DETAILED PROJECT REPORT
ON
INSTALLATION OF 5-AXIS MACHINE
(BANGALORE MACHINE TOOL CLUSTER)











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INSTALLATION OF 5 – AXIS CNC MACHINE

BANGALORE MACHINE TOOL CLUSTER

BEE, 2010

Detailed Project Report on Installation of 5 – Axis CNC Machine

Bangalore Machine Tool cluster, Karnataka (India)

New Delhi: Bureau of Energy Efficiency;

Detail Project Report No.:

For more information

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Petroleum Conservation Research Association

Bangalore

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List of Abbreviations

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
MoMSME	Ministry of Micro Small and Medium Enterprises
SIDBI	Small Industries Development Bank of India

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 one of the recommendations made in the cluster manual is Installation of 5-axis machine

The benefits of five-axis machining are the machines ability to machine complex shapes in a single set-up. This reduces the machinist setup time and increases production rates. By eliminating multiple set-ups, time and errors are reduced. Additionally, the feature-to-features accuracy is improved because the same zero or datum reference frame is used throughout the manufacturing process. Other advantages of five axis machining is the since simultaneous movement is allowed along the X and Y axis, shorter and more rigid tools may be used. Also, higher spindle/cutting tool speeds may be achieved while reducing the load on the cutting tool.

Shorter and thicker cutters also reduce vibration when machining deep pockets or contoured features with three-axis machines. Example applications for five axis CNC machining are complex three dimensional profiles. These geometric are common for impellers, turbine blades, and plastic mould tools. And under proper maintenance will serve the owner for a period of 15 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)	192.40
2.	Electricity saving	kWh	54768
3.	Monetary benefit	` (in lakhs)	63.99
4.	Simple payback period	Year	3.01
5.	NPV	` (in lakhs)	92.57
6.	IRR	%age	19.99
7.	ROI	%age	20.45
8.	DSCR	Ratio	1.52
9.	CO2 reduction	Tonnes/annum	41.1
10.	Procurement and implementation schedule	week	12

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 grinding machines, ID grinding 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.

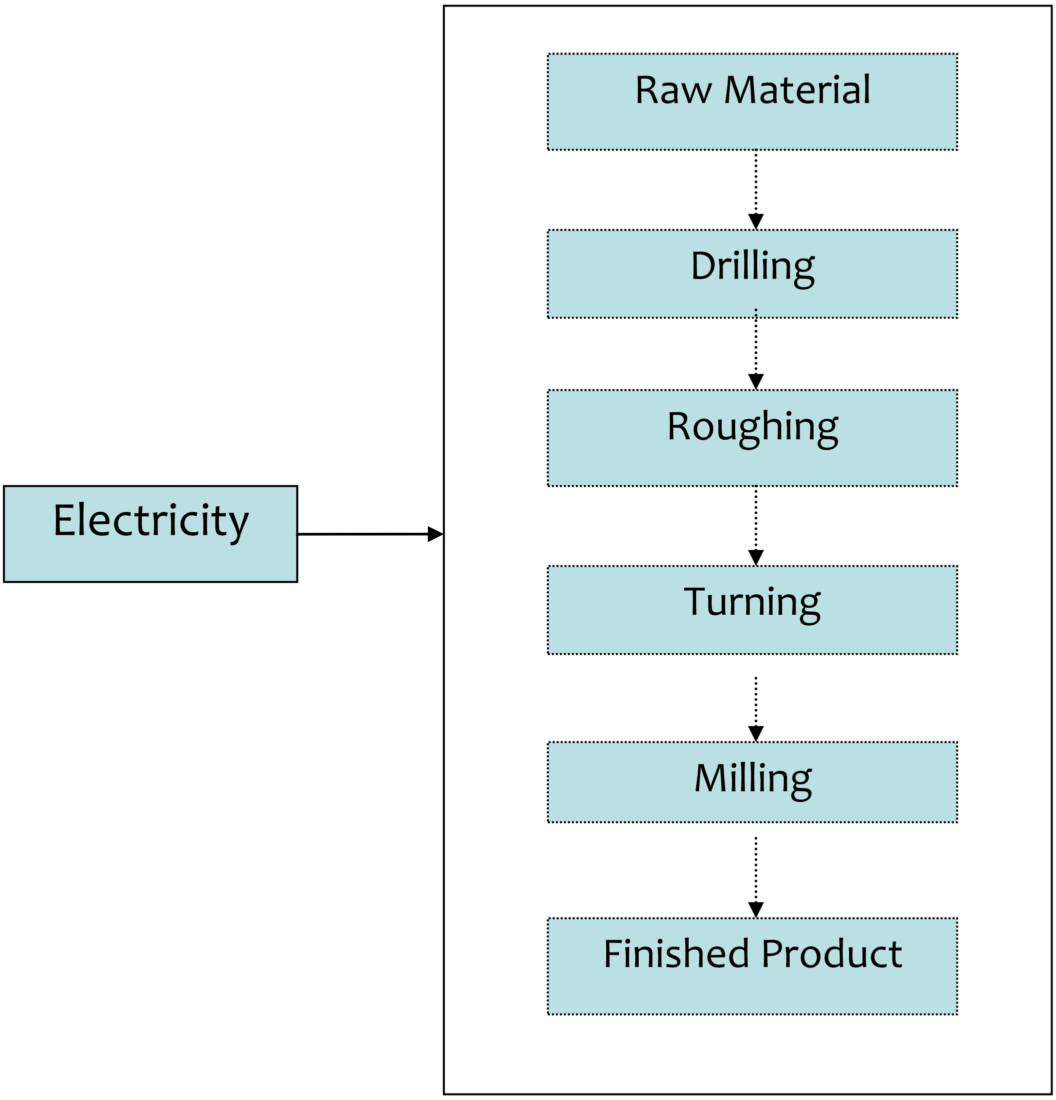


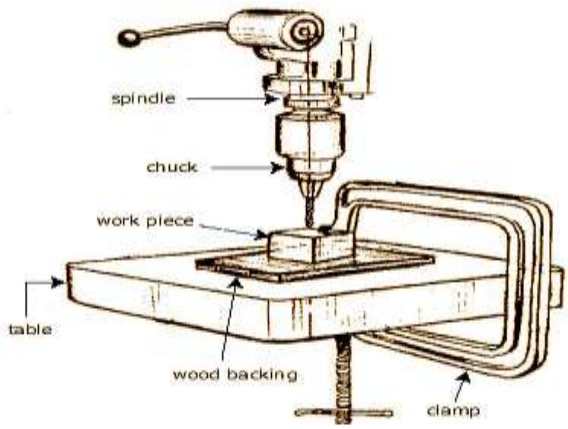
Figure 1.1 Process flow chart of typical Machine Tools Unit

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 hole is made when a drill exits the opposite side of the work; in blind hole the drill does not exit the work piece.

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.



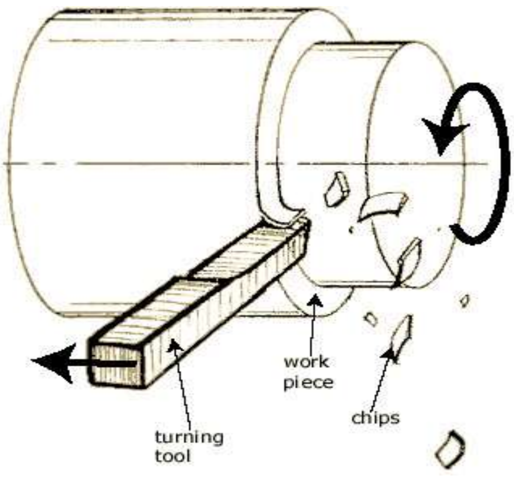
Drilling may affect the mechanical properties of the work piece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the work piece to become more susceptible to corrosion at the stressed surface.

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.

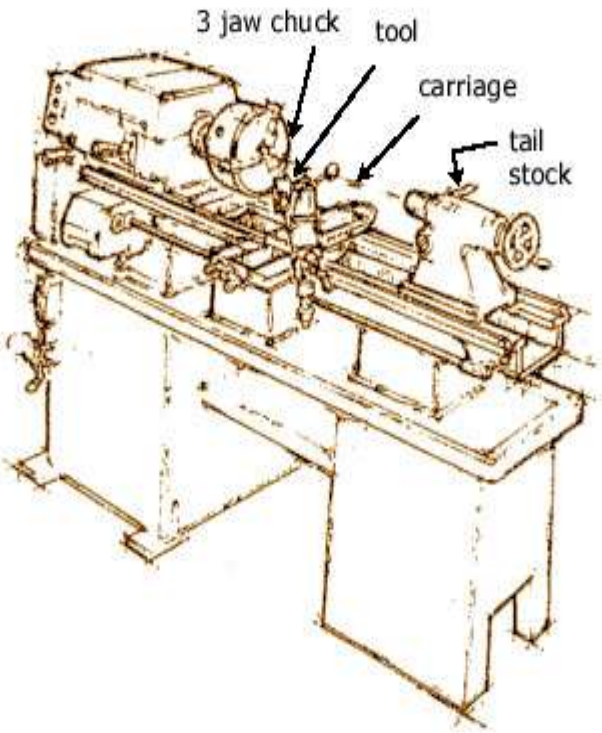
When possible drilled holes should be located perpendicular to the work piece surface. This minimizes the drill bit's tendency to "walk", that is, to be deflected, which causes the hole to be misplaced. The higher the length-to-diameter ratio of the drill bit, the higher the tendency to walk.

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 lathe, 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 lathe, which frequently requires continuous supervision by the operator, or by using a computer controlled and automated lathe 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 lathe.

