DETAILED PROJECT REPORT
ON
REPLACEMENT OF CONVENTIONAL MILLING M/C TO CNC MILLING M/C











Bureau of Energy Efficiency

Prepared By

Reviewed By

REPLACEMENT OF CONVENTIONAL MILLING MACHINE BY A CNC MILLING MACHINE
OR
INSTALLATION OF NEW CNC MILLING MACHINE

BANGALORE MACHINE TOOL CLUSTER

BEE, 2010

Detailed Project Report on Replacement of Conventional Milling Machine by A CNC Milling 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
EA	Energy Audit
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
MSME	Micro Small and Medium Enterprises
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 recommendation made in the cluster manual is listed below:

Replacement of conventional milling machines with CNC milling machine or new CNC milling machine

CNC milling machines (also called *machining centers*) are computer controlled vertical mills with the ability to move the spindle vertically along the Z-axis. This extra degree of freedom permits their use in die sinking, engraving applications, and 2.5D surfaces such as relief sculptures. When combined with the use of conical tools or a ball nose cutter, it also significantly improves milling precision without impacting speed, providing a cost-efficient alternative to most flat-surface hand-engraving work

CNC machines can exist in virtually any of the forms of manual machinery, like horizontal mills. The most advanced CNC milling-machines, the multi axis machine, add two more axes in addition to the three normal axes (XYZ). Horizontal milling machines also have a C or Q axis, allowing the horizontally mounted workpiece to be rotated, essentially allowing asymmetric and eccentric turning. The fifth axis (B axis) controls the tilt of the tool itself.

When all of these axes are used in conjunction with each other, extremely complicated geometries, even organic geometries such as a human head can be made with relative ease with these machines. But the skill to program such geometries is beyond that of most operators. 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 lakh)	73.41
2	Electricity savings	kWh/Year	79941
3	Monetary benefit	` (in lakh)	28.86
4	Simple payback period	Year	2.54
5	NPV	` (in lakh)	54.59
6	IRR	%age	25.30
7	ROI	%age	21.47
8	DSCR	ratio	1.84
9	CO_2 Reduction	tonne/Annum	60
10	Procurement and implementation schedule	week	8

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.

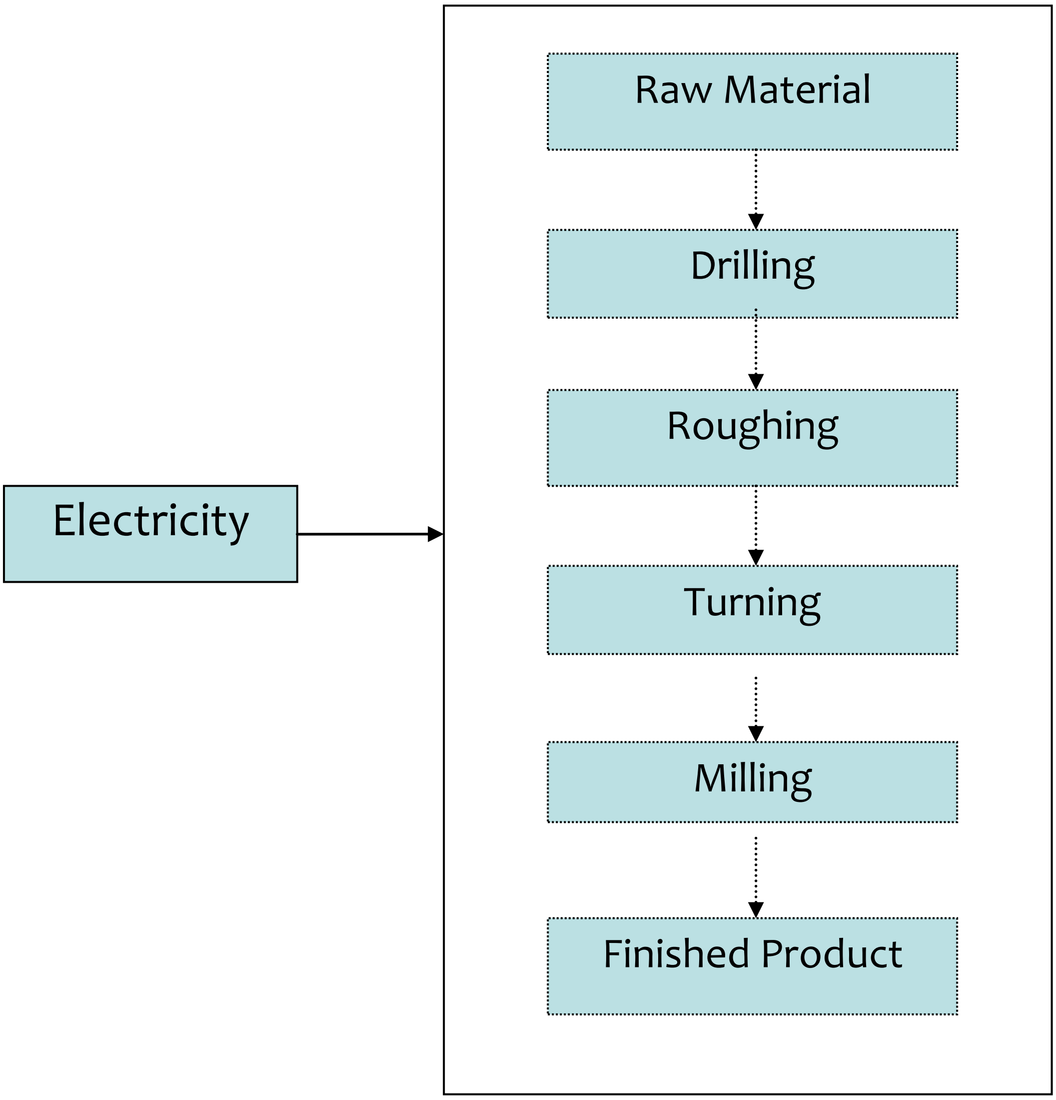
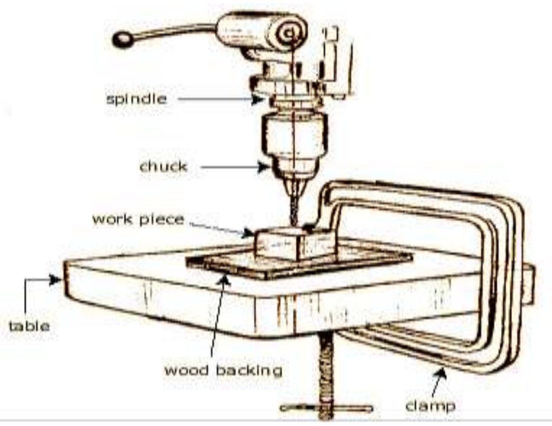
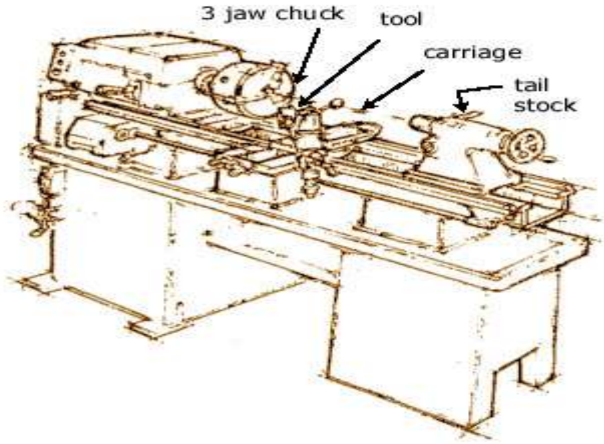


Figure 1.1 Process flow chart of typical Machine Tools Unit

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 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.

