of a partial mirror, until it achieves sufficient energy to escape as a stream of monochromatic coherent light. Mirrors or fiber optics are typically used to direct the coherent light to a lens, which focuses the light at the work zone. The narrowest part of the focused beam is generally less than 0.0125 in (0.3175 mm). In diameter, Depending upon material thickness, kerf widths as small as 0.004 in (0.1016 mm) are possible. In order to be able to start cutting from somewhere else than the edge, a pierce is done before every cut. Piercing usually involves a high-power pulsed laser beam which slowly makes a hole in the material, taking around 5–15 seconds for ½-inch-thick (13 mm) stainless steel, for example. The parallel rays of coherent light from the laser source often fall in the range between 1/16 inch to 1/2 inch (1.5875 mm to 12.7 mm) in diameter. This beam is normally focused and intensified by a lens or a mirror to a very small spot of about 0.001 inch (0.0254 mm) to create a very intense laser beam. In order to achieve the smoothest possible finish during contour cutting, the direction of beam polarization must be rotated as it goes around the periphery of a contoured workpiece. For sheet metal cutting, the focal length is usually between 1.5 inches and 3 inches (38.1 mm and 76.2 mm). There are many different methods in cutting using lasers, with different types used to cut different material. Some of the methods are vaporization, melt and blow, melt blow and burn, thermal stress cracking, scribing, cold cutting and burning stabilized laser cutting.

Industrial Laser Cutting of Steel with Cutting Instructions Programmed Through the CNC Interface

- Vaporization cutting the focused beam heats the surface of the material to boiling point and generates a keyhole. The keyhole leads to a sudden increase in absorptive quickly deepening the hole. As the hole deepens and the material boils, vapor generated erodes the molten walls blowing eject out and further enlarging the hole. Non melting material such as wood, carbon and thermo set plastics are usually cut by this method**.**

Amount of heat input required for various material at various thicknesses using a $CO_2$ laser in (watts)

| Material | Material thickness (in) | | | | |
|---|---|---|---|---|---|
| | 0.02 | 0.04 | 0.08 | 0.125 | 0.25 |
| Stainless steel | 1000 | 1000 | 1000 | 500 | 250 |
| Aluminum | 1000 | 1000 | 1000 | 3800 | 10000 |
| Mild steel | - | 400 | - | 500 | - |
| Titanium | 250 | 210 | 210 | - | - |
| Plywood | - | - | - | - | 650 |
| Boron/epoxy | - | - | - | 3000 | - |

- ***Melt and blow or fusion cutting*** uses high-pressure gas to blow molten material from the cutting area, greatly decreasing the power requirement. First the material is heated to melting point then a gas jet blows the molten material out of the kerf avoiding the need to raise the temperature of the material any further. Materials cut with this process are usually metals.

- ***Thermal stress cracking*** Brittle materials are particularly sensitive to thermal fracture, a feature exploited in thermal stress cracking. A beam is focused on the surface causing localized heating and thermal expansion. This results in a crack that can then be guided by moving the beam. The crack can be moved in order of m/s. It is usually used in cutting of glass.

- ***Reactive cutting also called "burning stabilized laser gas cutting", "flame cutting".*** Reactive cutting is like oxygen torch cutting but with a laser beam as the ignition source. Mostly used for cutting carbon steel in thicknesses over 1 mm. This process can be used to cut very thick steel plates with relatively little laser power.

- ***Tolerances and surface finish*** New laser cutters have positioning accuracy of 10 micrometers and repeatability of 5 micrometers. Standard roughness Rz increases with the sheet thickness, but decreases with laser power and cutting speed. When cutting low carbon steel with laser power of 800 W, standard roughness Rz is 10 μm for sheet thickness of 1 mm, 20 μm for 3 mm, and 25 μm for 6 mm.

$$Rz = 12.528*(S^{0.542})/((P^{0.528})*(V^{0.322})),$$

Where: S = steel sheet thickness in mm;

P = laser power in kW (some new laser cutters have laser power of 4 kW.);

V = cutting speed in meters per minute.

This process is capable of holding quite close tolerances, often to within 0.001 inch (0.025 mm) Part geometry and the mechanical soundness of the machine have much to do with tolerance capabilities. The typical surface finish resulting from laser beam cutting may range from 125 to 250 micro-inches (0.003 mm to 0.006 mm).

The production rate is limited by a number of factors. Maximum cutting rate is limited by a number of factors, including laser power, material thickness, process type (reactive or inert,) and material properties. Common industrial systems (1 kW+) will cut carbon steel metal from 0.020 inch to 0.5 inch (0.508 mm and 12.7 mm) in thickness. For all intents and purposes, a laser can be up to thirty times faster than standard sawing.

**Figure 2.1 CNC LASER Cutting Machine operations**

### 2.1.3 Technology specification

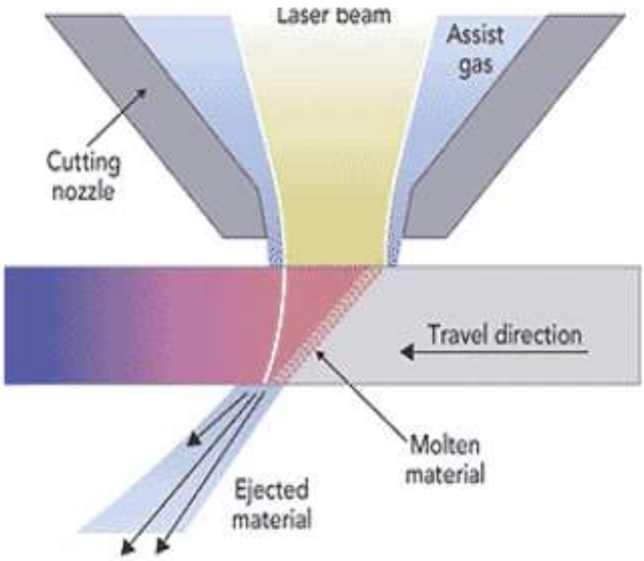
There are generally three different configurations of industrial laser cutting machines: Moving material, Hybrid, and Flying Optics systems. These refer to the way that the laser beam is moved over the material to be cut or processed. For all of these, the axes of motion are typically designated X and Y axis. If the cutting head may be controlled, it is designated as the Z-axis. Moving material lasers have a stationary cutting head and move the material under it. This method provides a constant distance from the laser generator to the workpiece and a single point from which to remove cutting effluent. It requires less optics, but requires moving the workpiece. This style machine tends to have the fewest beam delivery optics, but also tends to be the slowest. Hybrid lasers provide a table which moves in one axis (usually the X-axis) and move the head along the shorter (Y) axis. This results in a more constant beam delivery path length than a flying optic machine and may permit a simpler beam delivery system. This can result in reduced power loss in the delivery system and more capacity per watt than flying optics machines. Flying optics lasers feature a stationary table and a cutting head (with laser beam) that moves over the workpiece in both of the horizontal dimensions. Flying optics cutters keep the workpiece stationary during processing and often do not require material clamping. The moving mass is constant, so dynamics are not affected by varying size of the workpiece. Flying optics machines are the fastest type, which is advantageous when cutting thinner workpiece. Flying optic machines must use some method to take into account the changing beam length from near field (close to resonator) cutting to far field (far away from resonator) cutting. The same discussion applies to five and six-axis machines, which permit cutting formed work pieces. In addition, there are various methods of orienting the laser beam to a shaped workpiece, maintaining a proper focus distance and nozzle standoff, etc. The main specifications are shown in Table 2.1.

**Table 2.1 Equipment Speciation**

| Machine Speciation | |
|---|---|
| LASER type | CO2, flying optic |
| Working Area (WxD) | 1300 x 900 mm (51.1" x 35.4") |
| Motor type | Servo stepper |
| Surface finish | 125 to 250 micro-inches (0.003 mm to 0.006 mm) |
| Tolerances | 0.001 inch (0.025 mm) |
| Laser microjet | Water-jet guided |
| Laser beam width | 0.0125 in (0.3175 mm) |
| Kerf | 0.004 in (0.1016 mm) |
| Piercing time | 5–15 seconds for ½-inch-thick (13 mm) stainless steel |
| Beam focus | 0.001 inch (0.0254 mm) |
| Focal length | 1.5 inches and 3 inches (38.1 mm and 76.2 mm) |
| positioning accuracy | 1 micrometers |
| repeatability | .5 micrometers |
| laser power | 800 W |
| standard roughness Rz | 10 µm for sheet thickness of 1 mm, 20 µm for 3 mm |
| X-axis | 5 m |
| Y-axis | 12 m |
| Max. Part Size (WxD) | 1360 x ∞ mm (53.5 " x ∞ ") |
| Overall Dimension (WxDxH) | 1800 x 1480 x 1070 mm (70.8" x 58.3" x 42.1") |
| Motion Control | CNC commands (G, M code) |
| **Machine Speciation** | |
| PC Communication | RS-232 serial port with supplied cable |
| Memory Buffer | 2 MB |
| Focus Lens | 2.0" (Standard) |
| Max. Speed | Up to 45 M/min traversing, 30 M/min cutting |
| Max. Part Size (WxD) | 1360 x ∞ mm (53.5 " x ∞ ") |
| Laser Power | 1Φ, 220VAC, 15Amp, 50/60 Hz |
| Driver | EZLASER DRIVER (CUTTER) (Standard) |
| CAM Software | EZLASER CAM (CUTTER) (Option) acceptable with DXF / HPGL / CNC code files |

| Machine Speciation | |
|---|---|
| Cutting Pallet | Aluminum frame to minimizing damage of reflecting laser light |
| Laser Power Control | Digital laser power control with automatic proportional pulsing and color link |
| **Facility Requirements** | |
| Host PC | Windows XP capable system |
| Air Assist | Compressor with Gas Tank to provide dry air, 20 Lit/min, 7kg/cm2 with 8mm diameter hose. |
| Exhaust System | One exhaust blower (2HP), Pressure 50 mmAq, Air flow 30m3/min with two 8" diameter hoses. |
| External Chiller | DI Water, 4000BTU (90D,140D) / 8000BTU (280D) / 18000BTU (200R), Cooling Capability Flow rate>5Lit/min. |

### 2.1.4 Suitability or integration with existing process




Laser cutting machines are used for precise contour cutting thin sheet. In industrial application nowadays various types and construction of laser cutting machines can be met. For contour cutting 3-D thin sheet parts laser cutting machines with rotation movements and laser robots are used. Laser generates the light beam that presents a tool in working process. Application of laser cutting machines made possible good quality of products, flexibility of production and enlargement of economy. The production of laser cutting machines began thirty years ago. The progress was very fast and at present time every year over 3000 laser cutting machines is installed in the world. Laser cutting is one of the largest applications of lasers in metal working industry. It is based on vaporize the material in a very small area by focused laser beam. Process characteristics are: uses a high energy beam of coherent light; beam is focused on an small spot on the work piece by a lens; focused beam melts, vaporizes, or combusts material; molten material is ejected out from the melt area by pressurized gas jet. Laser cutting is the high speed cutting with a narrow kerf width that results in superior and enhanced quality, higher accuracy and greater flexibility. In figure schematic is shown the laser cutting. By combining the laser beam and the machine providing motion, in addition to the applied numerically controlled system, it is possible to provide for a continual sheet cutting along the predetermined contour. The laser beam can cut very hard or abrasive materials. Cutting with lasers is a very cost effective process with low operating and maintenance costs and maximum flexibility. Nowadays in industrial application various types and construction of laser machines for contour cutting thin sheet can be met. Laser machines for contour cutting thin sheet present the product of high technology. They are composed of: laser, beam guiding, cutting head, coordinate table, system for energy supply and control unit. In fig. is shown the basic configuration of laser cutting machine. Laser, the optical quantum generator, generates the light beam that presents a tool in working process. By optical system in cutting head the laser beam is focused in diameter from 0,2 mm with the power density over 108 W/cm2. Since our desire is to remove the evaporated and molten material from the affected zone as soon as possible, the laser cutting is performed with a coaxial assist gas. The gas blowing increases the feed rate for as much as 40 %. Cutting process along contour is realized with the movement of laser beam or workpiece. Machine for movements is accordance with necessities of laser machine. For variety of work laser machine have a support tables who can be supplied: a simple cutting grid, a cutting table with transportable and removable pallets and a change-over table. In industrial application nowadays various types and construction of laser cutting machines can be met. It depends on, first of all, what method is used to realize a relative movement between the laser beam and a workpiece. The form and the configuration of laser cutting machine depend on form and dimension of workpiece as well as on demanded precision and working quality. By contour cutting 2-D thin sheet parts the use of machines with X-Y table coordinate is effective and real when CNC control unit is used for control. It is often a multi-axis mechanical system which permits linear movements. The CNC is claimed to be superior to types conventionally used in the manufacture of machine tools. It is up to 10 times quicker, compensates for overrun errors, adapts the programmed laser power to the processing speed, and controls the cutting gas pressure and the laser parameters. CNC laser-cutting machine offers an optimal solution to cut all kinds of sheet materials economically. For contour cutting 3-D thin sheet parts, rotation movements are added to laser cutting machines. Rotation movements are realized by rotation of cutting head or by rotation workpiece by added devices on worktable. Observing the variants of realized laser cutting machines the tendency of principles “flying optics” is evident. The principle is based on spacious, mechanical and automatic movement of optical parts of system for laser beam transmission an deviation and optical system for focusing laser beam by cutting head, which are optically and mechanically connected. Laser cutting systems are generally used for cutting prototypes or small production runs from sheet stock. Hard tooling is usually more economical for high volumes. However, one high volume application in which lasers have found a niche is trimming automobile parts. These are now being made of thinner materials, and trim dies capable of cutting to the required tolerances are so expensive that laser cutting is cost competitive even for the large lot sizes involved. Lasers are used in place of traditional punching or nibbling to cut:

- Jet engine combustion chamber liners
- Elevator and escalator panels
- Heat exchanger plates
- Electrical and office equipment enclosures
- Air-conditioning ductwork
- Saw blades.