When turning, a piece of material (wood, metal, plastic, or stone) is rotated and a cutting tool is traversed along 2 Axis 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 lathes 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 lathe is the only machine tool that can reproduce itself.

The turning processes are typically carried out on a lathe, 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 grinding operations. Hard turning, when applied for purely stock removal purposes, competes favourably with rough grinding. However, when it is applied for finishing where form and dimension are critical, grinding is superior. Grinding 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:

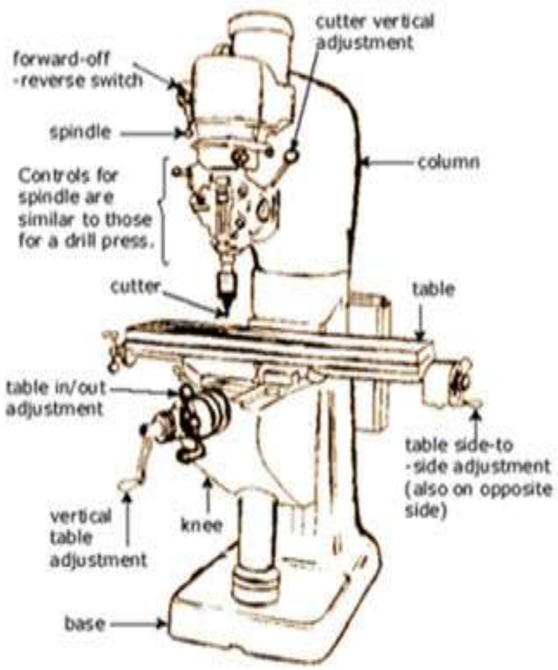
- ***Boring***

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. Lineboring (line boring, line-boring) implies the former. Backboring (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).

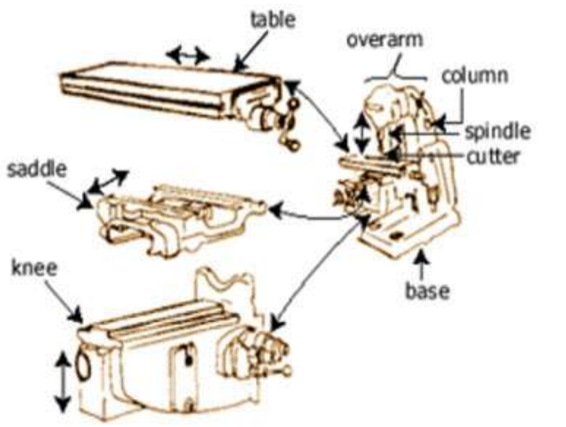
- ***Knurling***

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 lathe 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.



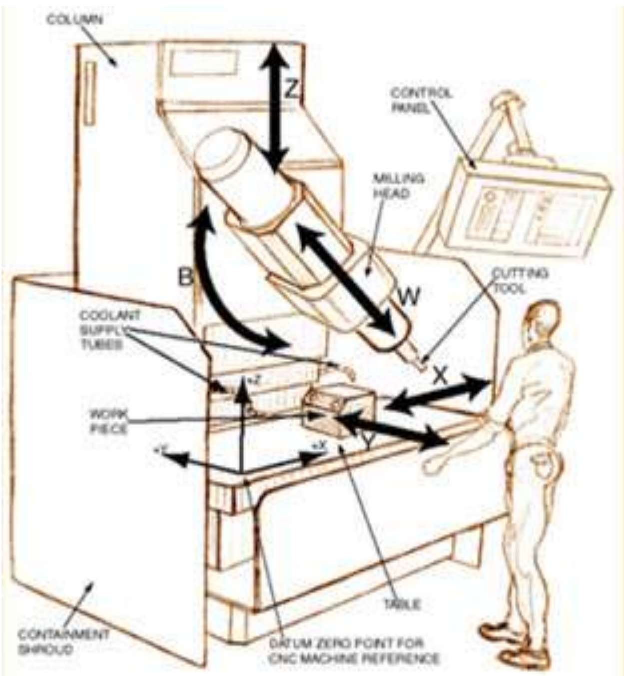
Milling Process

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 grinding 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 Axis that they possess. Axis are labeled as x and y for horizontal 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 Axis: 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 horizontal 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 horizontal 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 are having the backup power generator (Diesel Based) to meet the demand in case of grid 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 is required to achieve the desired material properties. In heat treatment units of the clusters, which are very few in number (only 14 %) electricity is being used 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.

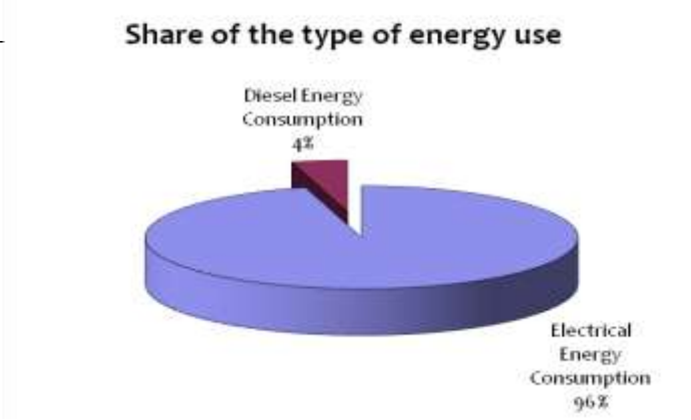


Figure 1.2: Share of Energy Type used in the Machine Tool Units

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 their 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 the major energy is spent towards removing the metal, as per the specifications of the product, while carrying out jobs such as milling, turning, grinding 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 2 axis CNC machines and performing jobs in two or three steps for Multi – Axis Projects whereas some units are using the conventional machines which are completely depends on the operator skills.

The existing technology required two or three times setup of the job on 2 – axis CNC 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.

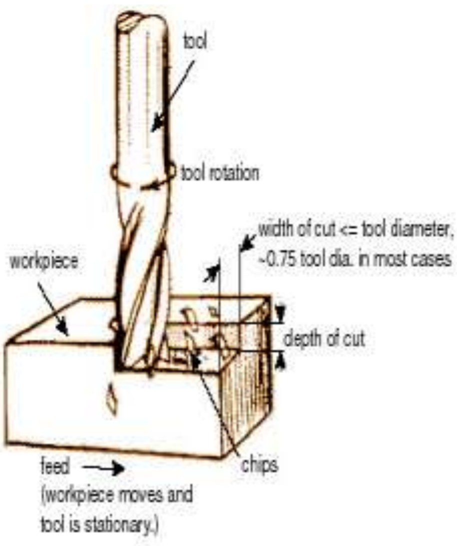
1.3.1 Description of technology/equipment

The machine tool 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, lathes and automats, boring, milling, drilling, grinding, 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 were 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 Axis of a machine, monitoring of the controller and machine tools performance, and monitoring of the cutting process. For a basic three Axis milling machine, with the CNC systems, there could be coordination of feeding velocity and position control of the entire three Axis. 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 Axis 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 grinding capabilities on the machining center. Internationally, machining centers are mostly built with at least 5 Axis. 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 tool 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 manufacturing process 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 total 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 ` 92413 per tonne.

Table 1.2 Energy Consumption Pattern of Machine Tools Cluster

S.No	Particular	Benchmarking	
		Unit	Value
1	Specific Energy Consumption	kWh/Tonne	1533
2	Average Energy Cost	`/Tonne	7665
3	Cost of Material	`/annum	57083
4	Other Cost (Man Power/Utility)	`/tonne	27671
5	***Average Production***	***`/tonne***	***92419***
6	Annual Production	Tonne/annum	96
7	Annual Production Cost	`/annum	8872224

1.4.1 Design and operating parameters /specification

In present scenario 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

S. No.	Type of Fuel	Unit	Value	Equivalent Energy (GJ)	%age Contribution
1	Electricity	kWh/year	147,132	529.8	100

problem.

Based on measured actual electricity consumption by the existing technology (96 tonnes produced annually)

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:

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 to collect 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 were 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.

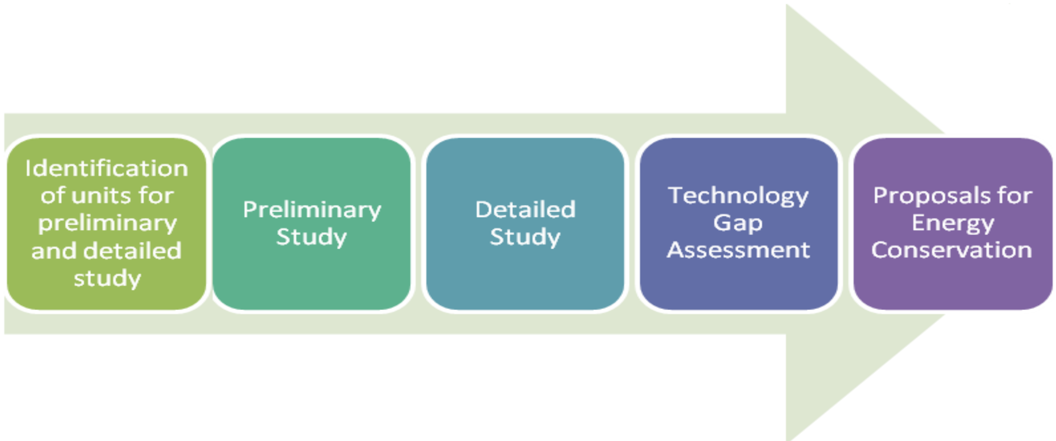


Figure 1.3 Energy auditing methodology

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 current average life cycle is not 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

In new modern manufacturing industry, machine has become more efficient, complicated and fully automated. This type of new generation machines only requires fewer man powers to operate because of automation functions. Thus this new feature will be able to increase the volume of production but it requires new maintenance principles.