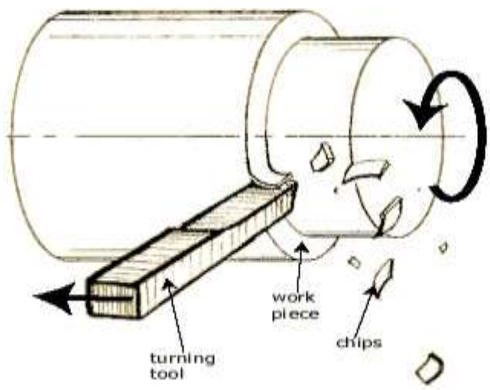
Drilling may affect the mechanical properties of the work piece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the work piece to become more susceptible to corrosion at the stressed surface.

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 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 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 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 a 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.

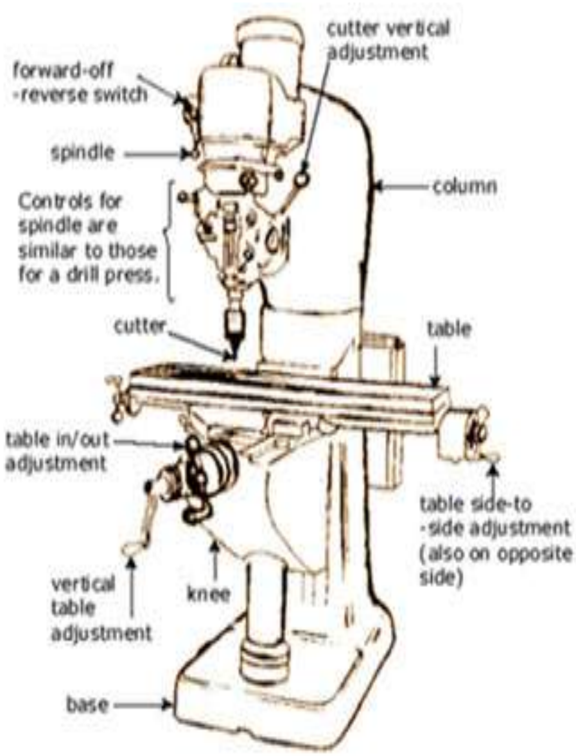
There are various types of boring. The boring bar may be supported on both ends (which only works if the existing hole is a through hole), or it may be supported at one end. Lineboring (line boring, line-boring) implies the former. Backboring (back boring, back-boring) is the process of reaching through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

- ***Knurling***

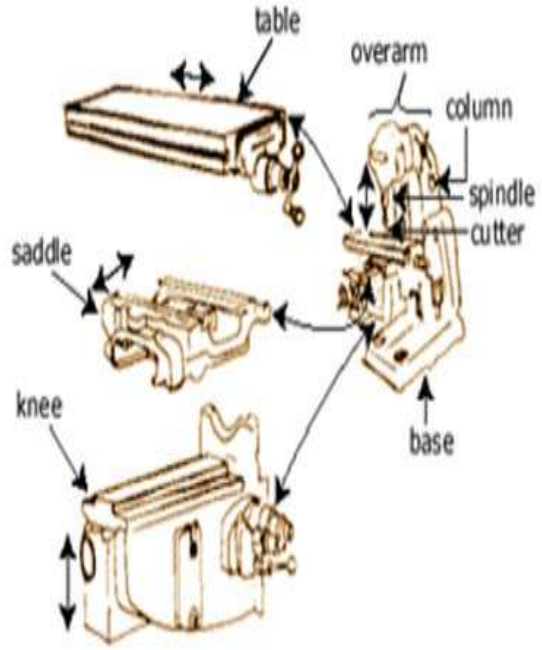
The cutting of a serrated pattern onto the surface of a part to use as a hand grip using a special purpose knurling tool.Threading both standard and non-standard screw threads can be turned on a lathe using an appropriate cutting tool. (Usually having a 60, or 55° nose angle) Either externally, or within 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

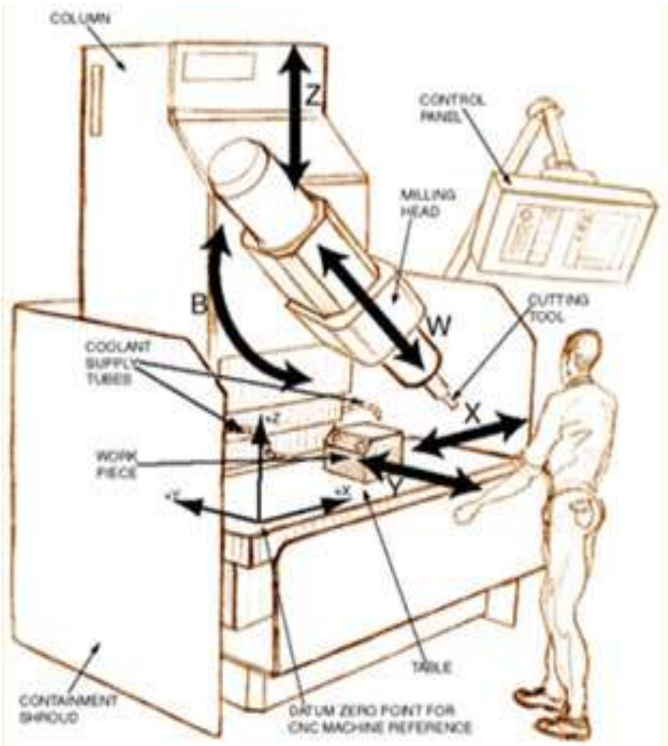
Milling is the most common form of machining, a material removal process, which can create a variety of features on a part by cutting away the unwanted material. The milling process requires a milling machine, work piece, fixture, and cutter. The work piece is a piece of pre-shaped material that is secured 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 axes that they possess. Axes 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 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 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 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.