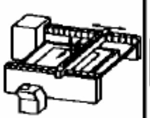
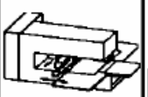
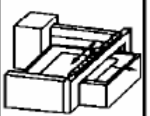
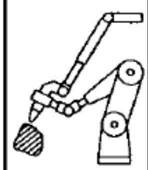
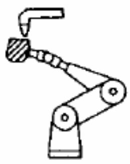
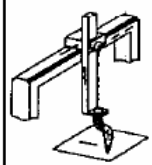
Laser beams are used to drill

- Car door lock holes
- Oil holes in engine and transmission parts
- Cooling holes in turbine engine vanes and blades
- Mounting holes in printed circuit boards

Important characteristics for a cutting laser are:

- Overrated power output. A laser with slightly more power than you think you need will give you flexibility to expand your product range.
- True TEM, mode. Not all lasers can operate in this mode.
- Proven reliability. **A** laser model that is known to function consistently and accurately in a shop floor environment probably provides the best return on investment.

### 2.1.5 Superiority over existing technology

| GEOMETRY OF WORKPIECE: 2D | | | | GEOMETRY OF WORKPIECE: 3D | | | |
|---|---|---|---|---|---|---|---|
| WORKPIECE: Fixed | | WORKPIECE: Movable | | WORKPIECE: Fixed | | WORKPIECE: Movable | |
| LASER BEAM: Fixed | LASER BEAM: Movable | LASER BEAM: Fixed | LASER BEAM: Movable | LASER BEAM: Fixed | LASER BEAM: Movable | LASER BEAM: Fixed | LASER BEAM: Movable |
| No realized | Variant 1 | Variant 2 | Variant 3 | No realized | Variant 4 | Variant 5 | Variant 6 |
| - |  Flying optics |  x, y - table |  x - table y - optics | - |  |  |  |

Modern laser cutting robots have totally flying optics architecture. All movements are made by the focusing head and the workpiece remains stationary. Laser robot takes the laser beam along any continuous pre-programmed path in three-dimensional space, then cuts with accuracy, speed and quality. The speed and acceleration on the main axes of the new generation of robotic systems are 60 m/min and 23 m/s2. Integration of the laser beam guiding in the robot arm structure offers great advantages compared to conventional systems with external laser beam guiding. All limitations of the accessibility to dimensional components are eliminated due to the high movability and the compact design of the slim hand articulation module. Due to the centre outlet of the laser beam on the wrist, the 6th axis of the robot may be omitted, and the free space can be used for passage of the beam. This solution offers the following advantages: compact construction of the robot hand articulation, very good accessibility to 3-dimensional components, favorable work envelope and high degree of freedom of motion, high cutting speeds, high path accuracy and economic price. By laser robot it is necessary to adapt the position of the focusing lens to the real position of the workpiece. The robot is fitted with a capacitive sensor on the head for adapt the position and focusing the lens. The sensor is interfaced to the robot control and can read the real position of the workpiece. The robot consequently moves the lens so as to always be correctly in focus. In this way the best quality cut edge is obtained. Laser robot works with automatic programmable laser control and with adaptive focusing head. Sensors of workpieces, sensors of safety and sensors of process increase convenience, reliability and safety of work with laser robots. The need for such high performance is due to the fact that the focused laser beam has a well-defined offset (the focal length) and therefore such dynamics are more to direct the tool than for the actual working phases. Special software that permits accommodation of coordination laser power with cutting speed are present and desirable. Programming is carried out in collaboration with an off-line system by means of a personal computer. More and more systems are requested to be interfaced with various CAD/CAM systems. The most applicable laser robots are laser robot with Nd:YAG Laser and laser robot with $CO_2$ laser. For Nd:YAG laser, beam guiding is performed from a stationary high-performance Nd:YAG laser with up to 4 kW beam capacity via a flexible light cable in the upper arm of the robot up to the forced air cooled hand axis. The fiber optic cable is mounted here via a connector plug on the hand axis. The diverging laser beams emitted from the fiber optic cable are guided to the outlet opening at the hand axis via two integrated deviation mirrors. The deviation mirrors are designed as high-reflective coated quartz substrates. The exact position of the beam axis relative to the movement axis is adjusted via adjusting elements on the deviation mirrors. Collimation and focusing of laser beam is performed at the outlet opening of the hand axis via flange-mounted modules that can be flexibly adapted to the processing task. Application fields of Nd:YAG laser robot are: cutting of sheet metal components made of steel, stainless steel, aluminum; welding and soldering of sheet metal components made of steel, stainless steel, aluminum; welding of thermoplastic materials; hardening tool steels; build-up welding with wire and powder filler metal. The $CO_2$ laser is directly mounted adjustably on the upper arm of the robot with a mounting bracket. The beam exit of the laser is pointing opposite to the hand axis of the robot. Via two adjustable deviation mirrors made of surface-coated silicon the laser beam is coaxially guided into the fourth robot axis. Directly on the hand axis there is rigidly mounted a beam staggering module with two silicon deviation mirrors that guides the beam coming from the fourth axis to the first deviation mirror of the hand axis. Beam guiding in the hand axis is structured similar to the version for the Nd:YAG laser. Instead of the quartz substrates surface-coated silicon mirrors are used. At the outlet end of the hand axis there is mounted the cutting head where exact adjustment of the beam focus position as well as the position of the cutting nozzle via adjusting elements is possible. Application fields of CO2 laser robot are: cutting of textiles and plastic films; trimming of cloth-lined plastic parts; welding of plastic materials; trimming and cutting of injection molded parts; drilling and perforating of plastic components. Example of characteristics of laser robots with Nd:YAG laser via integrated fiber optic cable and CO2 laser with integrated laser beam guiding are shown. Laser-robot has brought about various improvements in quality, reduced costs and working times.

- Low connection power
- Low power consumption
- Low maintenance costs
- High speed
- High accuracy
- High repeatability
- Prototyping, an activity which normally costs a car manufacturer thousands of hours per year (the parts to be produced range from single pieces to a few dozen for experimental reproduction runs).
- Production in small batches, luxury or special cars, trucks and buses or parts for the aerospace industry.
- Production of spare parts where the robot flexibility is especially suited to following the diversified demand.
- Cutting of large turbine blade wing contours for rotors and stators. Flexibility of the systems is often the most important reason for its purchase since in the case of production start-up or small batch production, frequent modifications will be necessary.

### 2.1.6 Availability of technology

CNC based technology providers are basically multinational companies providing the services in all the major cities of the country. The technology is widely available and lots of national and multinational manufacturers are suppling their products to these industries including the machine tools industry.

### 2.1.7 Source of technology

This technology is already in use in some machine tools units in the cluster where the production requirment is ame. They also got the results of reduction in energy consumption as well as reduction in rejection of material and the technology is running successfully.

### 2.1.8 Service/technology providers

There are about 5 technology providers are available in the cluster for this system including Ace Micromatic Machine Tools Pvt. Ltd., Haas Automation, Jyoti CNC automation Pvt. Ltd., DMG Mori Seiki India Machines and Services Pvt. Ltd. And Mazak company is the service provider for this technology. They have the experience in supplying the multi – axis machine and provided consultancy & implementation support. The detailed contact information of all service providers is provided in annexure - .

### 2.1.9 Terms and condition of sales

Sales and after implementation of technology support information is provided in the annexure.

### 2.1.10 Process down time during implementation

The installation of CNC LASER Cutting Machine can be done in the 14 - 21 days, However the CNC LASER Cutting Machine is end to end solution of conventional Cutting and LASER cutting machine's cutting production process, implementation will not affect production. Thus implementation of this technology will not affect the process.

## 2.2 Life cycle assessment and risks analysis

In case installation of CNC LASER cutting machine, the technology and machine will continue to work up to 12 to 16 years under proper maintains. No need to any further huge modification after one time installation, in case of risk analysis there is a need of proper maintains and timely oiling.

## 2.1 Suitable unit/plant for implementation of proposed technology

The suitable units or plants for implementation of proposed technology are listed below

***1. M/s Fenwick & Ravi***

***2. M/s Mighty Machines Pvt. Ltd***

***3. M/s Sadbhava Fabricators Pvt. Ltd***

# 3 ECONOMIC BENEFITS FROM NEW ENERGY EFFICIENT TECHNOLOGY

## 3.1 Technical benefits

### 3.1.1 Fuel saving

A 1 kW CO, laser costs between $85,000 and $100,000. Adding computer controls, a system for moving the laser and/or workpiece, and the other necessary equipment increases the cost to between $250,000 and $500,000.While the initial cost of a laser cutting system is high, improved productivity and product quality, combined with low tooling and maintenance costs, make a system economical, especially for companies that produce a wide range of parts. In addition, the beam from a single laser can be shared by several workstations, so expansion may require adding only new workstations rather than an entire new system. To decide whether a laser cutting system would be cost-effective, you must know your real cost per part, including all overhead and benefit costs,. If you cannot justify your own system, there are many job shops willing to do contract laser cutting. Operating expenses include the cost of laser gases, assist jet gases, dry compressed air, and power, all of which vary with application. Average costs for all of these components together are $6-10/hr. Another operating cost is replacement of the With a laser cutting system a manufacturer is guaranteed quality cuts and high cutting rates in many different materials, both metals and nonmetals. **A** variety of parts can be produced with little lead time, since a new part requires only a new program much faster to write a program than to make or wait for new tooling This flexibility reduces inventory requirements and makes possible product and material diversification. With the increasing trend towards nonmetal parts, especially in automobiles, the ability to work with a range of materials is a definite competitive advantage. Laser systems also work well for selective hardening a variety of heat-treatable parts. The information in this issue of Tech commentary gives you an overview of the capabilities of laser processing systems. If you think your company could use such a system. look at the sources used in thls Tech-Commentary and talk with equipment vendors or job shop owners. Energy & Cost saving including the energy, material rejection, man power cost and utility cost for a typical unit by installation of CNC LASER cutting machine are tabulated below:

**Table 3.1 Energy savings estimation for CNC LASER Cutting machine**

| S.No | Particular | Unit | Conventional LASER Cutting machine | CNC LASER Cutting machine |
|---|---|---|---|---|
| 1 | Specific Energy Consumption | kWh/Tonne | 4476 | 3945 |
| 2 | Average Energy Cost | Rs./Tonne | 22380 | 19725 |
| 3 | Cost of Material | Rs,/annum | 500000 | 375000 |
| 4 | Other Cost (Man Power/Utility) | Rs./tonne | 250000 | 334000 |
| 5 | Average Production | Rs./tonne | 772380 | 728725 |

| S.No | Particular | Unit | Conventional Cutting machine | CNC LASER Cutting machine |
|---|---|---|---|---|
| 6 | Annual Production | Tonne/annum | 54.7 | 54.7 |
| 7 | Annual Production Cost | Rs./annum | 42249186 | 39861258 |
| 8 | Reduction in Production Cost | Rs./Tonne | | 43655 |
| 9 | Annual cost reduction | Rs./Annum | | 2387929 |

A CNC LASER Cutting machine will not only reduce the operartional cost of production but also increase the rate of the production in the same time. The estimated or feedback received from amny users of CNC LASER Cutting machine revels that the CNC LASER Cutting machine may produce two times production/ material at same time and at same energy consumption.