Five-Axis Machining Centers do not just move in the linear Axis X, Y and Z. Instead, these machines also move in two rotary Axis, often identified as A and B. The rotary Axis tilt the tool with respect to the part. Physically, it can be either the tool that tilts or the part that tilts. Different machines accomplish the rotary motion in different ways. Some machines move the rotary Axis only to position the tool or work outside of the cut. This is referred to as 3+2 machining. Moving the tool in this way dramatically increases the machining center's access to features at different angles or on different faces of the part. A machine capable of 3+2 machining often can reach all of the machined features of the part in a single setup. True five-axis machining refers to the ability to not just position the tool along the rotary Axis, but also to feed the tool through the cut using these Axis. Interpolated combinations of A-axis, B-axis and linear axis motions can allow the tool to smoothly follow a contoured surface. This type of machining has long been important in the aerospace industry, where machined parts follow the aerodynamic forms of aircraft.

With multi-axis machining, the main objectives are to achieve perfect surface quality, precision, and speed without any need for remachining. Within this context, workflow is typically characterized by the CAD-CAM-CNC process chain. From the CAD system right through to the control system, Siemens can offer an integrated solution for these requirements in the form of its SINUMERIK products. The machine controls are equipped with powerful, advanced functions which, when intelligently used, make the whole process of multi-axis programming and machining (particularly 5-axis machining) considerably easier while at the same time improving the results of production.

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.

CNC based systems that are perfectly suited to the demands of 5-axis machining as well as HSC applications:

- Energy efficient operations
- Simple to operate
- User-friendly programming at the machine
- Optimum performance throughout the CAD - CAM - CNC process chain
- Maximum control over quality at the machine
- Optimized 5-axis functions

Depending on the application, the requirements imposed on the control will vary and a whole range of different functions may be demanded. Within this context, 5-axis machining can be broken down into three broad areas:

- Free-form surfaces (mold making)
- Turbine and driving gear components (impellers, blisks)
- Structural parts (aviation industry)

2.1.2 Process chain for producing 5-axis workpieces

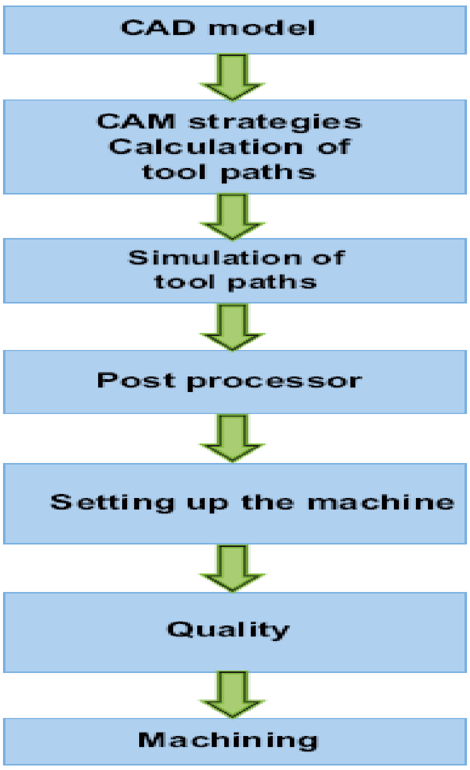


Figure 2.1 Process chain for producing 5-axis work pieces

2.1.3 Technology specification

Table 2.1(a) Equipment Speciation

Particular	*Value*	*Value*
TRAVELS	**S.A.E.**	**S.A.E.**
X Axis	38 "	965 mm
Y Axis	26 "	660 mm
Z Axis	25 "	635 mm
A Axis (tilt)	±120 °	±120 °
B Axis (rot)	360 °	360 °
Spindle Nose to Table (~ min)	-0.85 "	-21.6 mm
Spindle Nose to Table (~ max)	24.15 "	613.4 mm
SPINDLE	**S.A.E.**	**Metric**
Max Rating	20 hp	14.9 kW
Max Speed	7500 rpm	7500 rpm
Max Torque	75 ft-lb @ 1400 rpm	102 Nm @ 1400 rpm
Drive System	Direct Speed Belt Drive	Direct Speed Belt Drive
Max Torque w/opt Gearbox	250 ft-lb @ 450 rpm	339 Nm @ 450 rpm
Taper	CT or BT 40	CT or BT 40
FEEDRATES	**S.A.E.**	**Metric**
Rapids on X	710 in/min	18.0 m/min
Rapids on Y	710 in/min	18.0 m/min
Rapids on Z	710 in/min	18.0 m/min
Max Cutting	500 in/min	12.7 m/min
TRUNNION	**S.A.E.**	**Metric**
Platter Diameter	8.3 "	210 mm
Max Weight on Platter	200 lb	90.7 kg
Max Part Swing (reduced at tilt angles > ± 90°)	23.5 "	597 mm
T-Slot Width	0.625 "	15.88 mm
Number of Std T-Slots	6	6
Pilot Bore Dia	2.000 (+0.0005, -0.0) "	50.80 (+ 0.013, –0.0) mm
Pilot Bore Depth	5.10 "	129.5 mm
Rapids on A	3600 °/min	3600 °/min
Rapids on B	3600 °/min	3600 °/min

Particular	*Value*	*Value*
Max Cutting A	2000 °/min	2000 °/min
Max Cutting B	2000 °/min	2000 °/min
TOOL CHANGER	**S.A.E.**	**Metric**
Type	SMTC	SMTC
Capacity	24+1	24+1
Max Tool Diameter (adjacent empty)	6 "	152 mm
Max Tool Diameter (full)	3 "	76 mm
Max Tool Length (from gage line)	16 "	406 mm
Max Tool Weight	12 lb	5.4 kg
Tool-to-Tool (avg)	2.8 sec	2.8 sec
Chip-to-Chip (avg)	3.6 sec	3.6 sec
ACCURACY	**S.A.E.**	**Metric**
Positioning (±)	0.0002 "	0.005 mm
Repeatability	0.0001 "	0.003 mm
GENERAL	**S.A.E.**	**Metric**
Air Required	4 scfm, 100 psi	113 L/min, 6.9 bar
Coolant Capacity	95 gal	360 L
Power (options may increase requirement)	195-260 VAC/50 A 354-488 VAC/30 A	195-260 VAC/50 A 354-488 VAC/30 A
Machine Weight	15400 lb	6985 kg

The proposed machine model no and brief specifications is given in the table below

Table 2.1(b) DMU 60 monoBLOCK® | Technical data and features

Particular	Unit	Value
X- / Y- / Z-axis	mm	730 (630*)/560/560
Speed range up to	rpm.	12.000
Main drive (40 % DC)	kW	15 / 130
Rapid traverse and feed rate X/Y/Z	m/min	30
NC-rotary table, clamping area	mm	ø 600
Max. load	kg	500

The proposed energy consumption profile and the production cost including the material rejection cost reduction, cost of manpower and the cost of the utility system is given in table 2.2 below:

Table 2.2 Energy Consumption Profile

Particular	Unit	Value
Specific Energy Consumption	kWh/Tonne	1533
Average Energy Cost	`/Tonne	7665
Cost of Material Rejection	`/tonne	57083
Other Cost (Man Power/Utility)	`/tonne	27671
Average Production cost	***`/tonne***	***92419***

2.1.4 Suitability or integration with existing process

5 Axis machine is end to end solution for multi – axis machining process in machine tools manufacturing units. Multi-axis computerized numerical control (CNC) machines have become the application of choice for complex surface machining. These machine tools are widely used in the aerospace, automotive, tool and die making and other industries requiring complex shapes.

Collision-avoidance and geometric-error detection are critical issues for multi-axis CNC machining Simulation of tool paths and machine operations is desirable for cost and time savings. This detailed project report is prepared for the unit having average annual production rate of 90 – 100 tonne.

2.1.5 Superiority over existing technology

The benefits of 5 axis CNC machine is its ability to machine complex shapes in a single setup. This reduces the machinist setup time and incereases the production rate. The main advantage of 5 Axis machining is the ability to save time by machining complex shapes in a single set-up. Additional benefit comes from allowing the use of shorter cutters that permit more accurate machining.

Benefits of Positional 5 Axis Machining

- Ideal for machining deep cores and cavities
- Short cutters give increased accuracy and higher quality surface finish
- Allows the machining of undercuts
- Significant time benefits through use of only one set up

Benefits of Continuous 5 Axis Machining

- Ideal for Profiling parts
- Ideal for machining deep corners and cavities

- Shorter cutters give increased accuracy and higher quality surface finish
- Allows for machining with the flank or bottom of the tool
- Can be used with a full range of tool types
- Full gouge protection
- Can be used with models in STL format

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.

2.1.6 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.

2.1.7 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 - .

2.1.8 Terms and condition of sales

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

2.1.9 Process down time during implementation

The installation of 5 axis machine can be done in the 9 days, However the 5 axis machine is end to end solution of multi axis 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 multi – axis machine, the technology and machine will continue to work up to 15 years under proper maintains. No need to make any further huge modification after one time installation, in case of risk analysis there is a need of proper maintenance and timely oiling.

2.3 Suitable unit/plant for implementation of proposed technology

Multi – axis machine is suitable for the units involved in the production of morethan 2 and 3 axis job/product.