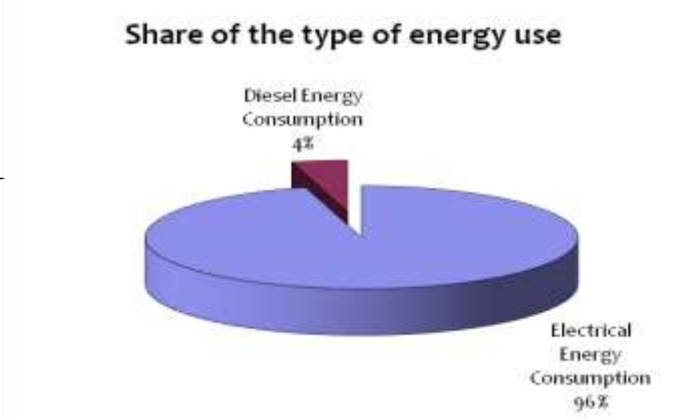


Figure 1.2: Share of Energy Type used in the Machine Tool Units

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, 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 Milling Machine uses a rotating milling cutter to produce machined surfaces by progressively removing material from a work piece. The vertical milling machine also can function like a drill press because the spindle is perpendicular to the table and can be lowered into the work piece.

Most of the units in the cluster are using the conventional milling machine in which the direction of rotation of cutter and the direction of feed of the work piece are opposite to each other. The cutting force is directed upwards. Hence the cutting increases from zero to maximum per tooth Cutter movement i.e., the thickness of the chip will be minimum at the beginning and maximum at the termination of the cutter (i.e., depth of cut = t' mm). These conventional machines are old technology has disadvantages like

- Quality of surface generated will be slightly wavy
- Lubrication is difficult.
- Needs heavy fixture since the cutting force results in lifting the workpiece.
- Need of high skills work force.

Table 1.2 Energy Consumption Pattern of Existing Technology

Particular	Unit	Case 1	Case2	Case 3
Annual electricity Consumption	kWh	68,460	73,944	139,020
Annual Fuel (HSD) consumption	Lts	800	800	800
Annual Energy Consumption	GJ	275.0	294.7	529.0
Average Specific Energy Consumption	GJ/T	5.5	15.8	44.08
Total Annual production	Tonnes	50.4	18.6	12
Reduction in Rejection rate out of replacement by CNC machine/ savings in amount	(`)	18000	18000	18000

Labour saving per month/ Annual savings due to labour charges	(` /`)	2000/ 24000	2000/24000	2000/24000

1.3.1 Description of technology/equipment

The milling machine is one of the most versatile machine tools in existence. In addition to straight milling of flat and irregularly shaped surfaces, it can perform gear and thread cutting, drilling, boring and slotting operations which are normally handled on machine tools designed specifically for these specific operations.

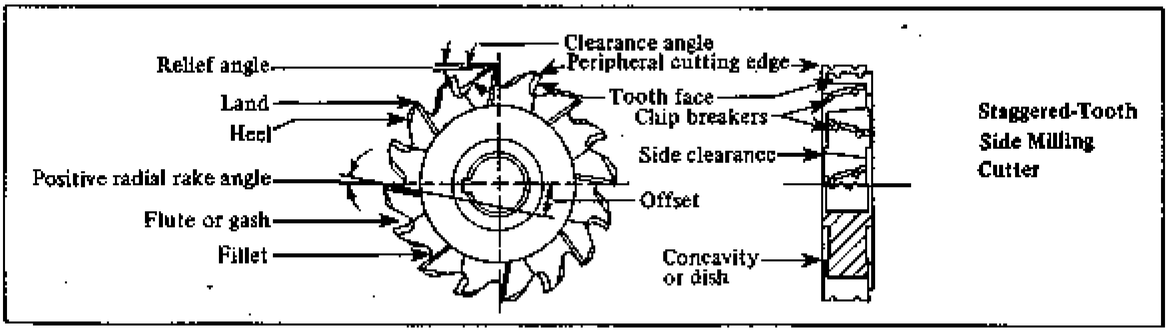
Types of Milling Machines

Milling machines can be broadly classified into the following types:

- Column and knee type of milling machines
- Bed type
- Rotary table
- Tracer controlled

Milling Cutters

A milling cutter is a cutting tool that is used on a milling machine. Milling cutters are available in many standard and special types, forms, diameters, and widths. The teeth maybe straight (parallel to the axis of rotation) or at a helix angle. The helix angle helps a



slow engagement of the tool distributing the forces .The cutter may be right-hand (to turn clockwise) or left-hand (to turn counterclockwise).The figure shows a typical end milling cutter.

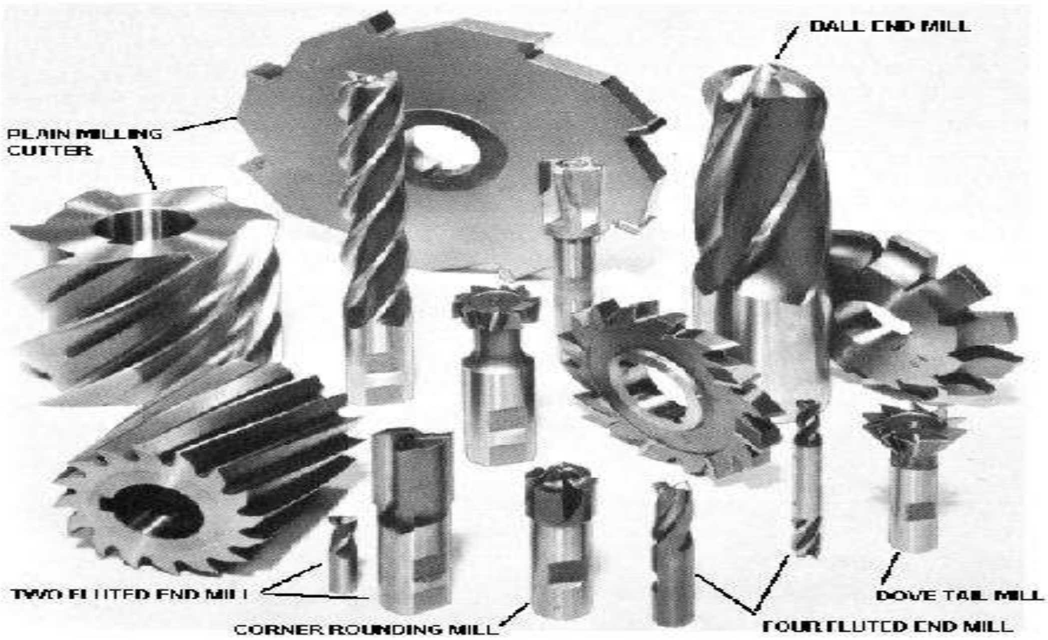
Features of Milling Cutters

Some of the terms used to identify the major features of a milling cutter are given in the figure.