***Note:-** *As in the proposed DPR Conventional LASER Cutting machine is replaced by CNC LASER Cutting Machine, it is assumed that it improves the overall productivity by 1.75 times i.e. 54.7 Tonnes/Annum in earlier case to 95.725 Tonnes/Annum after implementation. Accordingly, the energy saving could be achieved.Consequnetly, the O&M cost of machinery shall increase to 5 % with annual Escalation of 5 %.*

### 3.1.2 Improvement in product quality

CNC lasers achieve high productivity and accuracy by combining high axis speeds with optimal cutting conditions over the entire cutting area, using a unique constant beam length system. In most machines, the divergence of a laser beam is compensated by use of a telescope and/or adaptive optics. With these systems, however, a variation in cut quality over the cutting area can occur because of a change in the focal position and/or focal spot size. The constant beam length system of the Impulse eliminates the divergence of the laser beam, ensuring identical results over the entire cutting area, at optimal speeds, with superior edge quality. The edge function feature facilitates cutting sharp corners, particularly in thicker plate.

- Enhanced Productivity
- Accuracy and Part Quality
- Machine Durability and Reliability
- Unmatched Support Services

### 3.1.3 Increase in production

Laser Cutting System incorporates the latest in resonator technology, motion control systems, electronics, beam delivery, fiber optics communications and software technology to greatly enhance machine productivity, performance and accuracy. This machine outperforms punch presses and conventional lasers when cutting a wide range of materials and thicknesses.

### 3.1.4 Reduction in raw material consumption

The rejection of material in CNC LASER cutting is almost nill while comparing with existing system/technology. However, in the cost calculation about 40% of the existing rate of rejection is considered.

### 3.1.5 Reduction in other losses

Installation of CNC LASER cutting machine will result in reduction of the utility system like compressed air system to operate the numetic system and other general utility expanses due to fast rate of the production with comparision to the existing technology. Some of them are listed below:-

- The CNC LASER cutting gives high productivity in an economical way.
- It has the ability to produce variety of components without re-tooling and thereby saving in production cost.
- It is best suitable for regular and repetitive job work.

### 3.2 Monetary benefits

Monetary savings in a typical unit after installation of CNC LASER Cutting machine has been estimated around ` 41.79 lakh per annum. This figure has been arrived based on the annual reduction in energy, rate of material rejection and manpower cost savings in a typical unit multiplied by average annual production of the unit.

### 3.3 Social benefits

### 3.3.1 Improvement in working environment

The design of a CNC LASER cutting has evolved yet again however the basic principles and parts are still recognizable, the cutting holds the tools and indexes them as needed. The machines are often totally enclosed, due in large part to Occupational health and safety (OH&S) issues.With the advent of cheap computers, free operating systems such as Linux, and Windows open source CNC software, the entry price of CNC machines has plummeted.

### 3.3.2 Improvement in skill

Intervention of any new technology in any process/ industry requires improvement in skill set of workforce so as to run the process efficiently. This will also provide the development of skill sets of operators for CNC which will lead to energy efficient operations and quality product.

### 3.4 Environmental benefits

### 3.4.1 Reduction in effluent generation

As the existing and proposed technology is based on the low energy conservation and maximum output with saving of fuel and eletricity, hense saving nature and producing low carbon output per tonne.

### 3.4.2 Reduction in GHG emission such as $CO_2$, NOx, etc

There are significant reductions to be achieved in Green House Gas emission by adoption of advance CNC technology like CNC LASER cutting machine in machine tools industries. Reduction in electricity consumption translates into GHG reductions is estimated to be of $CO_2$ 38.12 tonne per annum for given energy saving and production.

### 3.4.3 Reduction in other emissions like SOx

As the existing and proposed technology is based on the clean fuel based operation therefore Sulphur is not present in electricity; hence there is no impact on SOX emissions.

# 4 IMPLEMENTATION OF NEW ENERGY EFFICIENT TECHNOLOGY

## 4.1 Cost of technology implementation

### 4.1.1 Cost of technology

The costs of equipments that will be required for Installation of CNC LASER Cutting machine are provided in Table 4.1 below:

**Table 4.1 Cost of equipment**

| S. No. | Particulars | Cost |
|---|---|---|
| 1 | Cost of CNC LASER cutting machine | `5075522 |

### 4.1.2 Other costs

**Table 4.2 Cost of civil work and consultancy**

| S. No. | Particulars | Cost |
|---|---|---|
| 1. | Cost of civil work | `1, 20,000/- |
| 2. | Electrical & Utility Expenses | ` 35,000/- |
| 3. | Cost of Consultancy and installation | ` 45,000/- |
| Total | Two Hundred thousand only/- | ` 200,000/- |

## 4.2 Arrangements of funds

The Japan International Cooperation Agency (JICA) has extended a Line of Credit to Small Industries Development Bank of India (SIDBI) for financing Energy Saving projects in Micro, Small and Medium Enterprises (MSMEs) Sector. The project is expected to encourage MSME units to undertake energy saving investments in plant & machinery / production process to reduce energy consumption, enhance energy efficiency, reduce$CO_2$ emissions and improve the profitability in the long. The financial parameters for assistance under the scheme are given in Table 4.3 below:

**Table 4.3 Financial parameters**

| *Parameter* | *Norms* |
|---|---|
| Minimum Assistance | ` 10 lakh |
| Minimum promoters contribution | 25% for existing units |
| Debt Equity Ratio Maximum | 2.5 :1 |
| Interest Rate | The interest rate is based on internal risk rating within the band given below :<br>_ Fixed rate: 9.50 – 10.0% p.a.<br>_ Floating rate: 9.75 – 10.5% p.a. |
| Security | First charge over assets acquired under the scheme; first/second charge over existing assets and collateral security as may be deemed necessary. |

| Parameter | Norms |
|---|---|
| Asset coverage | Minimum Asset Coverage should be 1.4: 1 for new units and 1.3: 1 for existing units. |
| Repayment period | Need based. Normally, the repayment period does not extend beyond 7 years. However, longer repayment period of more than 7 years can be considered under the Line if considered necessary |

## 4.3 Financial indicators

### 4.3.1 Cash flow analysis

Detail cash flow analysis for new proposed technology is given in Annexure–5.

### 4.3.2 Simple payback period

Payback period will be Little more than 1 Years. The estimated payback period is about 1.26 years.

### 4.3.3 Net Present Value (NPV)

Net Present Value of new project would work out ` 114.59 lakh.

### 4.3.4 Internal rate of return (IRR)

The after tax internal rate of return of the project works out to be 60.06%. Thus the project is financially viable.

### 4.3.5 Return on investment (ROI)

The average return on investment of the project activity works out at 27.81 %.

**Table 4.4 Financial indicator of proposed technology**

| Particulars | Unit | Value |
|---|---|---|
| Simple Pay Back period | Years | 1.26 |
| IRR | %age | 60.06 |
| NPV | ` in lakh | 114.59 |
| ROI | %age | 27.81 |
| DSCR | ratio | 3.25 |

## 4.4 Sensitivity analysis

In different situation energy saving may increase or decrease on the basis of this scenarios a sensitivity analysis in realistic, pessimistic and optimistic has been carried out on the basis of two scenarios as considers. (**Fuel saving increase by 5% Fuel saving decrease by 5%)**

**Table 4.5: Sensitivity analysis**

| Particulars | DSCR | IRR | ROI | NPV |
|---|---|---|---|---|
| Normal | 3.25 | 60.06 | 27.81 | 114.59 |
| 5% increase in fuel savings | 3.41 | 63.61 | 27.94 | 122.60 |
| 5% decrease in fuel savings | 3.08 | 56.52 | 27.67 | 106.59 |

Assuming all provision and resource input would be similar during economic analysis

### 4.5 Procurement and implementation schedule

The installation of CNC LASER cutting machine can be done in the 14 - 28 days, However the CNC LASER cutting machine is end to end solution of CNC LASER cutting production process, implementation will not affect production. Thus implementation of this technology will not affect the process.

**Table 4.6: Implementation Schedule**

| *S. No.* | *Activities* | *Weeks* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *1* | *2* | *3* | *4* | *5* | *6* | *7* |
| 1 | Procurement and Delivery | | | | | | | |
| 2 | Civil & Electrical Work | | | | | | | |
| 3 | Commissioning | | | | | | | |
| 4 | Training | | | | | | | |

**ANNEXURE**

## Annexure 1: Energy audit reports used for establishing

The results of detail energy audit for 3 Bangalore Machine tool cluster production units with specefic energy consuption are given below:

***Audit No. 1 study of existing technology used for benchmarking***

| Particular | | | | | |
|---|---|---|---|---|---|
| **Name of cluster unit studied** | **Unit** | **Unit 1** | **Unit 2** | **Unit 3** | **Value** |
| Specific Energy Consumption | kWh/Tonne | 975 | 868 | 11585 | 4476 |
| Average Energy Cost | `/Tonne | 4874 | 4342 | 57925 | 22380 |
| Raw material cost | `/Tonne | 500000 | 500000 | 500000 | 500000 |
| Other Cost (Utility) | `/Tonne | 334515 | 212370 | 203123 | 250000 |
| Average Production cost | `/Tonne | 797659 | 905605 | 1003861 | 772380 |
| Annual Production | Tonne | 130.5 | 21.6 | 12 | 54.7 |
| Annual Production Cost | `/annum | 104094503 | 19561061 | 12046332 | 42249186 |

***Study of existing technology and proposed technology***

| S.No | Particular | Unit | Conventional LASER Cutting machine | CNC LASER Cutting machine |
|---|---|---|---|---|
| 1 | Specific Energy Consumption | kWh/Tonne | 4476 | 3945 |
| 2 | Average Energy Cost | `/Tonne | 22380 | 19725 |
| 3 | Cost of Material | `/Tonne | 500000 | 375000 |
| 4 | Other Cost (Man Power/Utility) | `/Tonne | 250000 | 334000 |
| 5 | Average Production | `/Tonne | 772380 | 728725 |
| 6 | Annual Production | Tonne | 54.7 | 54.7 |
| 7 | Annual Production Cost | `/annum | 42249186 | 39861258 |
| 8 | Reduction in Production Cost | `/Tonne | | 43655 |
| 9 | Annual cost reduction | `/annum | | 2387929 |

| S. No | Particular | Unit | Conventional Gear Hobbing machine | CNC Gear Hobbing machine |
|---|---|---|---|---|
| 1 | Annual Production | Tonne/annum | 54.7 | 95.725 |
| 2 | Annual Production Cost | `/annum | 42249186 | 69757201 |
| 3 | Reduction in Production Cost | `/Tonne | | ***43655*** |
| 4 | Annual cost reduction | `/Annum | | ***4178875*** |

*****The savings are due to increased production and reduced production costs.***

- ✓ ***`43655*** Cost reduction per tonne
- ✓ ***95.725 tonne*** increased production

***95.725 x 43655 = 4178875***

**Annexure 2: Process sequence of dealing a workpiece at CNC LASER Cutting machine**

With powerful R&D strength, being market-oriented, many years of experiment and practice, JQ LASER has developed a new advanced solid laser cutting system with large format and gantry structure. In this machine, we employees YAG solid laser optical system, so that the optical mode is better, the cutting kerf gets smaller, and precision turns to be higher. The mechanical servo cutting head keeps in direct contact with the metal