3 ECONOMIC BENEFITS FROM NEW ENERGY EFFICIENT TECHNOLOGY

3.1 Technical benefits

3.1.1 Fuel saving

At present majority of the machine tools manufacturing units operate with 2 axis or 3 axis machine in steps. Existing technology requires two or three time set up of the job on the plate result in increase in time, energy and rejection. The existing technology also requires a skilled manpower to operate this type of prudction machinery.

Installation of 5 axis CNC machine is the ability to machine complex shapes in a single setup. This reduces the machinist setup time and incerease the production rate. The main advantage of 5 Axis machining is the ability to save time by machining complex shapes in a single set-up. Additional benefit comes from allowing the use of shorter cutters that permit more accurate machining. Energy & Cost saving including the energy, material rejection, man power cost and utility cost for a typical unit by installation of 5 – Axis Machine are tabulated below:

Table 3.1 Energy savings estimation for 5 – Axis Machine

S.No	Particular	Unit	2 Axis or 3 Axis Machine	5 Axis/Multi – Axis Machine
1	Specific Energy Consumption	kWh/Tonne	1533	1207
2	Average Energy Cost	`/Tonne	7665	6035
3	Cost of Material Rejection	`,/Tonne	57083	32503
4	Other Cost (Man Power/Utility)	`./tonne	27671	15793.5
5	Average Production cost	`./tonne	92419	54331.5
6	Annual Production	Tonne/annum	96	96
7	Annual Production Cost	`/annum	8872224	5215824
8	Reduction in Production Cost	`./Tonne	38087.5	
9	Annual cost reduction	`/Annum	3656400	

A 5 – Axis 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 multi – Axis machines revels that the 5- Axis machine may produce two times production/ material at same time and at same energy consumption.

***Note:-** *As in the proposed DPR 2- Axis CNC is replaced by 5- Axis CNC, it is assumed that it improves the overall productivity by 1.75 times i.e. 96 Tonnes/Annum in earlier case to 168 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 %.

*****Detailed breakup of savings is provided in the annexure 1***

3.1.2 Improvement in product quality

five-axis machine is presently one of the most versatile machine tools available and they are becoming increasingly common. This machening not only improve the quality of the product which is totaly designed by CNC machine with comparision to the exisitng manual set up based product.

The rejection of material in multi – axis CNC machining is almost nill while comparing with existing system/technology. Finally, high-speed cutting parameter coordination is executed by a CNC cycle for easy set-up and user-friendly activation of advanced motion control features. Excessive programming time is eliminated, because the adaptation of the CNC set-up is done according to the particular machining technique being employed.

3.1.3 Increase in production

A 5 – Axis 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 multi – Axis machines revels that the 5- Axis machine may produce two times production/ material at same time and at same energy consumption.

3.1.4 Reduction in raw material consumption

The rejection of material in multi – axis CNC machining 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 5 – Axis 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.

3.2 Monetary benefits

Monetary savings in a typical unit after installation of 5 – Axis machine has been estimated around ` 63.99 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

Proposed technology minimizes the surrounding temperature of tunnel kiln and also reduces the GHG emission.

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 clean fuel based operation. No effluent generation or reduction will afect.

3.4.2 Reduction in GHG emission such as CO2, NOx, etc

There are significant reductions to be achieved in Green House Gas emission by adoption of advance CNC technology like Multi – Axis Macxhine in machine tools industries. Reduction in electricity consumption translates into GHG reductions is estimated to be 41.1 tonne of CO_2 per Year.

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 Multi – Axis or 5 – Axis Machine are provided in Table 4.1 below:

Table 4.1 Cost of equipment

S. No.	Particulars	Cost
1	Cost of 5 – Axis Machine (CIF Chennai)	` 19000000

Cost of machine is in Euro at the rate of (1Euro = INR 64)with 35% of Taxes and Duties.

4.1.2 Other costs

Table 4.2 Cost of civil work and consultancy

S. NO.	Particulars	Cost
1.	Cost of civil work	` 1,00,000/-
2.	Electrical & Utility Expanses	` 1,00,000/-
3.	Cost of Consultancy and installation	` 40,000/-
Total	Two hundred and forty thousand only/-	` 2,40,000/-

Total investment in the proposed technology (including equipment cost & Other cost) is ` 192.40 lakh.

4.2 Arrangements of funds

Proposed financing for the replacement of 2 axis or 3 axis machine with 5 axis machine is made considering a debt equity ratio of 3:1, which is normally allowed by financial institutions for financing energy efficiency projects. On the basis of debt equity ratio of 3:1 the promoter's contribution works out to 25% of the project cost and the balance would be term loan from the Bank / FIs.

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

The estimated payback period is about 3.01 years.

4.3.3 Net Present Value (NPV)

Net Present Value of new project would work out ` 92.57 lakh.

4.3.4 Internal rate of return (IRR)

The after tax internal rate of return of the project works out to be 19.99%. 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 20.45 %.

Table 4.3 Financial indicator of proposed technology

Particulars	Unit	Value
Simple Pay Back period	Years	3.01
IRR	%age	19.99
NPV	` in lakh	92.57
ROI	%age	20.45
DSCR	ratio	1.52

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 10%

Fuel saving decrease by 10%

Table 4.4 Sensitivity analysis

Particulars	*IRR*	*NPV in lakh*	*ROI*	*DSCR*
Normal	19.99%	92.57	20.45%	1.52
10% increase in fuel savings	20.12%	93.76	20.48%	1.52
10% decrease in fuel savings	19.86%	91.37	20.42%	1.51

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

4.5 Procurement and implementation schedule

Total time period required for implementation of proposed mahcine will be 12 weeks. The installation of 5 – axis machine can be done in the 7 – 9 days, However the 5 – axis machine is end to end solution of multi axis production process, implementation will not affect production. Thus implementation of this technology will not affect the process. Details of procurmnet and implementation schduels are furnished at annexure 6.

ANNEXURE

Annexure – 1: Energy audit reports used for establishing

The results of detail energy audit for the machine cluster unit with energy consumption patern are given below:

Audit No. 1

Particular	Unit	Value
Specific Energy Consumption	kWh/Tonne	1533
Average Energy Cost	`Tonne	7665
Cost of Material Rejection	`,/tonne	57083
Other Cost (Man Power/Utility)	`./tonne	27671
Average Production cost	`./tonne	92419
Annual Production	Tonne	96
Annual Production Cost	`./annum	8872224

S.No	Particular	Unit	2 Axis or 3 Axis Machine	5 Axis/Multi – Axis Machine
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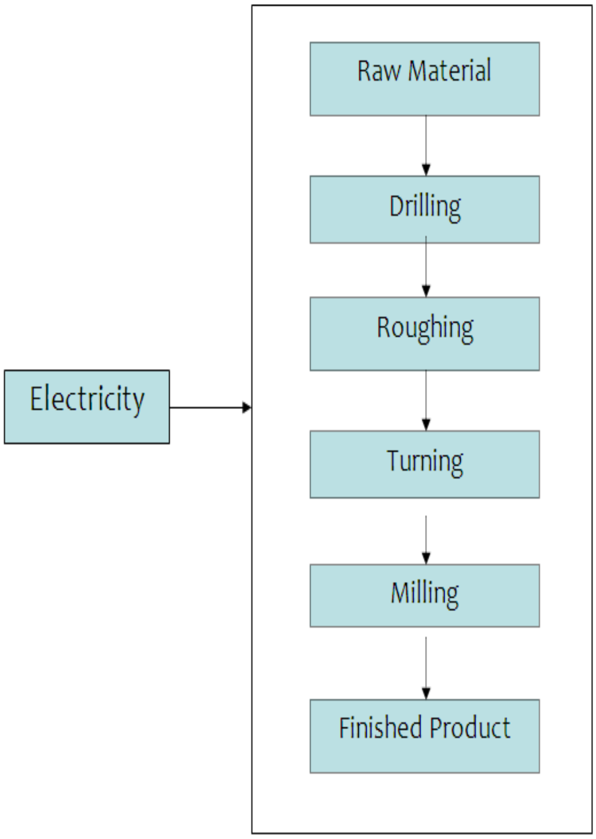
***Note:-** *As in the proposed DPR 2- Axis CNC is replaced by 5- Axis CNC, it is assumed that it improves the overall productivity by 1.75 times i.e. 96 Tonnes/Annum in earlier case to 168 Tonnes/Annum after implementation. Accordingly, the energy saving could be achieved.Consequnetly, the O&M cost of machinery shall increase to 5 % with annual Escalation of 5 %.*

S.No	Particular	Unit	2 Axis or 3 Axis Machine	5 Axis/Multi – Axis Machine
1	Average Production	`/tonne	92419	54331.5
2	Annual Production	Tonne/annum	96	168
3	Annual Production Cost	`/annum	8872224	9127692
4	Annual cost reduction	`/Annum		6398784