Types of Milling Cutters

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 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.



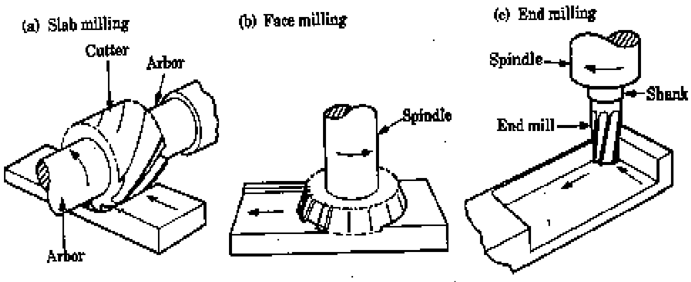
As with CNC turning centers, the Indian machine tools industry produces a range of CNC machining centers covering small to very large sizes. These machines are technologically more complex than turning machines. Typically, a CNC machining center has 3 linear movements, one rotary movement, apart from 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 up to 60 mpm are produced by the Indian industry.

Computer Numerical Control (CNC) machines are widely used in manufacturing industry. Traditional machines such as vertical millers, centre lathes, shaping machines, routers etc.

which required trained workforce for the operation, may replaced by computer control CNC machines.

1.3.2 Role in process

Milling is the process of cutting away material by feeding a workpiece past a rotating multiple tooth cutter. The cutting action of the many teeth around the milling cutter provides a fast method of machining. The machined surface may be flat, angular, or curved. The surface may also be milled to any combination of shapes. The machine for holding the workpiece, rotating the cutter, and feeding it is known as the Milling machine.



CLASSIFICATION OF MILLING

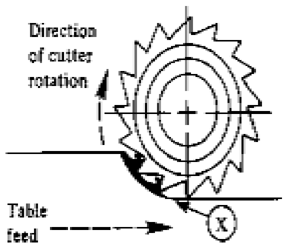
- ***Peripheral Milling***

In peripheral (or slab) milling, the milled surface is generated by teeth located on the periphery of the cutter body. The axis of cutter rotation is generally in a plane parallel to the workpiece surface to be machined.

- ***Face Milling***

In face milling, the cutter is mounted on a spindle having an axis of rotation perpendicular to the workpiece surface. The milled surface results from the action of cutting edges located on the periphery and face of the cutter.

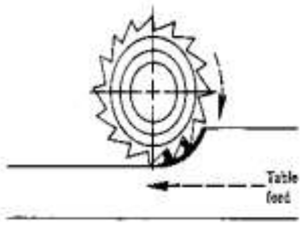
- ***End Milling***



The cutter in end milling generally rotates on an axis vertical to the workpiece. It can be tilted to machine tapered surfaces. Cutting teeth are located on both the end face of the cutter and the periphery of the cutter body.

METHODS OF MILLING

- ***Up Milling***

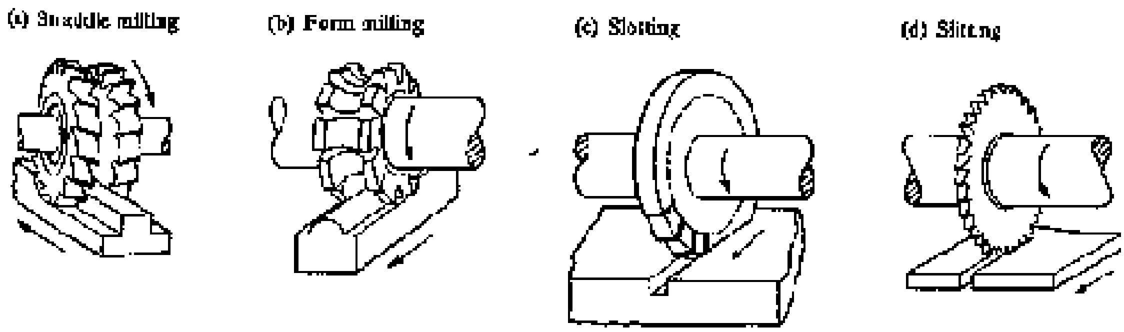


Up milling is also referred to as conventional milling. The direction of the cutter rotation opposes the feed motion. For example, if the cutter rotates clockwise, the workpiece is fed to the right in up milling.

- ***Down Milling***

Down milling is also referred to as climb milling. The direction of cutter rotation is same as the feed motion. For example, if the cutter rotates counterclockwise, the workpiece is fed to the right in down milling. The chip formation in down milling is opposite to the chip formation in up milling. The figure for down milling shows that the cutter tooth is almost parallel to the top surface of the workpiece. The cutter tooth begins to mill the full chip thickness. Then the chip thickness gradually decreases.

Other milling operations are shown in the figure.



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 is observed that the total production cost is about ` 157786.9 per tonne.

Table 1.3 Energy Consumption Pattern of Machine Tools Cluster

Particular	Unit	Case 1	Case2	Case 3	Value
Specific Energy Consumption	kWh/Tonne	1358.3	3975.5	11585	5639.6
Average Energy Cost	`/Tonne	6791.5	19877.5	57925	28198
Cost of Material Rejection	`/Tonne	18000	18000	18000	18000
Other Cost (Man Power/Utility)	`/Tonne	111476.2	111290.4	112000	111588.9
Average Production cost	`/Tonne	25267.7	39167.9	77925	157786.9
Annual Production	Tonne	50.4	18.6	12	27
Annual Production Cost	`/annum	1273492.1	728523	935100	4260246

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 problem.

S. No.	Type of Fuel	Unit	Value	Equivalent Energy (GJ)	%age Contribution
1	Electricity	kWh/year	68460	246.5	89.6

****Based on measured actual electricity consumption by the existing technology (50.4 tonnes produced annually)***

S. No.	Type of Fuel	Unit	Value	Equivalent Energy (GJ)	%age Contribution
1	Electricity	kWh/year	73,944	266.2	90.3

****Based on measured actual electricity consumption by the existing technology (18.6 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:

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

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

A milling machine is a machine tool used to machine solid materials. CNC Milling machine are often classed in two basic forms, horizontal and vertical, which refer to the orientation of the main spindle. Both types range in size from small, bench-mounted devices to room-sized machines. Unlike a drill press, which holds the workpiece stationary as the drill moves axially to penetrate the material, CNC Milling machine also move the workpiece radially against the rotating milling cutter, which cuts on its sides as well as its tip. Workpiece and cutter movement are precisely controlled to less than 0.001 in (0.025 mm), usually by means of precision ground slides and lead screws or analogous technology. CNC Milling machine may be manually operated, mechanically automated, or digitally automated via computer numerical control (CNC).