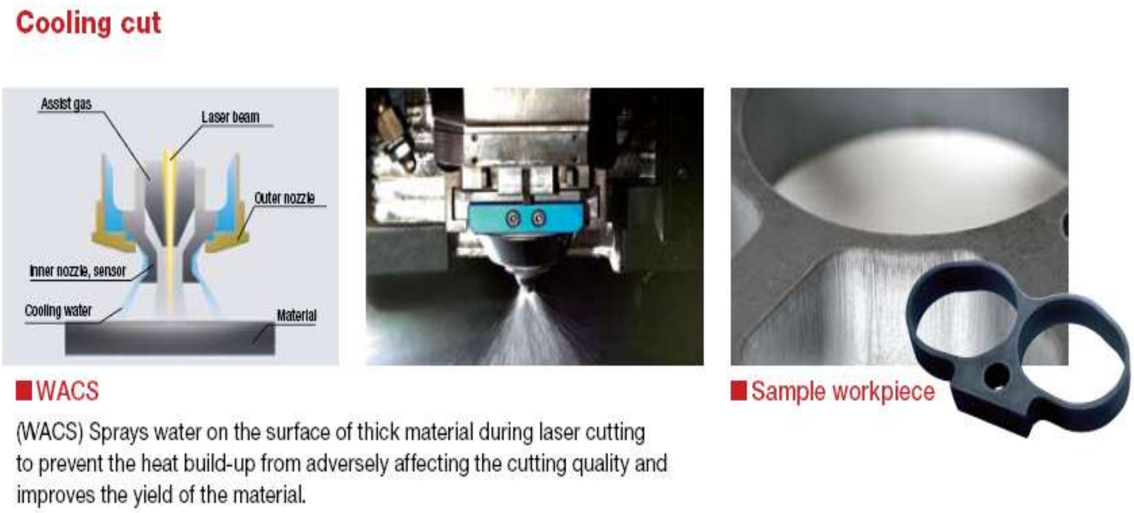
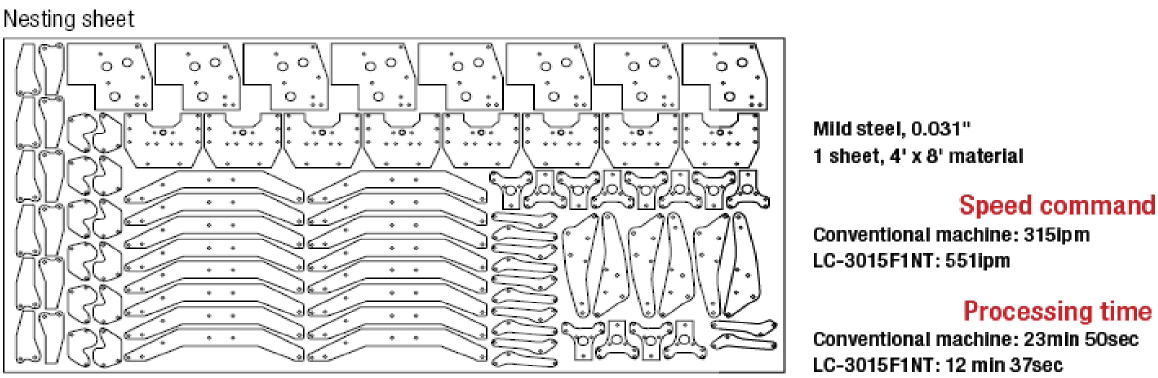
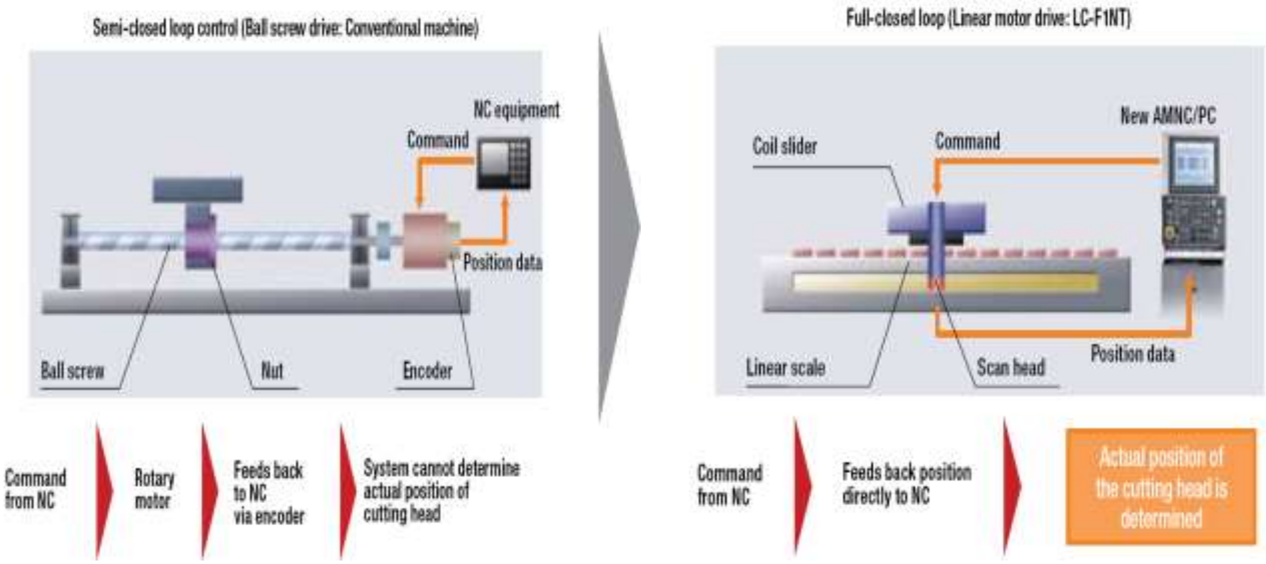



plate when moving. The focus point remains the same. Cutting speed and cutting effect within the whole working area is uniform. Dual-rail positioning and ball screw transmission improve the speed, precision, motion, dynamic performance and durability. In both vertical and horizontal directions of the machine, there are ultra-travel limit switch and polyurethane anti-collision block, which maximally ensure the safe operation of the machine. Automatic programming system outputs working order from graphics files. Computer simulates the processing path, sets layout automatically, improving the working efficiency and material utilization. The machine consists of solid laser cutting machine main part, high-power power supply, water cooling system, and computer console. It has the advantages of compact structure, easy operation Combination of brushes and roller balls fully supports the sheet, but lowers the noise, vibration, and scratching of the material. Flexible configuration of the machine can be achieved with thick or thin tooling styles selected by the requirements of the customer. In an economic climate that presents manufacturers with mounting pressures, it's important to know there are options for companies of all sizes that cut metal sheet or plate for their products. Recent developments in plasma and high-definition plasma technologies have made this method cost efficient, particularly for manufacturers that have used or are considering using laser cutting. Now, given the precision and quality that plasma cutting can provide, manufacturers can expect to save money and time using plasma technology on parts that may in the past have required laser cutting. Hyper therm has performed detailed analyses of these two thermal cutting methods; the graphs illustrate the cost savings of using plasma. Manufacturers will realize savings in both maintenance and operational costs. While use of $CO_2$ lasers is an expensive cutting method,

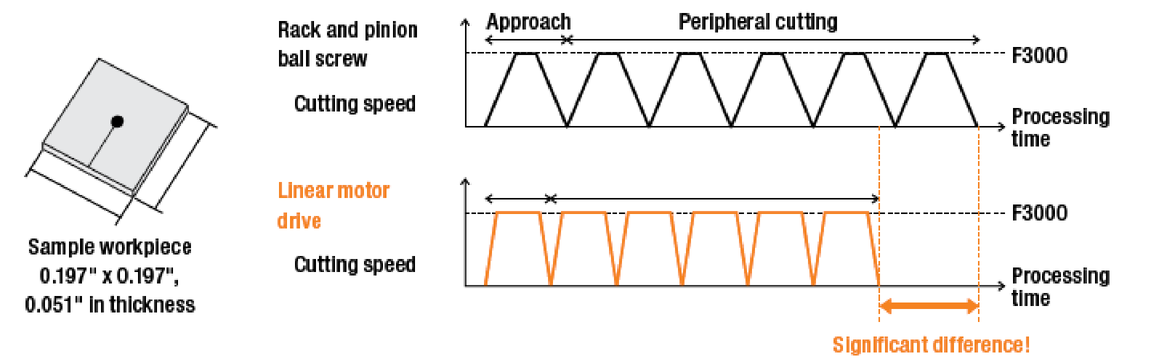


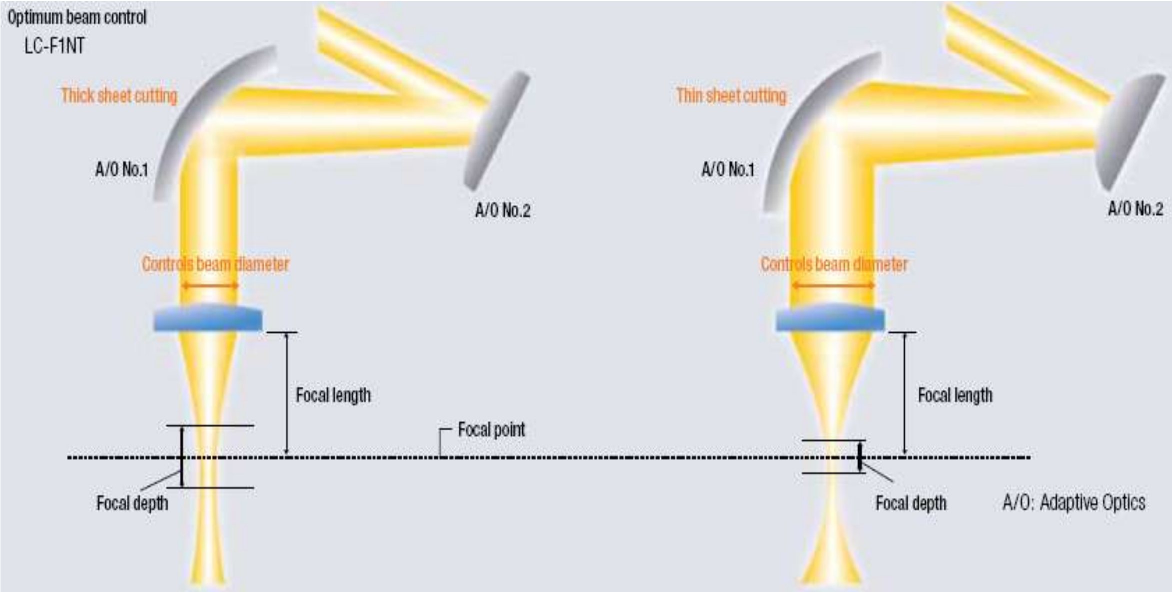

for some processes it may be the only method. But when an engineer or customer allows a manufacturer to recommend and use other means, plasma may prove to be the most economic and efficient option. For example, when cutting parts with holes or similar features that require extreme accuracy, plasma cutting can now (in some cases) accommodate tolerances once reserved for lasers. Other plasma uses include parts which have no tight tolerance areas such as outline edges or parts for weldments. While these examples illustrate the advantages of plasma over laser cutting, more difficult situations arise in through-holes, particularly in mounting holes, where hole taper and roundness are more of an issue. With today's high-definition plasma, even these tasks are now within the capabilities of a good plasma cutting machine, fitted with accurate CNC controls and a high-definition plasma torch. Lasers, with their relatively small heat affected zones (HAZs), have for decades been the mainstays of manufacturing when tight tolerance parts are produced with a thermal method But the relatively high costs of operation and ownership when choosing this method is an important consideration. Lasers come in a variety of shapes and sizes; the CO2 CNC flatsheet cutting machine is the most common type in most of today's manufacturing environments. High expenditures of energy are required to generate the laser beam, although little actually ends up focused on the cutting operation. Large chillers are needed to remove excess heat — another costly aspect of laser cutting. While laser operators are aware of the various inefficiencies associated with running an industrial multi-kilowatt laser cutting machine, and no doubt try to optimize their machines, this cutting process only runs in roughly the 3–5% overall efficiency range. Of all the energy required to power the laser, only a fraction of the expended power shows up on the work. The other 95% of the energy is removed in the form of heat, never doing any useful work on the part being cut. Some operators may power the resonator up or down depending on production time versus idle time in an effort to improve efficiency.