So the saving reaches to ***`6398784*** *(38088*168 tonne)*

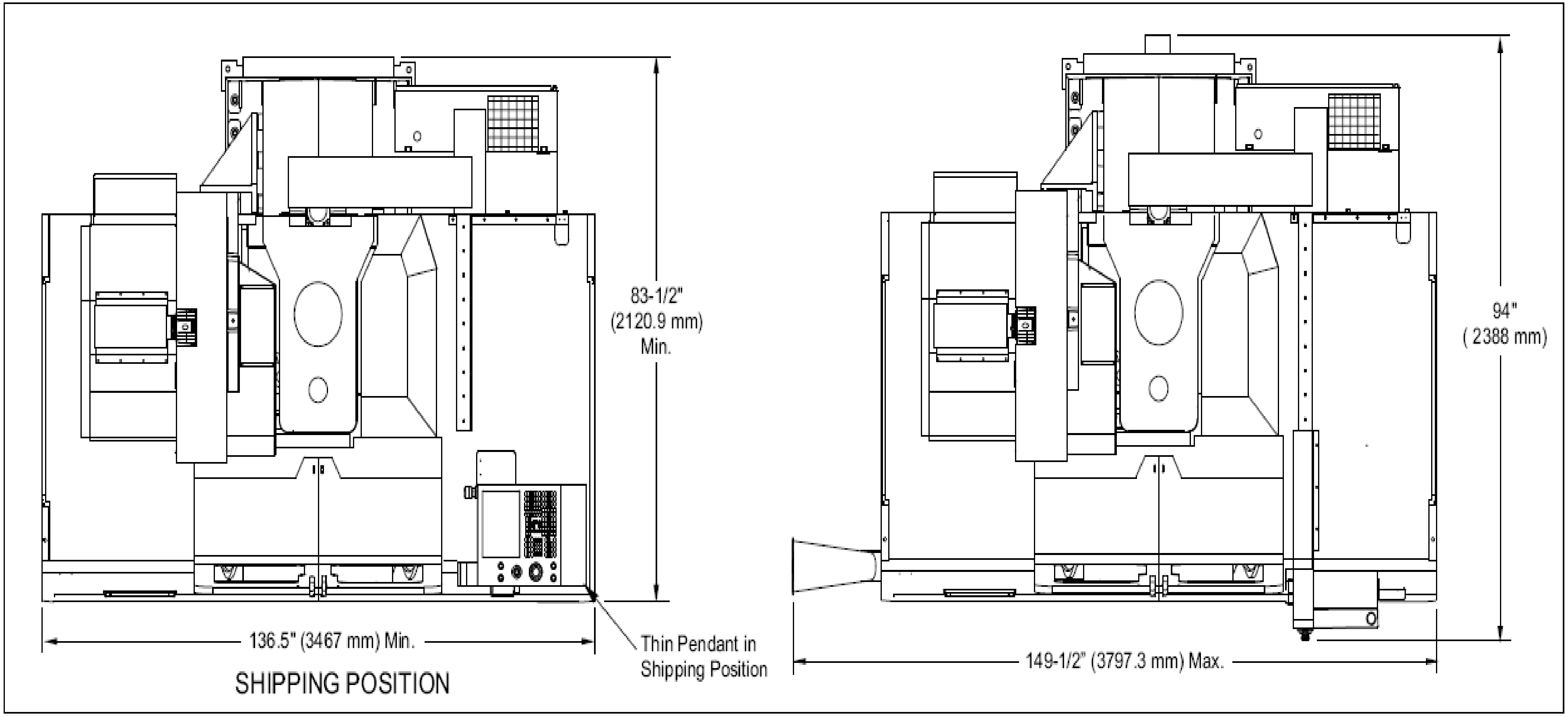
Annexure – 2: Process flow diagram

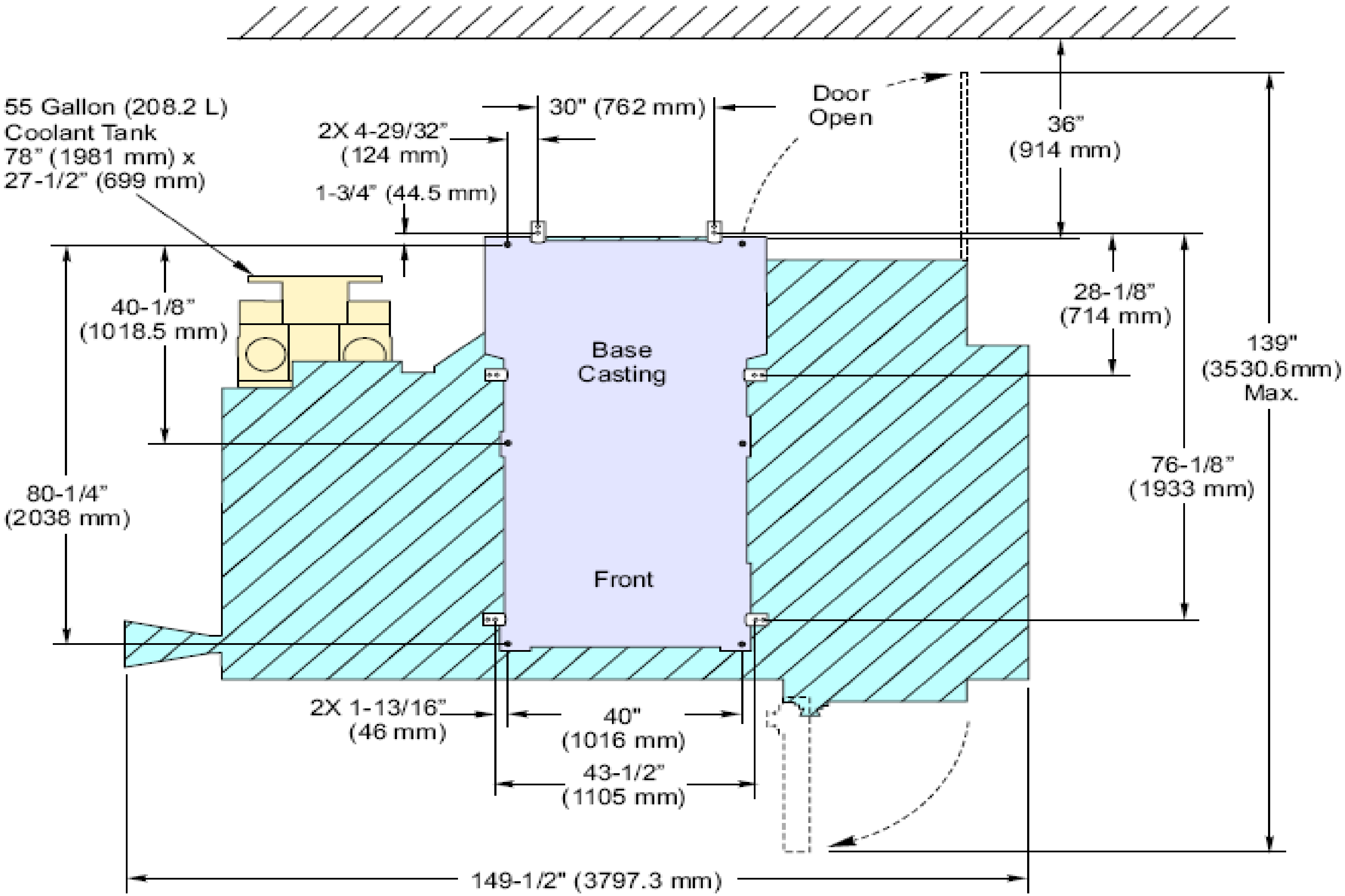
5 Axis machine is end to end solution for multi – axis machining process in machine tools manufacturing units. Multi-axis computerized numerical control (CNC) machines have become the application of choice for complex surface machining. These machine tools are widely used in the aerospace, automotive, tool and die making and other industries requiring complex shapes.