CNC Milling machine can perform a vast number of operations, from simple (e.g., slot and keyway cutting, planing, drilling) to complex (e.g., contouring, diesinking). Cutting fluid is often pumped to the cutting site to cool and lubricate the cut and to wash away the resulting swarf. The term “machining center” describes almost any CNC milling and drilling machine that includes an automatic tool changer and a table that clamps the workpiece in place. On a machining center (as contrasted with a turning machine), the tool rotates, but the work does not. The most basic variety of this type of machine is also the most basic CNC machine tool—a vertical machining center. While vertical machining centers can be high-end machines because of their precision and/or their size, a small and simple vertical machining center is a relatively low-cost CNC machine tool that often represents a new machine shop’s first machine tool purchase. The orientation of the spindle is the most fundamental defining characteristic of a machining center. Vertical machining centers and horizontal machining centers have (obviously) vertically and horizontally oriented spindles. Vertical machines generally favor precision while horizontal machines generally favor production—but these generalizations are loose, and plenty of machines break out of them. Other choices in machining center orientation include the universal machining center, which can change between vertical and horizontal spindle arrangement. More common than this is the five-axis machining center, which adds rotary motion to the machine’s linear motion. The machine pivots the tool and/or the part not only to mill and drill at various angles, but also to mill swept surfaces. Machining centers linked by an automated pallet system can form an automated machining cell. Such a cell can machine a queue of different parts without operator attention by shuttling the parts in and out of the various machines as appropriate. Related machines in this category include the boring mill, which generally describes a large machine for heavy and/or precise milling and hole making. Another related machine is the manual milling machine. Such a machine may have some basic programmability, but it generally lacks an automatic tool changer, meaning the tool change is a manual step.

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

2.1.2 Process chain for milling workpieces

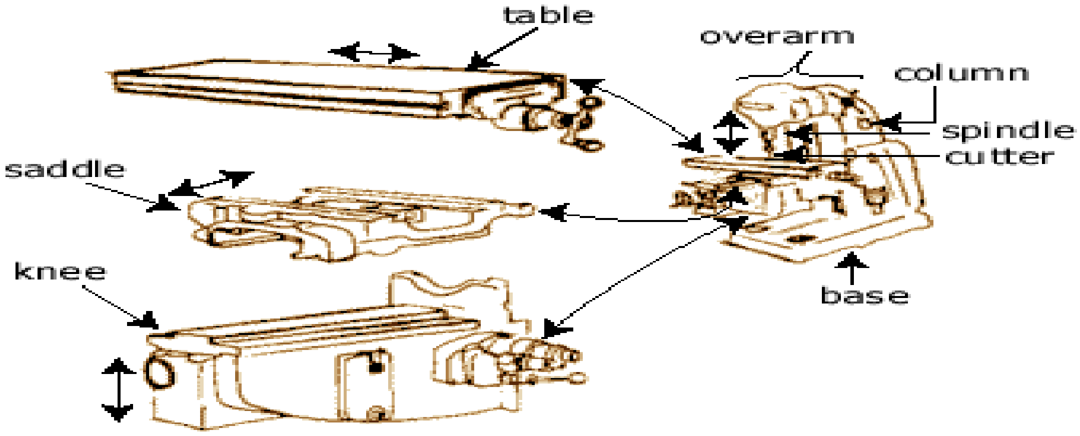


Figure 2.1 Process chain for milling workpieces

2.1.3 Technology specification

Table 2.1 Equipment Speciation

Equipment Speciation	
Particular	**Unit**
Table Size	9" x 42" (230 x 1066mm)
Longitudinal Travel	29 1/2" (750mm)

Cross Travel	12" (305mm))

Particular	Unit
Vertical Travel (Knee)	16" (406mm)
Table T-slots Quantity	3
Size	0.63" (16mm)
Maximum Workpiece Weight	750lbs (340kg)
Vertical Spindle Motor	2HP (3HP)
Spindle Speeds	50Hz 60 ~ 2280rpm (8 steps) 60Hz 80 ~ 2760rpm (8 steps)
Spindle Taper	R8 or NST30
Spindle Nose to Table	2 3/4" ~ 18 3/4" (70 ~ 476mm)
Spindle Centerline to Column Surface	2 3/4" ~18 3/4" (71 ~ 476mm))
Quill Travel	5" (127mm)
Automatic Vertical Feeds (per revolution of spindle)	0.0015", 0.003", 0.006" (0.04, 0.08, 0.14mm)
Head Swivel	(R&L)90°, (F&B)45°
Over arm Travel	12" (305mm)
Over arm Swivel	360°
Floor Space (L x W x H)	86 1/2" x 63" x 78 3/4" (2197 x 1600 x 2000mm)
Weights approx.	2380lbs (1080kg)

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

Table 2.2 Energy Consumption Profile

Particular	Unit	Value
Specific Energy Consumption	kWh/Tonne	4229.7
Average Energy Cost	Rs./Tonne	21148.5
Cost of Material Rejection	Rs,/tonne	4500
Other Cost (Man Power/Utility)	Rs./tonne	313.8
Average Production cost	Rs./tonne	25962.3

2.1.4 Suitability or integration with existing process

Milling is the process of machining flat, curved, or irregular surfaces by feeding the workpiece against a rotating cutter containing a number of cutting edges. The usual Mill consists basically of a motor driven spindle, which mounts and revolves the milling cutter, and a reciprocating adjustable worktable, which mounts and feeds the workpiece. CNC Milling machine are basically classified as vertical or horizontal. These machines are also classified as knee-type, ram-type, manufacturing or bed type, and planer-type. Most CNC Milling machine have self-contained electric drive motors, coolant systems, variable spindle speeds, and power-operated table feeds

Knee-type mills are characterized by a vertically adjustable worktable resting on a saddle which is supported by a knee. The knee is a massive casting that rides vertically on the milling machine column and can be clamped rigidly to the column in a position where the milling head and milling machine spindle are properly adjusted vertically for operation. The plain vertical machines are characterized by a spindle located vertically, parallel to the column face, and mounted in a sliding head that can be fed up and down by hand or power. Modern vertical CNC Milling machine are designed so the entire head can also swivel to permit working on angular surfaces.

The turret and swivel head assembly is designed for making precision cuts and can be swung 360° on its base. Angular cuts to the horizontal plane may be made with precision by setting the head at any required angle within a 180° arc. The plain horizontal milling machine's column contains the drive motor and gearing and a fixed position horizontal milling machine spindle. An adjustable overhead arm containing one or more arbor supports projects forward from the top of the column. The arm and arbor supports are used to stabilize long arbors. Supports can be moved along the overhead arm to support the arbor where support is desired depending on the position of the milling cutter or cutters.