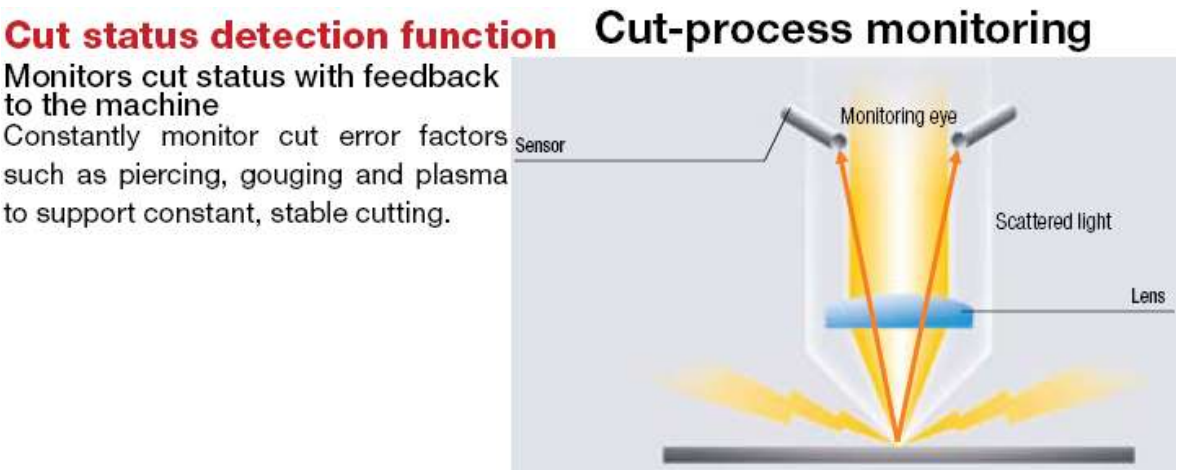
But other operators simply let the resonator operate at full output, regardless of whether or not the machine is actually cutting metal. The working process is illustrated below in the figure.

Cutting command speed, acceleration and cycle time*

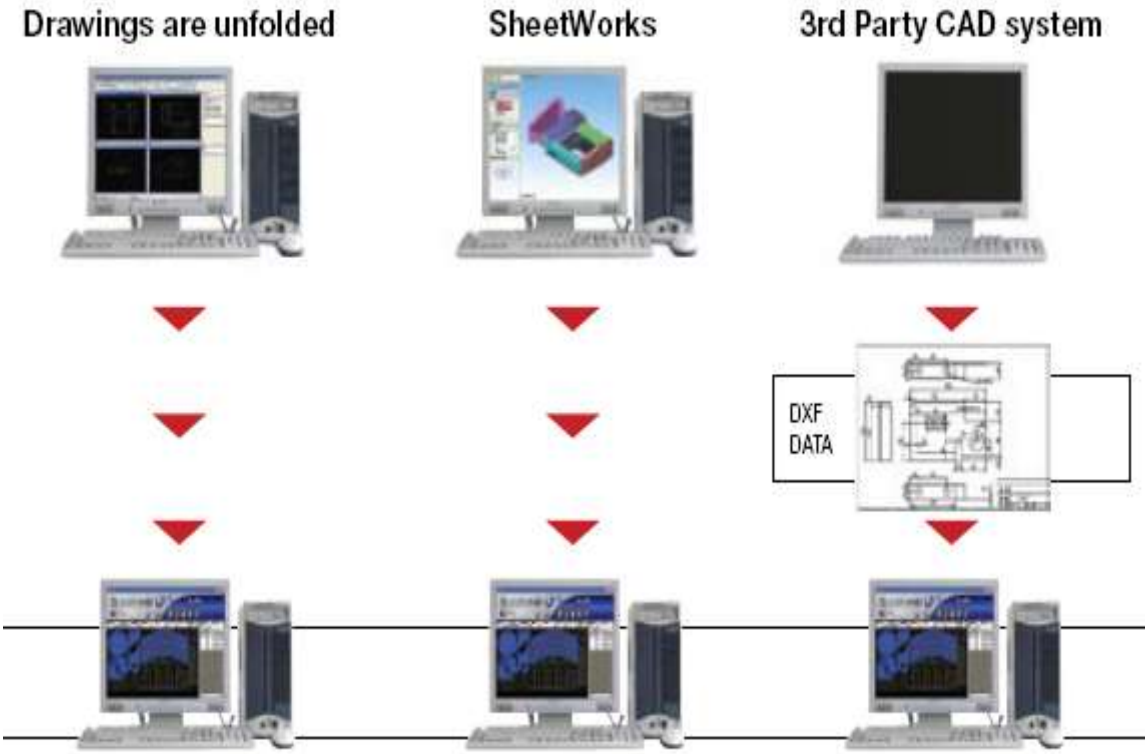



*Cycle time: The time from the beginning to end of a series of operations in a single process.