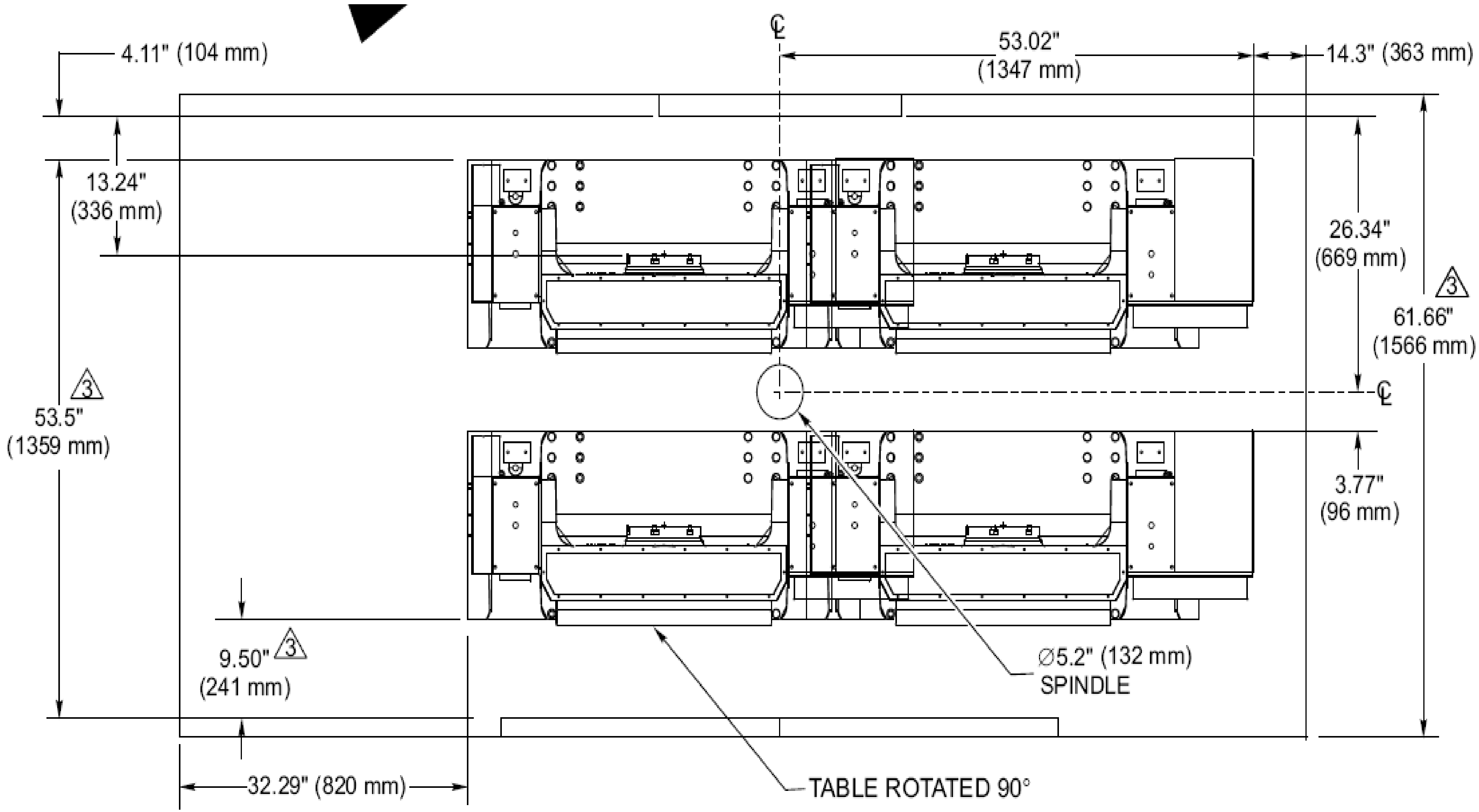


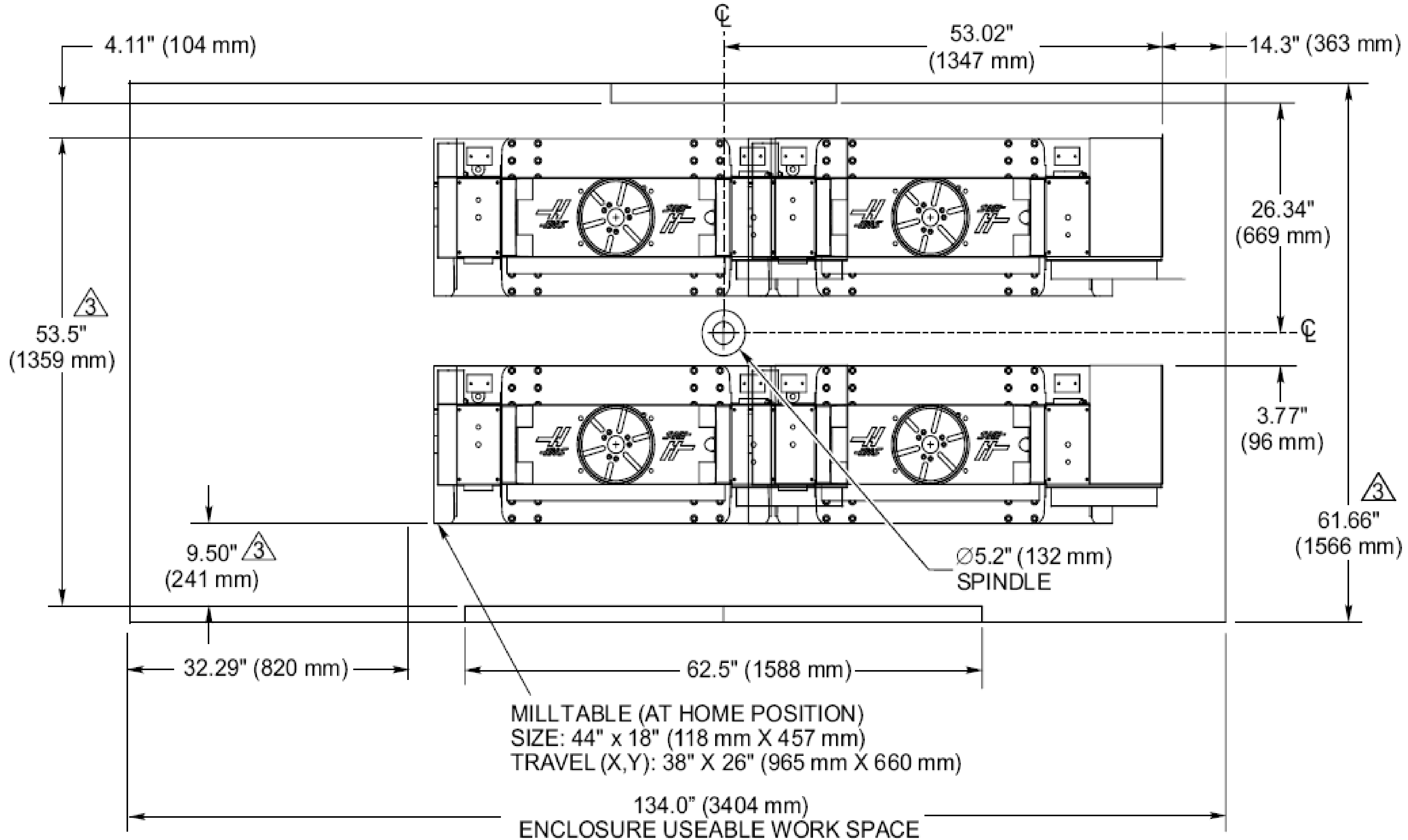
Annexure – 3 Technical Drawing of 5 Axis CNC Machines