2.1.5 Superiority over existing technology

CNC Milling machine can be used continuously 24 hours a day, 365 days a year and only need to be switched off for occasional maintenance. CNC Milling machine are programmed with a design which can then be manufactured hundreds or even thousands of times. Each manufactured product will be exactly the same. Less skilled/trained people can operate CNCs unlike manual lathes / CNC Milling machine etc. which need skilled engineers. Training in the use of CNCs is available through the use of 'virtual software'. This is software that allows the operator to practice using the CNC machine on the screen of a computer. The software is similar to a computer game.

- CNC Milling machine can be updated by improving the software used to drive the machines
- CNC Milling machine can be programmed by advanced design software such as Pro/DESKTOP®, enabling the manufacture of products that cannot be made by manual machines, even those used by skilled designers / engineers.
- Modern design software allows the designer to simulate the manufacture of his/her idea. There is no need to make a prototype or a model. This saves time and money.
- One person can supervise many CNC Milling machine as once they are programmed they can usually be left to work by themselves. Sometimes only the cutting tools need replacing occasionally.

A skilled engineer can make the same component many times. However, if each component is carefully studied, each one will vary slightly. A CNC machine will manufacture each component as an exact match.

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 CNC Milling machine center can be done in the 5-7 days, However the CNC Milling machine center is end to end solution of milling Process 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 Milling machine center, the technology and machine will continue to work up to 15 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.

2.3 Suitable unit/plant for implementation of proposed technology

CNC Milling machine center is suitable for the units involved in the production of bulk quantity and largecross section 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 CNC milling machine in steps. Existing technology required two or three timeset up of the job on the plate result in increase in time, energy and rejection. The existing technology also required a skilled manpower to operate this type of prudction machinery.

Installation of CNC Milling 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 CNC Milling center 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 CNC Milling Machine are tabulated below:

Table 3.1 Energy savings estimation for CNC Milling Machine

S.No	Particular	Unit	Milling Machine	CNC Milling Machine
1	Specific Energy Consumption	kWh/Tonne	5639.6	3947.72
2	Average Energy Cost	`/Tonne	28198	19738.6
3	Cost of Material Rejection	`/Tonne	18000	12500
4	Other Cost (Man Power/Utility)	`/tonne	111588.9	64467
5	Average Production	`/tonne	157786.9	96705.6
6	Annual Production	Tonne/annum	27	27
7	Annual Production Cost	`/annum	4260246	2611051
8	Reduction in Production Cost	`/Tonne	61081.3	
9	Annual Production Rate	Tonne/annum	27	
10	Annual cost reduction	`/Annum	1649195	

***Note:-** *As in the proposed DPR Conventional Milling Machine is replaced by CNC Milling Machine, it is assumed that it improves the overall productivity by 1.75 times i.e. 27 Tonnes/Annum in earlier case to 47.25 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

CNC Milling 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 totly desinged by CNC Milling machine with comparision to the exisitng manual set up based product.

The rejection of material in Milling 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. In Industry it is not efficient or profitable to make everyday products by hand. On a CNC machine it is possible to make hundreds or even thousands of the same item in a day. First a design is drawn using design software, then it is processed by the computer and manufactured using the CNC machine. This is a small CNC machine and can be used to machine woods, plastics and aluminium. In industry, CNC machines can be extremely large

3.1.3 Increase in production

Development of CNC milling machines has given a new direction to manufacturing business. Using these machines, industrial tasks can be done efficiently and with lots of ease. Now days, almost every company makes use of these machines to perform vast numbers of operations ranging from simple to complex.

While producing industrial products, it is not possible to turn or drill each material component manually. Apart from that the possibility of human error increases. CNC milling machines not merely help in turning out the parts at the desired speed but also reduce the cost of producing the required number of parts within a specified time frame. A milling machine is basically used to machine solid materials. Used with sharp cutting tools, it can be employed to get desired geometry. CNC milling bits is one of the most important components used in CNC milling machines. Basically used for cutting work, they are available in different sizes and shapes to provide desired result.

3.1.4 Reduction in raw material consumption

Modern CNC mills differ little in concept from the original model built at MIT in 1952. Mills typically consist of a table that moves in the X and Y axes, and a tool spindle that moves in the Z (depth). The position of the tool is driven by motors through a series of step-down gears in order to provide highly accurate movements, or in modern designs, direct-drive stepper motors. Closed-loop control is not mandatory today, as open-loop control works as long as the forces are kept small enough.

As the controller hardware evolved, the mills themselves also evolved. One change has been to enclose the entire mechanism in a large box as a safety measure, often with additional safety interlocks to ensure the operator is far enough from the working piece for safe operation. Most new CNC systems built today are completely electronically controlled.

3.1.5 Reduction in other losses

Installation of milling machine will result in reduction of the utility system like milling 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 CNC Milling machine has been estimated around ` 28.86 lakh per annum in the typical unit of the cluster. 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

Manual measurement combined with subsequent program adjustments can take many hours for parts like this shaft that have complex features. However, WFL has developed canned probing cycles for its machines to automatically measure such parts and update the NC code for the finishing operations. For this work piece example, a touch probe measures specific points on the gear teeth in the center of the shaft. In doing so, the gear's pitch diameter is determined as is the true position of the gear centerline. The true position of the gear centerline is really what's important. That's because the machining code (G-code) is automatically updated so all shaft features are machined to the gear's true (measured) centerline, not the machine's centerline. This ensures precise feature-to-feature accuracy after finish machining.

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 CNC Milling Macxhine in machine tools industries. Reduction in electricity consumption translates into GHG reductions is estimated about to be 60 tonne of CO_2 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 Milling Machine are provided in Table 4.1 below:

Table 4.1 Cost of equipment

S. No.	Particulars	Cost
1	Cost of CNC Machine	` 71,31,364

4.1.2 Other costs

Table 4.2 Cost of civil work and consultancy

S. NO.	Particulars	Cost
1.	Cost of civil work	` 1,60,200/-
2.	Electrical & Utility Expanses	` 49,800/-
	Total Two hundred ten thousand	` 2,10,000/-

Total investment in the proposed technology (including equipment cost & Other cost) is ` 73.41 lakh.

4.2 Arrangements of funds

Proposed financing for the replacement of Conventional Milling machine with CNC Milling 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

Payback period will be 2.54 Years.

4.3.3 Net Present Value (NPV)

Net Present Value of new project would work out ` 54.59 lakh.

4.3.4 Internal rate of return (IRR)

The after tax internal rate of return of the project works out to be 25.30 %. 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 21.47 %.