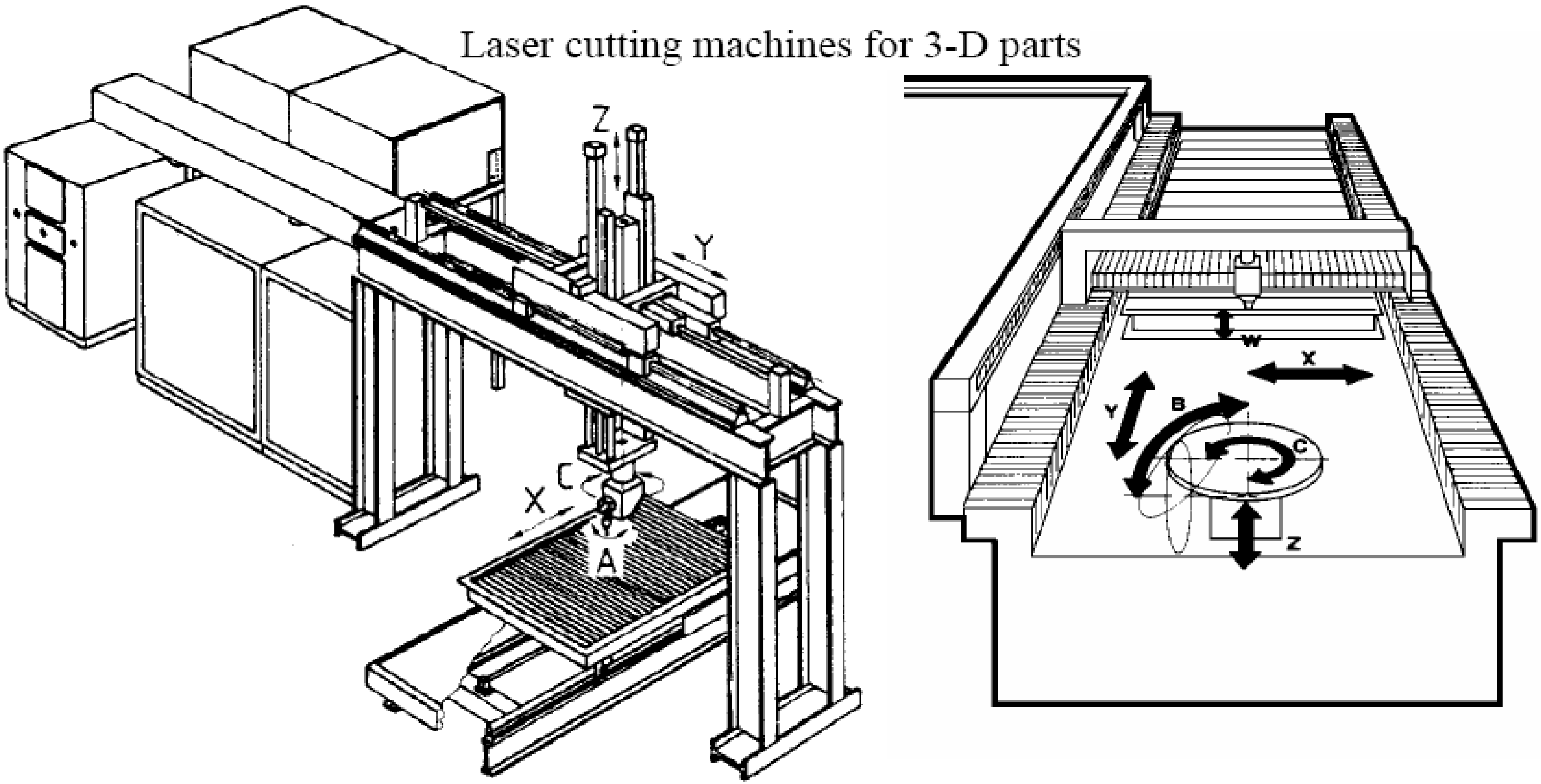



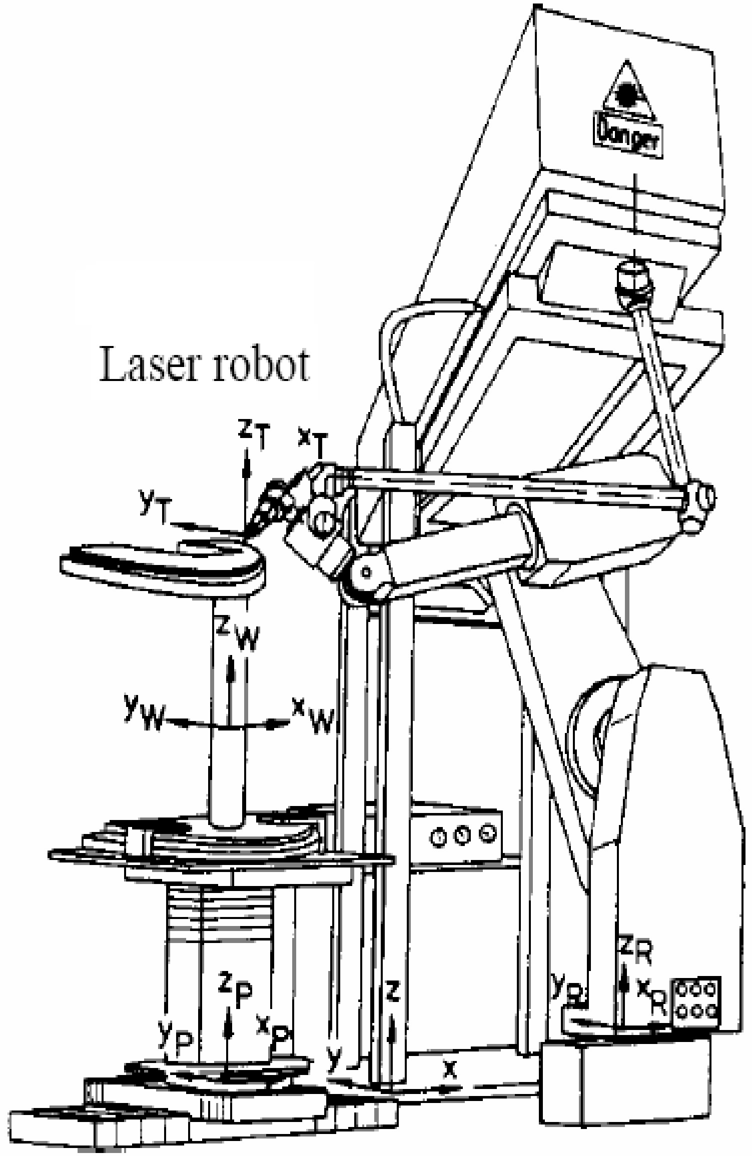

*The CNC LASER Cutting Machine (Process)*

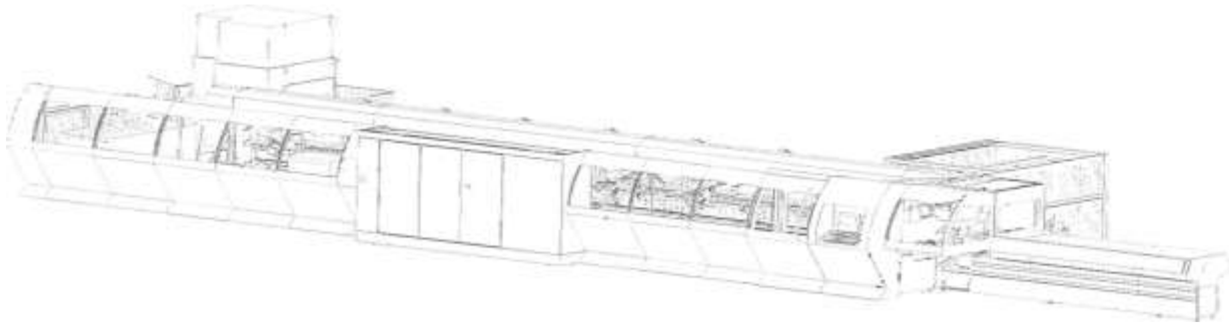


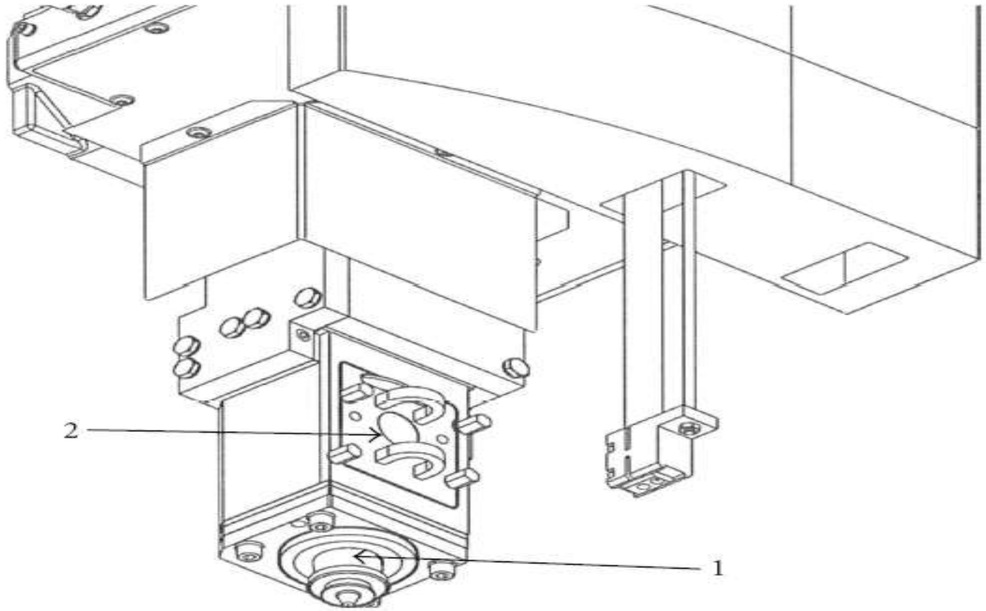

***The CNC LASER Cutting Machine (Process)***

**Annexure 3: Technical Drawing of CNC LASERCutting machine**

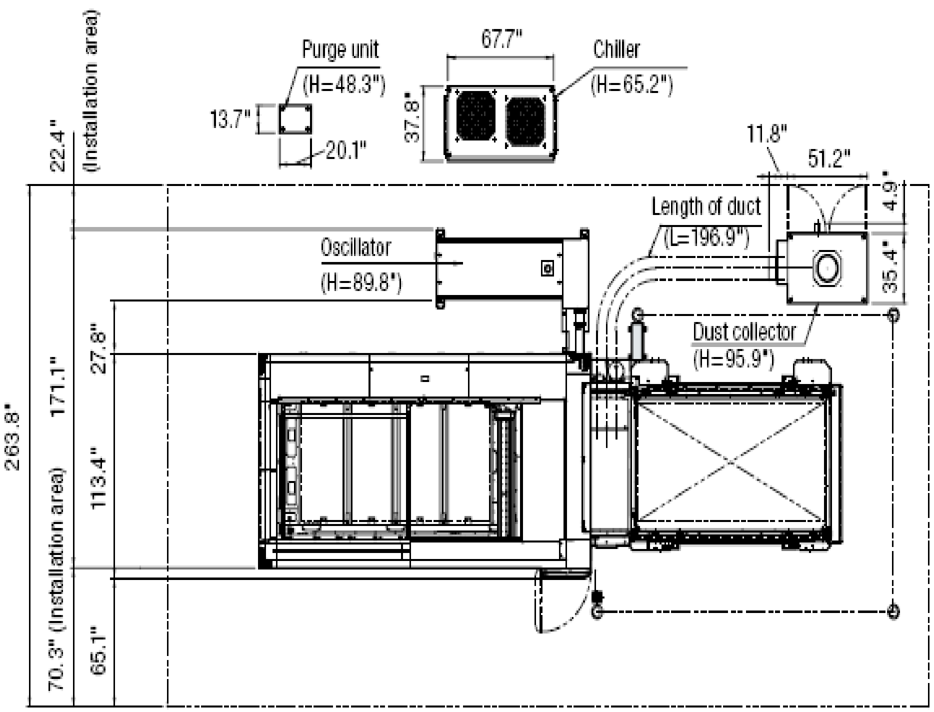


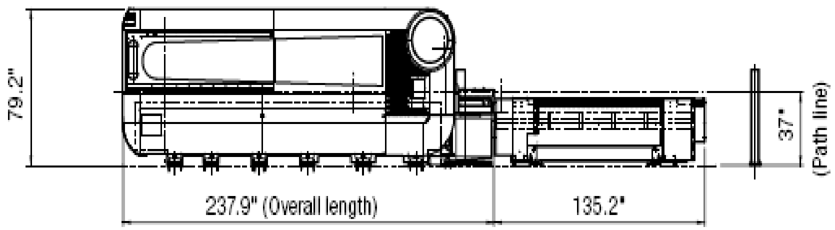


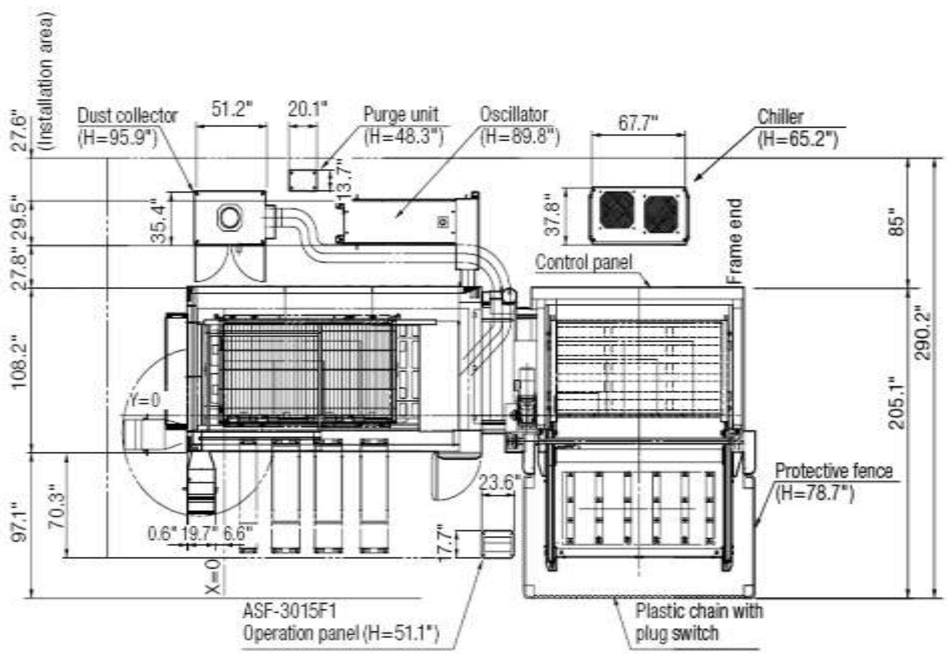



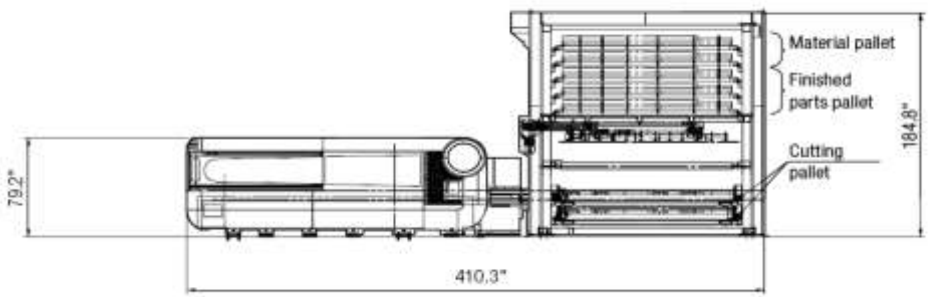



The cutting head. 1 refers to focusing lens seat which houses optical path pressurization air and service gas. 2 refers to the "autofocus" mobile head.




LC-3015F1NT+ASF-3015F1 Fork pallet changer (right output)

**_Floor Plan_**

## Annexure 4: Detailed financial calculations & analysis for financial indicators

### *Assumption*

| ***Name of the Technology*** | ***CNC LASER Cutting Machine*** | | |
|---|---|---|---|
| ***Rated Capacity*** | | | |
| ***Details*** | ***Unit*** | ***Value*** | ***Basis*** |
| No of working days | Days | 300 | Feasibility Study |
| No of Shifts per day | Shifts | 2 | Feasibility Study |
| ***Proposed Investment*** | | | |
| Plant & Machinery | ` (in lakh) | 50.76 | Feasibility Study |
| Cost of modification in civil construction | ` (in lakh) | 1.20 | Feasibility Study |
| Cost of consultancy | ` (in lakh) | 0.80 | Feasibility Study |
| IDC | ` (in lakh) | - | Feasibility Study |
| Total Investment | ` (in lakh) | 563.05 | Feasibility Study |
| ***Financing pattern*** | | | |
| Own Funds (Equity) | ` (in lakh) | 13.19 | Feasibility Study |
| Loan Funds (Term Loan) | ` (in lakh) | 39.57 | Feasibility Study |
| Loan Tenure | years | 6 | Assumed |
| Moratorium Period | Months | 3 | Assumed |
| Repayment Period | Months | 60 | Assumed |
| Interest Rate | %age | 10.00 | SIDBI Lending rate |
| ***Estimation of Costs*** | | | |
| O & M Costs | % on Plant & Equip | 4.00 | Feasibility Study |
| Annual Escalation | %age | 5.00 | Feasibility Study |
| ***Estimation of Revenue*** | | | |
| Production Cost Saving (Electricity, Material, Manpower & Utility) | ` /Year | 4178875 | |
| St. line Depn. | %age | 5.28 | Indian Companies Act |
| IT Depreciation | %age | 15.00 | Income Tax Rules |
| Income Tax | %age | 33.99 | Income Tax |

### *Estimation of Interest on Term Loan* (` *in lakh)*

| Years | Opening Balance | Repayment | Closing Balance | Interest |
|---|---|---|---|---|
| 1 | 39.57 | 2.70 | 36.87 | 4.57 |
| 2 | 36.87 | 6.80 | 30.07 | 3.38 |
| 3 | 30.07 | 7.40 | 22.67 | 2.68 |
| 4 | 22.67 | 8.20 | 14.47 | 1.91 |
| 5 | 14.47 | 9.30 | 5.17 | 1.03 |
| 6 | 5.17 | 5.17 | 0.00 | 0.15 |

### *WDV Depreciation*

| ***Particulars / years*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** |
|---|---|---|---|---|---|
| ***Plant and Machinery*** | | | | | |
| Cost | 52.76 | 10.55 | | | |
| Depreciation | 42.20 | 8.44 | | | |
| WDV | 10.55 | 2.11 | | | |

### *Projected Profitability*

| Particulars / Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| ***Revenue through Savings*** | | | | | | | | |
| Total Revenue (A) | 41.79 | 41.79 | 41.79 | 41.79 | 41.79 | 41.79 | 41.79 | 41.79 |
| **Expenses** | | | | | | | | |
| O & M Expenses | 2.64 | 2.77 | 2.91 | 3.05 | 3.21 | 3.37 | 3.53 | 3.71 |
| Total Expenses (B) | 2.64 | 2.77 | 2.91 | 3.05 | 3.21 | 3.37 | 3.53 | 3.71 |
| PBDIT (A)-(B) | 39.15 | 39.02 | 38.88 | 38.74 | 38.58 | 38.42 | 38.25 | 38.08 |
| Interest | 4.57 | 3.38 | 2.68 | 1.91 | 1.03 | 0.15 | - | - |
| PBDT | 34.58 | 35.64 | 36.20 | 36.83 | 37.55 | 38.27 | 38.25 | 38.08 |
| Depreciation | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 |
| PBT | 31.79 | 32.85 | 33.42 | 34.04 | 34.76 | 35.48 | 35.47 | 35.29 |
| Income tax | - | 9.24 | 12.31 | 12.52 | 12.76 | 13.01 | 13.00 | 12.94 |
| Profit after tax (PAT) | 31.79 | 23.61 | 21.11 | 21.53 | 22.00 | 22.48 | 22.47 | 22.35 |