Shipping Position

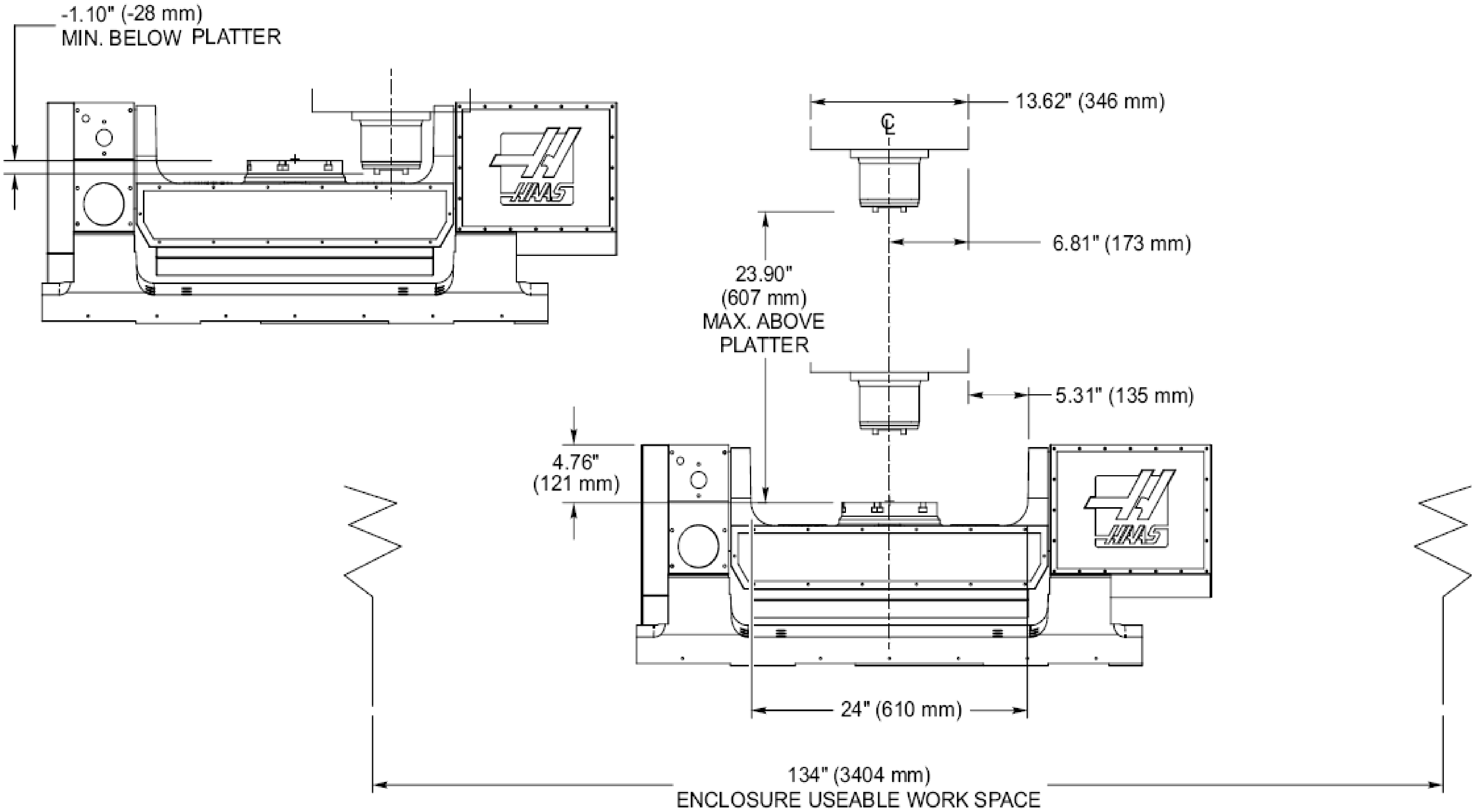


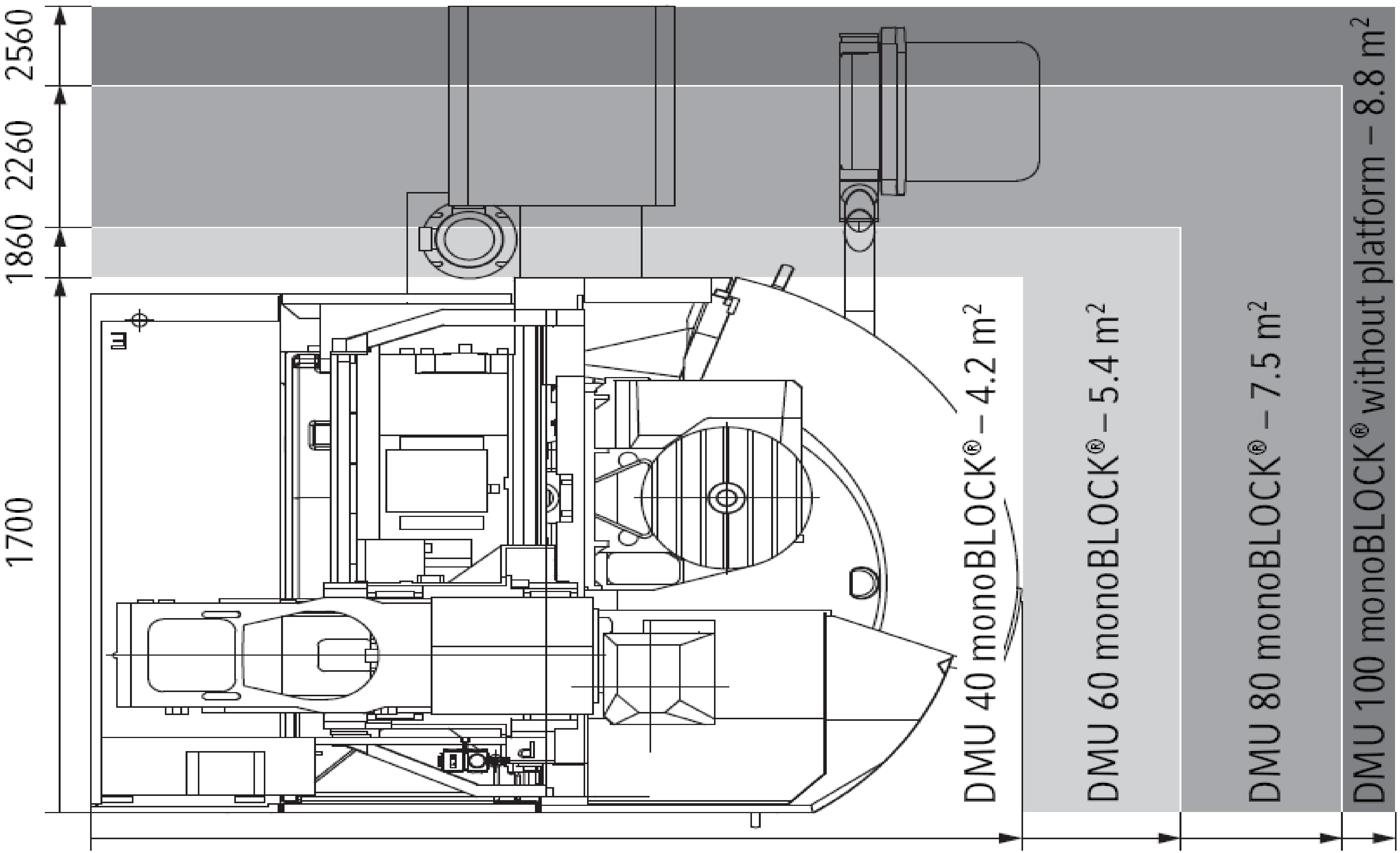

55 Gallon (208.2 L)
Coolant Tank
78" (1981 mm) x
27-1/2" (699 mm)
2X 4-29/32"
(124 mm)
1-3/4" (44.5 mm)
30" (762 mm)
Door
Open
36"
(914 mm)
40-1/8"
(1018.5 mm)
Base
Casting
28-1/8"
(714 mm)
139"
(3530.6mm)
Max.
80-1/4"
(2038 mm)
76-1/8"
(1933 mm)
Front
2X 1-13/16"
(46 mm)
40"
(1016 mm)
43-1/2"
(1105 mm)
149-1/2" (3797.3 mm)


4.11" (104 mm)
53.02" (1347 mm)
14.3" (363 mm)
13.24" (336 mm)
26.34" (669 mm)
61.66" (1566 mm)
53.5" (1359 mm)
3.77" (96 mm)
9.50" (241 mm)
Ø5.2" (132 mm) SPINDLE
32.29" (820 mm)
TABLE ROTATED 90°



4.11" (104 mm)
53.02"
(1347 mm)
14.3" (363 mm)
26.34"
(669 mm)
3.77"
(96 mm)
53.5"
(1359 mm)
61.66"
(1566 mm)
9.50"
(241 mm)
Ø5.2" (132 mm)
SPINDLE
32.29" (820 mm)
62.5" (1588 mm)
MILLTABLE (AT HOME POSITION)
SIZE: 44" x 18" (118 mm X 457 mm)
TRAVEL (X,Y): 38" X 26" (965 mm X 660 mm)
134.0" (3404 mm)
ENCLOSURE USEABLE WORK SPACE


-1.10" (-28 mm)
MIN. BELOW PLATTER
13.62" (346 mm)
6.81" (173 mm)
23.90"
(607 mm)
MAX. ABOVE
PLATTER
5.31" (135 mm)
4.76"
(121 mm)
24" (610 mm)
134" (3404 mm)
ENCLOSURE USEABLE WORK SPACE



2560
2260
1860
1700
DMU 40 monoBLOCK® – 4.2 m²
DMU 60 monoBLOCK® – 5.4 m²
DMU 80 monoBLOCK® – 7.5 m²
DMU 100 monoBLOCK® without platform – 8.8 m²

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

Assumption

Name of the Technology	Five - Axis CNC Machine		
Rated Capacity	NA		
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)	190	Feasibility Study
Cost of modification in civil construction	` (in lakh)	1.00	Feasibility Study
Electricity & utility expenses	` (in lakh)	1.00	Feasibility Study
Cost of consultancy	` (in lakh)	0.40	Feasibility Study
Total Investment	` (in lakh)	192.40	Feasibility Study
Financing pattern			
Own Funds (Equity)	` (in lakh)	48.10	Feasibility Study
Loan Funds (Term Loan)	` (in lakh)	144.30	Feasibility Study
Loan Tenure	years	5	Assumed
Moratorium Period	Months	6	Assumed
Repayment Period	Months	66	Assumed
Interest Rate	%age	10.00	SIDBI Lending rate
Estimation of Costs			
O & M Costs	% on Plant & Equip	5.00	Feasibility Study
Annual Escalation	%age	5.00	Feasibility Study
Estimation of Revenue			
Electricity saving	kWh/Tonne	326	
Annual production	Tonne/Annum	168	
Cost	`/kWh	5	
Other savings	`/Annum	36457.5	
St. line Depn.	%age	5.28	Indian Companies Act
IT Depreciation	%age	80.00	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	144.30	6.00	138.30	16.76
2	138.30	12.00	126.30	13.28
3	126.30	15.00	111.30	11.95
4	111.30	18.00	93.30	10.31
5	93.30	24.00	69.30	8.26
6	69.30	27.00	42.30	5.70
7	42.30	27.50	14.80	3.00
8	14.80	14.80	0.00	0.44
		144.30		

WDV Depreciation

Particulars / years	1	2
Plant and Machinery		
Cost	192.40	38.48
Depreciation	153.92	30.78
WDV	38.48	7.70

Projected Profitability

Particulars / Years	1	2	3	4	5	6	7	8	9	10
Revenue through Savings										
Total Revenue (A)	63.99	63.99	63.99	63.99	63.99	63.99	63.99	63.99	63.99	63.99
Expenses										
O & M Expenses	9.62	10.10	10.61	11.14	11.69	12.28	12.89	13.54	14.21	14.92
Total Expenses (B)	9.62	10.10	10.61	11.14	11.69	12.28	12.89	13.54	14.21	14.92
PBDIT (A)-(B)	54.37	53.89	53.38	52.85	52.29	51.71	51.10	50.45	49.77	49.06
Interest	16.76	13.28	11.95	10.31	8.26	5.70	3.00	0.44	-	-
PBDT	37.61	40.60	41.43	42.54	44.04	46.01	48.10	50.01	49.77	49.06
Depreciation	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16
PBT	27.45	30.44	31.28	32.38	33.88	35.85	37.94	39.85	39.62	38.90
Income tax	-	3.34	14.08	14.46	14.97	15.64	16.35	17.00	16.92	16.68
Profit after tax (PAT)	27.45	27.11	17.19	17.92	18.91	20.21	21.59	22.85	22.70	22.23

Computation of Tax

`(in lakh)

Particulars / Years	1	2	3	4	5	6	7	8	9	10
Profit before tax	27.45	30.44	31.28	32.38	33.88	35.85	37.94	39.85	39.62	38.90
Add: Book depreciation	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16
Less: WDV depreciation	153.92	30.78	-	-	-	-	-	-	-	-
Taxable profit	(116.31)	9.82	41.43	42.54	44.04	46.01	48.10	50.01	49.77	49.06
Income Tax	-	3.34	14.08	14.46	14.97	15.64	16.35	17.00	16.92	16.68

Projected Balance Sheet `(in lakh)