Table 4.4 Financial indicator of proposed technology

Particulars	Unit	Value
Simple Pay Back period	Years	2.54
IRR	%age	25.30
NPV	` in lakh	54.59
ROI	%age	21.47
DSCR	ratio	1.84

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	IRR	NPV	ROI	DSCR
Normal	25.30%	54.59	21.47%	1.84
5% increase in electricity saving	25.54%	55.46	21.51%	1.86
5% decrease in electricity saving	25.06%	53.71	21.44%	1.83

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

4.5 Procurement and implementation schedule

The installation of CNC Millling Machine can be done in the 7 – 9 days, However the CNC Millling machine is end to end solution of milling production process, implementation will not affect production. Thus implementation of this technology will not affect the process.

Table 4.5 Implementation Schedule

S. No.	***Activities***	***Weeks***				
		1	***2***	***3***	***4***	***5***
1	Procurement and Delivery					
2	Civil & Electrical Work					
3	Commissioning					

ANNEXURE

Annexure 1: Energy audit reports used for establishing

The results of detail energy audit for machine tools units are given below:

Audit No. 1

Particular	Unit	Case - 1	Case - 2	Case - 3	Average
Specific Energy Consumption	kWh/Tonne	1358.3	3975.5	11585	5639.6
Average Energy Cost	`/Tonne	6791.5	19877.5	57925	28198
Cost of Material Rejection	`/Tonne	18000	18000	18000	18000
Other Cost (Man Power/Utility)	`/Tonne	111476.2	111290.4	112000	111588.9
Average Production cost	`/Tonne	25267.7	39167.9	77925	157786.9
Annual Production	Tonne	50.4	18.6	12	27
Annual Production Cost	`/annum	1383492.1	838523	2035100	4260246

Energy savings estimation for CNC Milling Machine

S. No	Particular	Unit	Milling Machine	CNC Milling Machine
1	Specific Energy Consumption	kWh/Tonne	5639.6	3947.72
2	Average Energy Cost	`/Tonne	28198	19738.6
3	Cost of Material Rejection	`/Tonne	18000	12500
4	Other Cost (Man Power/Utility)	`/tonne	111588.9	64467
5	Average Production	`/tonne	157786.9	96705.6
6	Annual Production	Tonne/annum	27	27
7	Annual Production Cost	`/annum	4260246	2611051
8	Reduction in Production Cost	`/Tonne		61081.3
9	Annual cost reduction	`/Annum		1649195

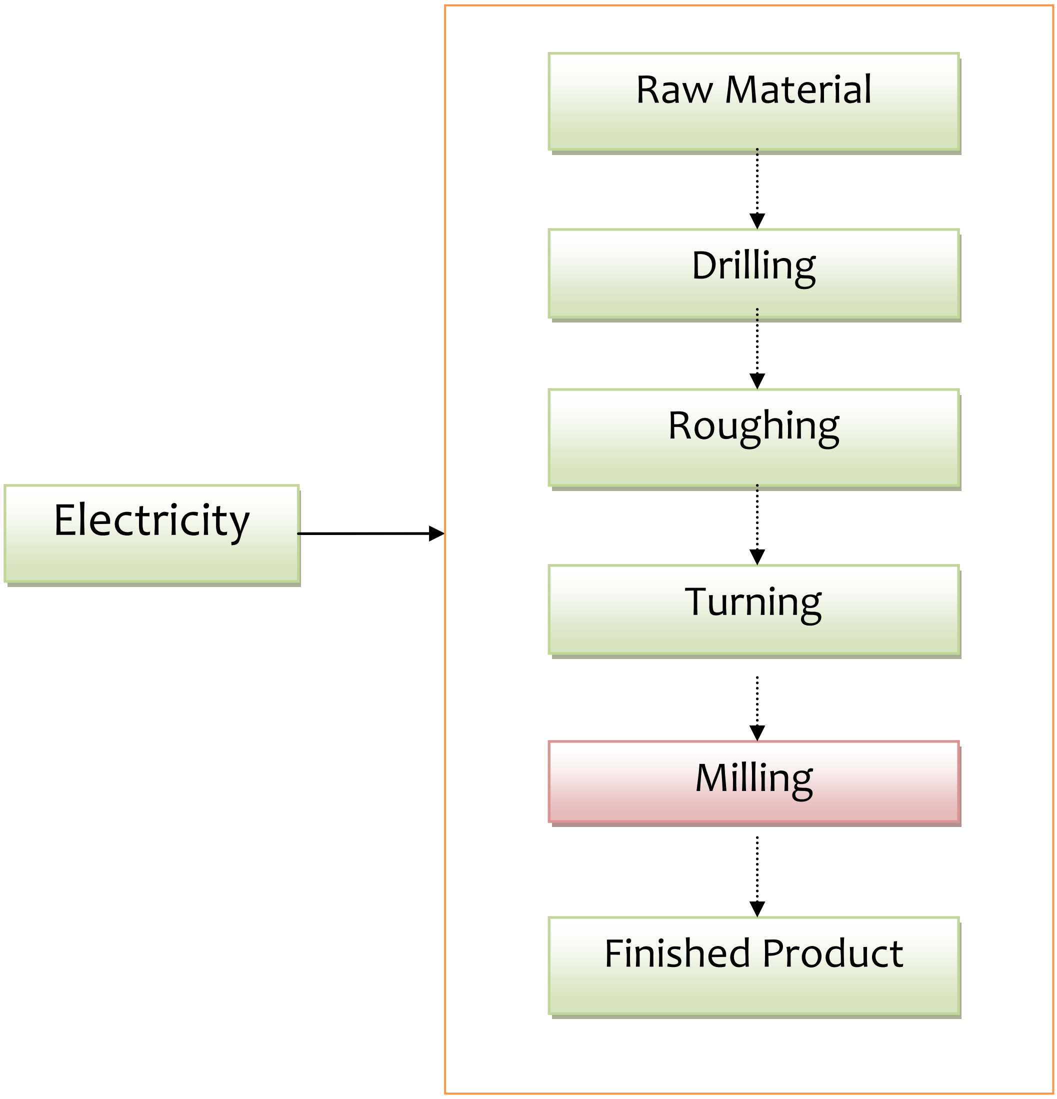
***Note:-** *As in the proposed DPR Conventional Lathe is replaced by CNC Lathe, it is assumed that it improves the overall productivity by 1.75 times i.e. 31.2*

Tonnes/Annum in earlier case to 54.60 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	Conventional Lathe Machine	CNC Lathe Machine
1	Average Production	`/tonne	157786.9	96705.6
2	Annual Production	Tonne/annum	27	47.25
3	Annual Production Cost	`/annum	7455431.03	4569340
4	Annual cost reduction	`/Annum		2886091