### *Computation of Tax* *`(in lakh)*

| Particulars / Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Profit before tax | 31.79 | 32.85 | 33.42 | 34.04 | 34.76 | 35.48 | 35.47 | 35.29 |
| Add: Book depreciation | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 |
| Less: WDV depreciation | 42.20 | 8.44 | - | - | - | - | - | - |
| Taxable profit | (7.63) | 27.19 | 36.20 | 36.83 | 37.55 | 38.27 | 38.25 | 38.08 |
| Income Tax | - | 9.24 | 12.31 | 12.52 | 12.76 | 13.01 | 13.00 | 12.94 |

### *Projected Balance Sheet* *`(in lakh)*

| Particulars / Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| ***Liabilities*** | | | | | | | | |
| Share Capital (D) | 13.19 | 13.19 | 13.19 | 13.19 | 13.19 | 13.19 | 13.19 | 13.19 |
| Reserves & Surplus (E) | 31.79 | 55.40 | 76.51 | 98.04 | 120.04 | 142.52 | 164.98 | 187.33 |
| Term Loans (F) | 36.87 | 30.07 | 22.67 | 14.47 | 5.17 | 0.00 | 0.00 | 0.00 |
| Total Liabilities D)+(E)+(F) | 81.85 | 98.65 | 112.37 | 125.69 | 138.39 | 155.70 | 178.17 | 200.52 |
| ***Assets*** | | | | | | | | |
| Gross Fixed Assets | 52.76 | 52.76 | 52.76 | 52.76 | 52.76 | 52.76 | 52.76 | 52.76 |
| Less: Accm. Depreciation | 2.79 | 5.57 | 8.36 | 11.14 | 13.93 | 16.71 | 19.50 | 22.28 |
| Net Fixed Assets | 49.97 | 47.18 | 44.40 | 41.61 | 38.83 | 36.04 | 33.26 | 30.47 |
| Cash & Bank Balance | 31.88 | 51.47 | 67.97 | 84.08 | 99.57 | 119.66 | 144.91 | 170.04 |
| Total Assets | 81.85 | 98.65 | 112.37 | 125.69 | 138.39 | 155.70 | 178.17 | 200.52 |
| Net Worth | 44.98 | 68.59 | 89.70 | 111.23 | 133.23 | 155.70 | 178.17 | 200.52 |
| Dept equity ratio | 2.80 | 2.28 | 1.72 | 1.10 | 0.39 | 0.00 | 0.00 | 0.00 |

### *Projected Cash Flow:* *`(in lakh)*

| Particulars / Years | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| ***Sources*** | | | | | | | | | |
| Share Capital | 13.19 | - | - | - | - | - | - | - | - |
| Term Loan | 39.57 | | | | | | | | |
| Profit After tax | | 31.79 | 23.61 | 21.11 | 21.53 | 22.00 | 22.48 | 22.47 | 22.35 |
| Depreciation | | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 |
| Total Sources | 52.76 | 34.58 | 26.39 | 23.90 | 24.31 | 24.79 | 25.26 | 25.25 | 25.13 |
| ***Application*** | | | | | | | | | |
| Capital Expenditure | 52.76 | | | | | | | | |
| Repayment of Loan | - | 2.70 | 6.80 | 7.40 | 8.20 | 9.30 | 5.17 | - | - |
| Total Application | 52.76 | 2.70 | 6.80 | 7.40 | 8.20 | 9.30 | 5.17 | - | - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Net Surplus | - | 31.88 | 19.59 | 16.50 | 16.11 | 15.49 | 20.09 | 25.25 | 25.13 |
| Add: Opening Balance | - | - | 31.88 | 51.47 | 67.97 | 84.08 | 99.57 | 119.66 | 144.91 |
| Closing Balance | - | 31.88 | 51.47 | 67.97 | 84.08 | 99.57 | 119.66 | 144.91 | 170.04 |

***Calculation of Internal Rate of Return*** ***`(in lakh)***

| ***Particulars / months*** | ***0*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** | ***7*** | ***8*** |
|---|---|---|---|---|---|---|---|---|---|
| Profit after Tax | | 31.79 | 23.61 | 21.11 | 21.53 | 22.00 | 22.48 | 22.47 | 22.35 |
| Depreciation | | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 |
| Interest on Term Loan | | 4.57 | 3.38 | 2.68 | 1.91 | 1.03 | 0.15 | - | - |
| Cash outflow | (52.76) | - | - | - | - | - | - | - | - |
| Net Cash flow | (52.76) | 39.15 | 29.78 | 26.57 | 26.22 | 25.82 | 25.41 | 25.25 | 55.61 |
| ***IRR*** | 60.06% | | | | | | | | |
| ***NPV*** | 114.59 | | | | | | | | |

***Break Even Point*** ***`(in lakh)***

| ***Particulars / Years*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** | ***7*** | ***8*** |
|---|---|---|---|---|---|---|---|---|
| ***Variable Expenses*** | | | | | | | | |
| Operation & Maintenance Exp (75%) | 1.98 | 2.08 | 2.18 | 2.29 | 2.40 | 2.52 | 2.65 | 2.78 |
| Sub Total (G) | 1.98 | 2.08 | 2.18 | 2.29 | 2.40 | 2.52 | 2.65 | 2.78 |
| ***Fixed Expenses*** | | | | | | | | |
| Operation & Maintenance Exp (25%) | 0.66 | 0.69 | 0.73 | 0.76 | 0.80 | 0.84 | 0.88 | 0.93 |
| Interest on Term Loan | 4.57 | 3.38 | 2.68 | 1.91 | 1.03 | 0.15 | 0.00 | 0.00 |
| Depreciation *(H)* | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 |
| Sub Total (I) | 8.02 | 6.86 | 6.19 | 5.46 | 4.62 | 3.78 | 3.67 | 3.71 |
| Sales (J) | 41.79 | 41.79 | 41.79 | 41.79 | 41.79 | 41.79 | 41.79 | 41.79 |
| Contribution (K) | 39.81 | 39.71 | 39.61 | 39.50 | 39.38 | 39.26 | 39.14 | 39.01 |
| Break Even Point (L= G/I) (%) | 20.14% | 17.28% | 15.63% | 13.81% | 11.73% | 9.63% | 9.38% | 9.52% |
| Cash Break Even {(I)-(H)} (%) | 13.14% | 10.26% | 8.59% | 6.76% | 4.66% | 2.53% | 2.26% | 2.38% |
| Break Even Sales (J)*(L) | 8.42 | 7.22 | 6.53 | 5.77 | 4.90 | 4.02 | 3.92 | 3.98 |

***Return on Investment*** ***`(in lakh)***

| ***Particulars / Years*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** | ***7*** | ***8*** | ***Total*** |
|---|---|---|---|---|---|---|---|---|---|
| Net Profit Before Taxes | 31.79 | 32.85 | 33.42 | 34.04 | 34.76 | 35.48 | 35.47 | 35.29 | 273.11 |
| Net Worth | 44.98 | 68.59 | 89.70 | 111.23 | 133.23 | 155.70 | 178.17 | 200.52 | 982.12 |
| **ROI** 27.81% | | | | | | | | | |

***Debt Service Coverage Ratio*** ***`(in lakh)***

| ***Particulars / Years*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** | ***7*** | ***8*** |
|---|---|---|---|---|---|---|---|---|
| **Cash Inflow** | | | | | | | | |
| Profit after Tax | 31.79 | 23.61 | 21.11 | 21.53 | 22.00 | 22.48 | 22.47 | 22.35 |
| Depreciation | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 | 2.79 |
| Interest on Term Loan | 4.57 | 3.38 | 2.68 | 1.91 | 1.03 | 0.15 | 0.00 | 0.00 |
| Total (M) | 39.15 | 29.78 | 26.57 | 26.22 | 25.82 | 25.41 | 25.25 | 25.13 |

***Debt***

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Interest on Term Loan | 4.57 | 3.38 | 2.68 | 1.91 | 1.03 | 0.15 | 0.00 | 0.00 |
| Repayment of Term Loan | 2.70 | 6.80 | 7.40 | 8.20 | 9.30 | 5.17 | 0.00 | 0.00 |
| Total (N) | 7.27 | 10.18 | 10.08 | 10.11 | 10.33 | 5.32 | 0.00 | 0.00 |
| Average DSCR (M/N) | 3.25 | | | | | | | |

## Annexure 5: Details of procurement and implementation plan

| S. No. | Activity | Weeks | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1 | Service Contract | | | | | | | | | | | |
| 2 | Civil Modification | | | | | | | | | | | |
| 3 | Commissioning | | | | | | | | | | | |
| 4 | Training | | | | | | | | | | | |
| 5 | Trail operation | | | | | | | | | | | |

## Annexure 6: Details of technology/equipment and service providers

| Name of Organization | Communication Address | Contact No. |
|---|---|---|
| GMT Engineers Pvt. Ltd. | M. Santhana Raman<br>+91 9003082277<br>H-7A Krupa Colony First Avenue<br>Ashok Nagar Chennai 600083 | +91 44 24896028<br>+91 44 23711881<br>Fax +91 44 24892990<br>chennai@gmtoffice.com<br>www.gmtengineers.com |
| DMG Mori Seiki India Machines and Services Pvt Ltd | "Parimala Towers"<br>#64 Jalahalli Camp Cross,<br>Off MES Road, Yeshwanthpur<br>IN-560022 Bangalore. | Phone: +91 80 40896508 |
| Haas Automation | Manav Marketing Pvt Ltd<br>430-431,12TH cross, 4th Phase, Peenya Industrial Area, Bangalore 560058 India | 91-80-4117 9452/53 |
| Intelmac machine tools Pvt.ltd. | No.95/90, "Sowjanya" 1st Floor, 19th Main,1st 'N' Block, Rajajinagar, BANGALORE - 560 010. INDIA | kiran@intelmacindia.com<br>Tel: +91-80-32982722,<br>+91-80-23577655.<br>Fax: +91-80-23474508 |
| Mazak company | Concord Towers,<br>14th Floor, UB City,<br>Bangalore | |

**Annexure 7: Quotations or Techno-commercial bids for new technology/equipment**

# GMT ENGINEERS PVT LTD

R018-08/2011 August 12, 2011.

**M/s. Petroleum Conservation Research Association,**
(Under the Ministry of Petroleum & Natural Gas – Govt. of India)
" T.M.B. Mansion", 1st Floor, 739, Anna Salai, Chennai – 600 002.
Phone: 044 – 2841 8018 / 2852 0417. Fax: 044 – 2852 1662.
Mb: 09442630838.
Email : thangadurai@pcra.org / athangadurai1@gmail.com Web: www.pcra.org

**Kind Attn.: Mr. A. Thangadurai, Deputy Director.**

Dear Sirs,

On behalf of our Principals, we take pleasure in submitting our **least and final offer** for your kind perusal.

| SL.NO. | PARTICULARS | Qty | Price in US$ |
|---|---|---|---|
| 1 | Laser Metal Cutting Machine Model TQL-LCY 620-3015 (Large Scale), Effecting Working Area 3000X1500mm | | FOB Shanghai |
| | MODEL : TQL-LCY 620-3015 | One | 82,000.00 |
| | | | |
| | **TOTAL** | | 82,000.00 |

**SAMPLE PICTURE IMAGE**

H-7A, KRUPA COLONY, FIRST AVENUE, ASHOK NAGAR, CHENNAI 600 083
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# GMT ENGINEERS PVT LTD

## TECHNICAL PARAMETER

| Technical parameter | |
|---|---|
| Cutting thickness:0.1mm-8mm(good cut) | Electrical source:380V/50HZ/100A |
| Max. output power:620W | X,Y,Z axis geometric positioning accuracy: ≤±0.08mm/1000mm |
| Laser wavelength:1064nm | X,Y,Z axis re-orientation accuracy:≤±0.02mm |
| Pulse frequency:1--300HZ | Machine weight: about 4000kg |
| Min. line width:0.15mm | Cooling mode:7P water-cooling |
| Total Power:16 kw | Max. cutting speed:35mm/s(around 1mm metal) |

| Applibale material and Maximum Cuting Thickness | |
|---|---|
| Cutting Material | Max. cutting depth |
| Mild Steel | 0.1-8mm(good cut);10mm(max. cut) |
| Stainless steel | 0.1-6 mm |
| Copper | 0.5-3 mm |
| Aluminum | 0.5-3 mm |
| Zinc | 0.5-3 mm |

| Machine Consumables | | |
|---|---|---|
| Consumables name | Quantity | Lifespan(hours) |
| Xenon lamp | 2pc | 500-600 |
| Full reflection lens | 1set | 800 |
| Half reflection lens | 1set | 500 |
| Beam expander lens | 1pc | 500 |
| Focus Lens | 1pc | 1200 |
| 45 degree lens | 1pc | 1500 |
| Protection lens | 1pc | 300 |
| Brass nozzle | 1pc | 1500 |

Remark:The above data are tested under on normal machine conditions,working 8hours/day.