Particulars / Years	1	2	3	4	5	6	7	8	9	10
Liabilities										
Share Capital (D)	48.10	48.10	48.10	48.10	48.10	48.10	48.10	48.10	48.10	48.10
Reserves & Surplus (E)	27.45	54.56	71.75	89.67	108.58	128.79	150.38	173.24	195.93	218.16
Term Loans (F)	138.30	126.30	111.30	93.30	69.30	42.30	14.80	0.00	0.00	0.00
Total Liabilities D)+(E)+(F)	213.85	228.96	231.15	231.07	225.98	219.19	213.28	221.34	244.03	266.26
Assets										
Gross Fixed Assets	192.40	192.40	192.40	192.40	192.40	192.40	192.40	192.40	192.40	192.40
Less: Accm. Depreciation	10.16	20.32	30.48	40.63	50.79	60.95	71.11	81.27	91.43	101.59
Net Fixed Assets	182.24	172.08	161.92	151.77	141.61	131.45	121.29	111.13	100.97	90.81
Cash & Bank Balance	31.61	56.88	69.23	79.31	84.38	87.75	92.00	110.21	143.06	175.45
Total Assets	213.85	228.96	231.15	231.07	225.98	219.19	213.28	221.34	244.03	266.26
Net Worth	75.55	102.66	119.85	137.77	156.68	176.89	198.48	221.34	244.03	266.26
Dept equity ratio	2.88	2.63	2.31	1.94	1.44	0.88	0.31	0.00	0.00	0.00

Projected Cash Flow: `(in lakh)

Particulars / Years	0	1	2	3	4	5	6	7	8	9	10
Sources											
Share Capital	48.10	-	-	-	-	-	-	-	-	-	-
Term Loan	144.30										
Profit After tax		27.45	27.11	17.19	17.92	18.91	20.21	21.59	22.85	22.70	22.23
Depreciation		10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16
Total Sources	192.40	37.61	37.27	27.35	28.08	29.07	30.37	31.75	33.01	32.86	32.39
Application											
Capital Expenditure	192.40										
Repayment of Loan	-	6.00	12.00	15.00	18.00	24.00	27.00	27.50	14.80	-	-
Total Application	192.40	6.00	12.00	15.00	18.00	24.00	27.00	27.50	14.80	-	-
Net Surplus	-	31.61	25.27	12.35	10.08	5.07	3.37	4.25	18.21	32.86	32.39
Add: Opening Balance	-	-	31.61	56.88	69.23	79.31	84.38	87.75	92.00	110.21	143.06

Closing Balance	-	31.61	56.88	69.23	79.31	84.38	87.75	92.00	110.21	143.06	175.45

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

Particulars / months	0	1	2	3	4	5	6	7	8	9	10
Profit after Tax		27.45	27.11	17.19	17.92	18.91	20.21	21.59	22.85	22.70	22.23
Depreciation		10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16
Interest on Term Loan		16.76	13.28	11.95	10.31	8.26	5.70	3.00	0.44	-	-
Cash outflow	(192.40)	-	-	-	-	-	-	-	-	-	-
Salvage value											89.81
Net Cash flow	(192.40)	54.37	50.55	39.30	38.39	37.33	36.07	34.75	33.45	32.86	122.20
IRR	19.99%										
NPV	92.57										

Break Even Point *`(in lakh)*

Particulars / Years	1	2	3	4	5	6	7	8	9	10
Variable Expenses										
O & M Cost	7.22	7.58	7.95	8.35	8.77	9.21	9.67	10.15	10.66	11.19
Sub Total (G)	7.22	7.58	7.95	8.35	8.77	9.21	9.67	10.15	10.66	11.19
Fixed Expenses										
Operation & Maintenance Exp (25%)	2.41	2.53	2.65	2.78	2.92	3.07	3.22	3.38	3.55	3.73
Interest on Term Loan	16.76	13.28	11.95	10.31	8.26	5.70	3.00	0.44	0.00	0.00
Depreciation *(H)*	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16
Sub Total (I)	29.32	25.97	24.76	23.25	21.34	18.93	16.38	13.98	13.71	13.89
Sales (J)	63.99	63.99	63.99	63.99	63.99	63.99	63.99	63.99	63.99	63.99
Contribution (K)	56.77	56.41	56.03	55.63	55.22	54.78	54.32	53.83	53.33	52.79
Break Even Point (L= G/I) (%)	51.65%	46.03%	44.18%	41.80%	38.64%	34.55%	30.16%	25.98%	25.71%	26.31%
Cash Break Even {(I)-(H)} (%)	33.75%	28.02%	26.05%	23.54%	20.25%	16.01%	11.45%	7.10%	6.66%	7.07%
Break Even Sales (J)*(L)	33.05	29.45	28.27	26.74	24.73	22.11	19.30	16.62	16.45	16.83

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

Particulars / Years	1	2	3	4	5	6	7	8	9	10	Total
Net Profit Before TAxis	27.45	30.44	31.28	32.38	33.88	35.85	37.94	39.85	39.62	38.90	347.59
Net Worth	75.55	102.66	119.85	137.77	156.68	176.89	198.48	221.34	244.03	266.26	1699.53
ROI	20.45%										

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

Particulars / Years	1	2	3	4	5	6	7	8	9	10
Cash Inflow										
Profit after Tax	27.45	27.11	17.19	17.92	18.91	20.21	21.59	22.85	22.70	22.23
Depreciation	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16	10.16
Interest on Term Loan	16.76	13.28	11.95	10.31	8.26	5.70	3.00	0.44	0.00	0.00
Total (M)	54.37	50.55	39.30	38.39	37.33	36.07	34.75	33.45	32.86	32.39

Debt

Interest on Term Loan	16.76	13.28	11.95	10.31	8.26	5.70	3.00	0.44	0.00	0.00
Repayment of Term Loan	6.00	12.00	15.00	18.00	24.00	27.00	27.50	14.80	0.00	0.00
Total (N)	22.76	25.28	26.95	28.31	32.26	32.70	30.50	15.24	0.00	0.00
Average DSCR (M/N)	1.52									

Note: **-** As the proposed machinery is CNC Lathe it is expected that the machine will be fetching good market value even after the project period of 10 Years. Therefore, in this case the Salvage value is expected to be at least net value after providing Depreciation for the project life and this value is considered as the cash flow in the last i.e. 10th year of the project life for simplification. In the alternative case we have to consider the other model where cash flow has to be calculated beyond the project life of 10 Years (perpetuity).

Annexure – 5: Details of procurement and implementation plan

S.No.	Activity	Weeks											
		1	2	3	4	5	6	7	8	9	10	11	12
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.*
Ace Micromatic Machine Tools Pvt.Ltd	Plot no.533, 10th main, 4th Phase, Peenya Industrial area, Bangalore-560058	
DMG Mori Seiki India Machines and Services Pvt Ltd	"Parimala Towers" #64 Jalahalli Camp Cross, Off MES Road, Yeshwanthpur IN-560022 Bangalore.	Phone: +91 80 40896508
Haas Automation	Manav Marketing Pvt Ltd 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 Tel: +91-80-32982722, +91-80-23577655. Fax: +91-80-23474508
Mazak company	Concord Towers, 14th Floor, UB City, Bangalore	

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

DMG — innovative technologies
www.gildemeister.com

Price Specification

DMU 60 monoBLOCK

Highlights

- **High speeds with** 0.7 g acceleration as standard, up to 30 m/min feed and rapid traverse and fast axes for advanced mould making applications
- **Tool magazines with 24 pockets** as standard.
- **Multi-purpose machine with 3 axes** as standard, optional 3+2, 4 or 5 axes
- **Compact monoBLOCK® design** and **low machine height** with a large work area and a long z-traverse together with an **integrated scraper-band chip conveyor as standard**

05/08/2010
Transport zone: India: Sheva/Chennai/Mumbai

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DECKEL MAHO
DMU 60 monoBLOCK

Price Specification

EUR

Basic machine

P-A0348*	DMU 60 monoBLOCK Universal Milling Machine 730 mm x 560 mm x 560 mm / Main drive: Motor spindle 12,000 rpm 15 kW / 20 hp (40% duty cycle); 10 kW / 13.5 hp (100% duty cycle) Spindle taper SK 40 to DIN 69871 Tool clamping to DIN 69872 Manual swivel milling head Tool change system pick-up 24 magazine pockets SK 40 Rigid table 1,000 mm x 600 mm Chip conveyor 3D CNC control
P-B0052*	3D control Heidenhain iTNC 530
P-C0176*	NC rotary table integrated in rigid table d 600 mm / d 23.6 in 1,000 mm x 600 mm / 39.4 in x 23.6 in 1x T-slot 14 H7 / 0.55 H7 (alignment slot, table centre) 8x T-slots 14 H12 / 0.55 H12 (clamping slots) distance between slots: 63 mm / 2.4 in max. table load: 500 kg / 1,100 lbs Basic machine without rigid table
P-W0246*	Controlled NC swivel milling head (B-axis) incl. hydraulic clamping Spindle offset 100 mm / 4 in Swivel range -120°/+30° Traverse range X-axis reduced by 100 mm / 4 in
P-K0220*	Infrared measuring probe Type Renishaw PP60 optical (OMP 60) SK 40 or optionally chosen spindle taper
P-G0004	Spray pistol with pump 1 bar/40 l/min 14.5 psi/10.4 gallon/min (theoretical pump performance)
P-H0021	Electronic handwheel iTNC 530

DMU 60 monoBLOCK / Series 2245 valid 01/12/2010 - 30/01/2011 / Price status: 05/08/2010

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P-G0054*	Package for tropical climate for ambient temperature max. 40° Celsius includes air conditioner electrical cabinet and active cooling for motor spindle

Services machine

P-P0862	Packing sea crate basic machine with tool magazine 24 magazine pockets
P-P1040	Dispatch basic machine

The total cost of the machine on CIF Chennai basis will be EUR 298,730=00

The best package price on CIF Chennai basis will be EUR 220,000=00

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(Ministry of Power, Government of India)
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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)
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India SME Technology Services Ltd
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