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# GMT ENGINEERS PVT LTD

## MACHINE CONSTRUCTION & FEATURES

**GANTRY TYPE MECHANICAL STRUCTURE, COMPACT TAKING UP SMALL AREA**

- One to five Tons in weight, 12mm Thickness Square steel tube and 25mm (T steel panel
- Beautiful and dignified in appearance, war industry technics and backfir treatment; high working efficiency and safety performance, it can obtain mor than 10 years lifespan

**WORKING TABLE**

- High precision CNC Working Table
- Special designed small pneumatic wheel carriers, the metal sheet to be cut may slide along the machine body for easy loading
- Strip working Table; Alu material, put cutting sheet on it

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GMT ENGINEERS PVT LTD

**GERMANY IMPORTED YAG GENERATOR**

1. The generator consist of YAG Crystal Rod, Golden Chamber, xeon Lamp; lifetime of Xeon Lamp is about 500 – 600 hours, YAG crystal Rod is 15,000 hours ( nearly 3 years), high quality Golden Chamber will be never broken)

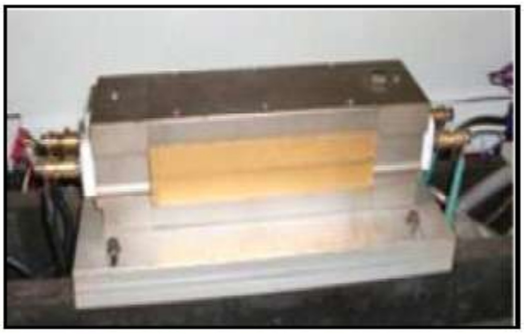
2. This dual xenon-pumped laser is cost effective and easy to maintain; operators can replace the consumables and maintain the product independently after two days training.

**OPTICAL SYSTEM**

- When the laser beam come out, it will be transmitted by reflecting lens, amplifying lens, focusing lens, then it reflects a high intensity laser radiation to the metal surface, finalled a constant external light path complished

- Our imported beam expander lens can shorten the focal depth of the laser, thus the focused energy is further concentrated to effectively improve the processing speed

- Red light preview functions; the red light as its coaxial instructions and works as the adjustment standard of the optical system as well as the instruction position of work spot



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# GMT ENGINEERS PVT LTD

**AUTOMATIC FOCUSING HEIGHT FOLLOWER**

Germany improved technology and adopt Chinese patents, it is one of the key elements to successful metal cutting. An automatic sensor senses the capacitance from the tip of the isolated cutting nozzle to the metal being cut.

This data is then fed in to the height follower controller. The gap between the metal being cut and the cutting nozzle can be adjusted until the desired gap is obtained. As the cutting process begins the auto focus will track the contour of the metal keeping a constant focal point while cutting metal.

**CUTTING HEAD**

Magnetic control, easy to disassemble and unti-crash protection

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# GMT ENGINEERS PVT LTD

**DRIVE SYSTEM**

- Imported Japan-made (Panasonic etc) Servo system ensures the possibility of realizing extreme precise positioning with the excellent dynamic response acceleration property and closed loop control method, and that makes moving positioning mechanism operate smoothly, reliably and free of maintenance

- Motors in X,Y,Z axis; each power 3000W, 1500W, 150W; location accuracy : ≤±0.04mm

**IMPORTED BALL SCREW TRANSMISSION**

High precision, D50mmn other similar supplier only use D25-30mm


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GMT ENGINEERS PVT LTD

**IMPORTED LINEAR GUIDERAIL**

The reduction gear used in large scale cutting machine, it can protect the ball screws transmission well

**GERMANY BRAND REDUCTION GEAR**

Installed in our large scale laser machine on Y Axis, it can protect the Ball screw transmission and keep the smooth operation of the mechanism

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GMT ENGINEERS PVT LTD

**CONTROL SYSTEM**: Industrial PC, easy operation and automatic programming.

**LASER POWER SUPPLY STYSTEM:**

Laser power supply adopts the latest switching power supply (double-lamp pump), it consists of main circuit, control circuits, circuit protection, pre-ignition and maintain circuit with the flow, the pressure, water flow protection device

**COOLING SYSTEM & PURGING SYSTEM**

7p Precision Temperature-Control Display Water Chiller, our chiller' s compressor (imported famous brand), evaporator with high-quality titanium tubes (Stainless Steel Plate evaporator for non-standard products), circulating multi-stage pumps with stainless steel materials, refrigerant drying systems use filters, thermal expansion valve to get high quality, high efficiency and low noise' s performance. And turbo flow intellectual switch is for controlling the temperature of cooling water in laser lamp;the flow control is for ensuring long-term continuously operation of the laser generator.

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GMT ENGINEERS PVT LTD

**GAS SUPPLY SYSTEM:**

- The gas can flow away the cutting dust, keep the clean of the machine and working environment.
- Air, Oxygen and Nitrogen, Argon gas, Xenon gas and other inert gases can be used to cut. Oxygen cuts thicker than Nitrogen, but Nitrogen cuts smoother than Oxygen on the edge. Normally, customers will buy gas from local market, it's cheap and convenient, and customers can choose different gas to cut metals accroding to the metal thickness.

**OPERATION CUT SYSTEM SOFTWARE, SUPPORT AUTOCAD,CORELDRAW:**

The professional cutting software which supports cutting path in dxf, plt and other graphic formats; capable of setting cutting parameters in different layers; combining joined lines to ensure automatic splice of curve nodes; smoothing fold lines to obtain smooth cuts; optimized immediately after the completion of graphic design, thus improve the productivity. By making use of the compensation function of this professional cutting software, various cutting accuracy grades may be obtained.

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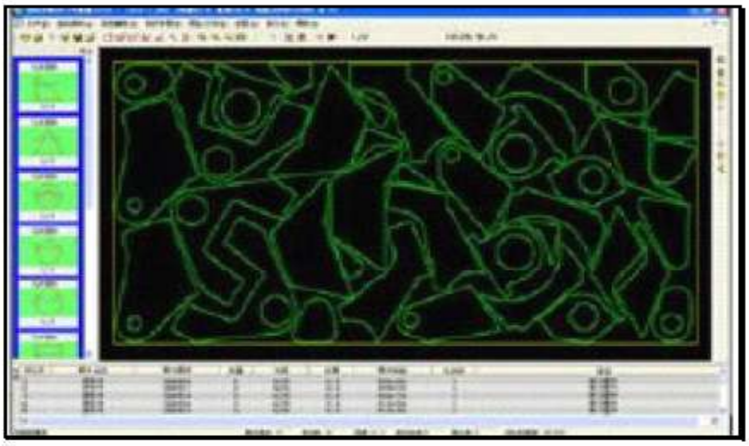
# GMT ENGINEERS PVT LTD

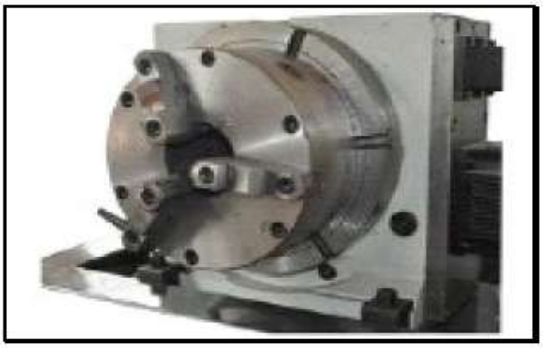
**NESTING SOFTWARE:**

- It provides full-featured management capabilities and complete cutting solution
- Its features of optimization and co-ordination for multiple sheets significantly improve the comprehensive utilization rate. The advanced and practical function of cutting optimization improves the cutting efficiency and reduces the cutting cost considerably.
- It is with strong graphics processing and import capabilities and it supports all versions formats of CAD file. Abundant functions of aggregating statistics and reporting data for cutting materials



**ROTARY SYSTEM (OPTIONAL ITEM):**

This is optional item for cutting round shape and square shape metal pipe/tube. The clamping range is 10-200 mm. Other diameter can be customized.



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# GMT ENGINEERS PVT LTD

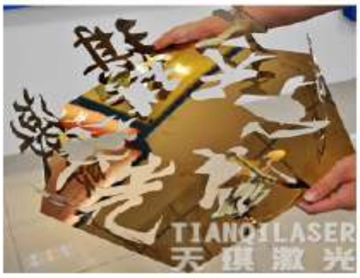
**AIR COMPRESSOR(OPTIONAL ITEM):**

We usually use the compressed air from the air compressor for gas supply, since it would be very economic.

## Appicable Industry and Cutting Samples

YAG laser cutting machine has been widely used in manufacture billboard, sheet metal structure, high-low voltage electric cabinet, textile machinery, kitchenware, metal artware, etc; processing material like Stainless steel, carbon steel, mild steel, alloy steel, spring steel, copper, brass, aluminium sheet, gold, silver, titanium sheet and pipe.







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# GMT ENGINEERS PVT LTD

**TERMS & CONDITIONS**

- Please note that the prices mentioned above are after deducting all trade discount applicable.
- Price: The price is firm and is FOB SHANGHAI
- Customs Duties and other levies involved in Import to be borne by you.
- Sea freight, Customs Clearing Charges, Insurance, Local Transport, Unloading at actuals extra to your a/c.
- The above cost does not include LC Opening charges & any other applicable charges between your Bankers & our principal's bankers.
- Payments: 100% irrevocable LC atsight
- Despatch: 30 working days after order and drawing confirmed or receipt of LC whichever is later.
- Order to be made in favor of our principal.
- The price is for Standard Specifications in case of Customer's special specification the price would be increased.
- Original Proforma Invoice for opening LC shall be forwarded from our principal at the time of placement of orders.
- Our Company will send technical engineer to the Customer location to installation and training, all expenses to the technical engineer to be borne by you.
- Customer needs to pay air rounds ticket、visa application、local transport、a local translator、 three meals (lunch at 12:00noon)、hotel charges.
- VALIDITY: 10 DAYS.

Thanking you,

Yours faithfully,
for **GMT ENGINEERS PVT LTD**

**M. Santhana Raman,**
**Product Manager.**
**Mobile: +91-90030 82277.**

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**Bureau of Energy Efficiency (BEE)**
(Ministry of Power, Government of India)
4th Floor, Sewa Bhawan, R. K. Puram, New Delhi – 110066
Ph.: +91 – 11 – 26179699 (5 Lines), Fax: +91 – 11 – 26178352
Websites: www.bee-india.nic.in, www.energymanagertraining.com

**PCRA, Southern Region**
Petroleum Conservation Research Association T.M.B. Mansion, First Floor, 739, Anna Salai,
Chennai – 600002

**System & Solution (India)**
www.sas.ind.in
ems@sas.ind.in

**India SME Technology Services Ltd**
DFC Building, Plot No.37-38,
D-Block, Pankha Road,
Institutional Area, Janakpuri,
New Delhi-110058
Tel: +91-11-28525534,
Fax: +91-11-28525535
Website: www.techsmall.com