*So the saving reaches to `**2886091** (61081.3*47.25 tonne)*

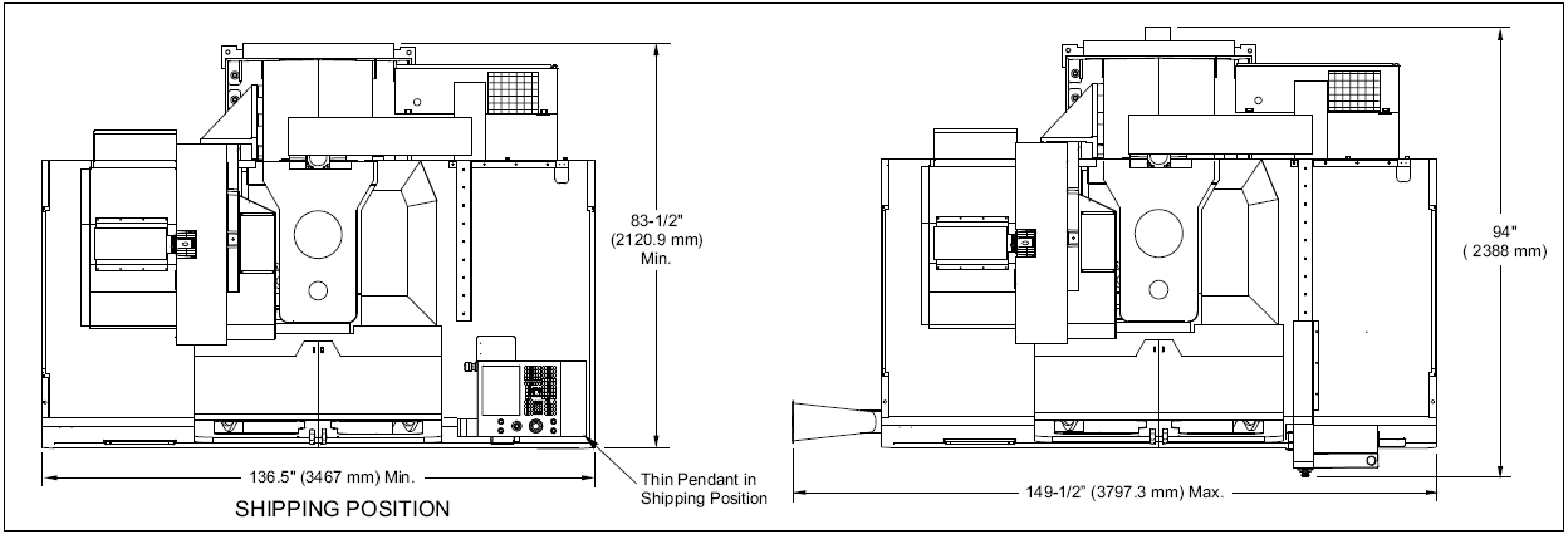
Annexure 2: Process flow diagram

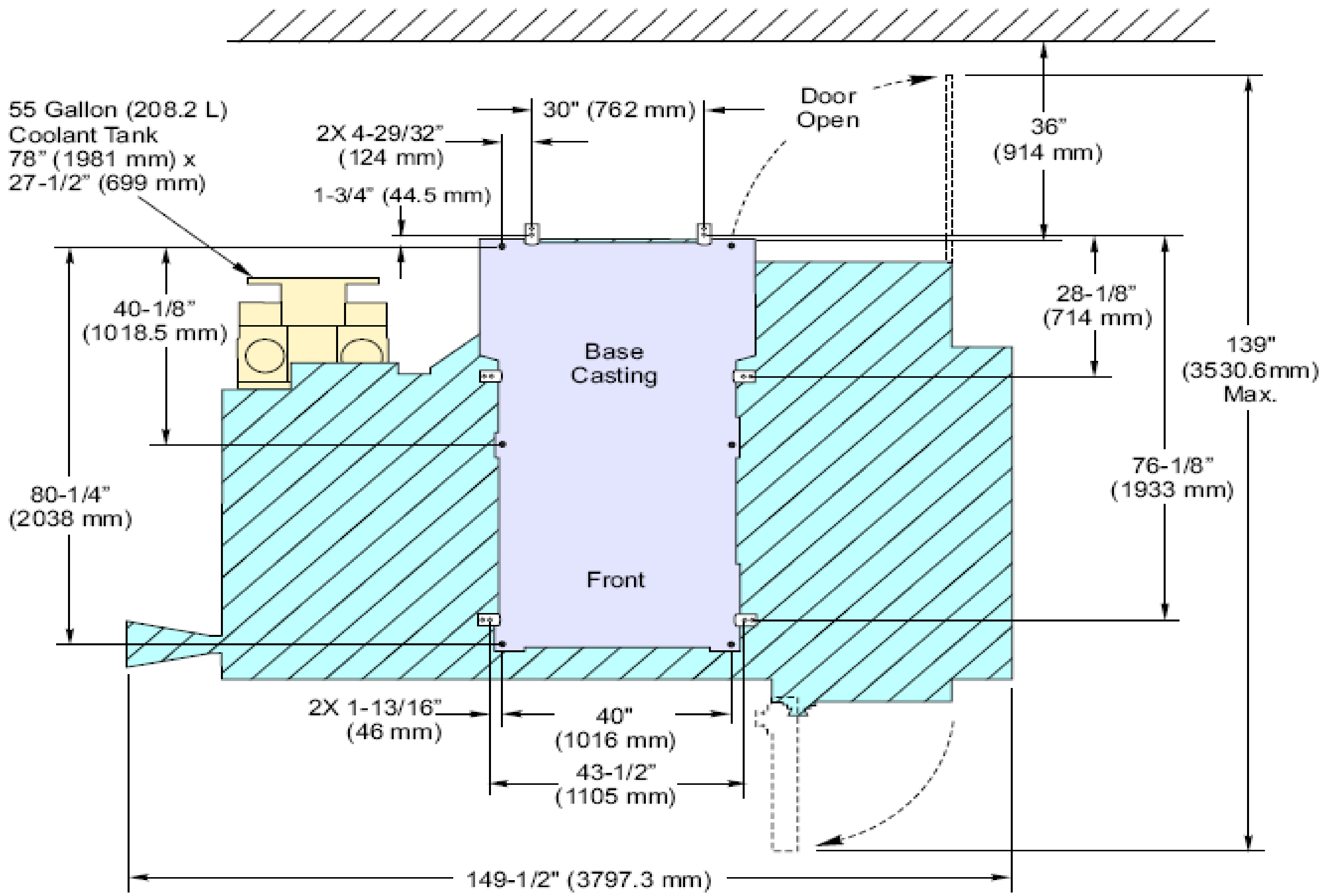


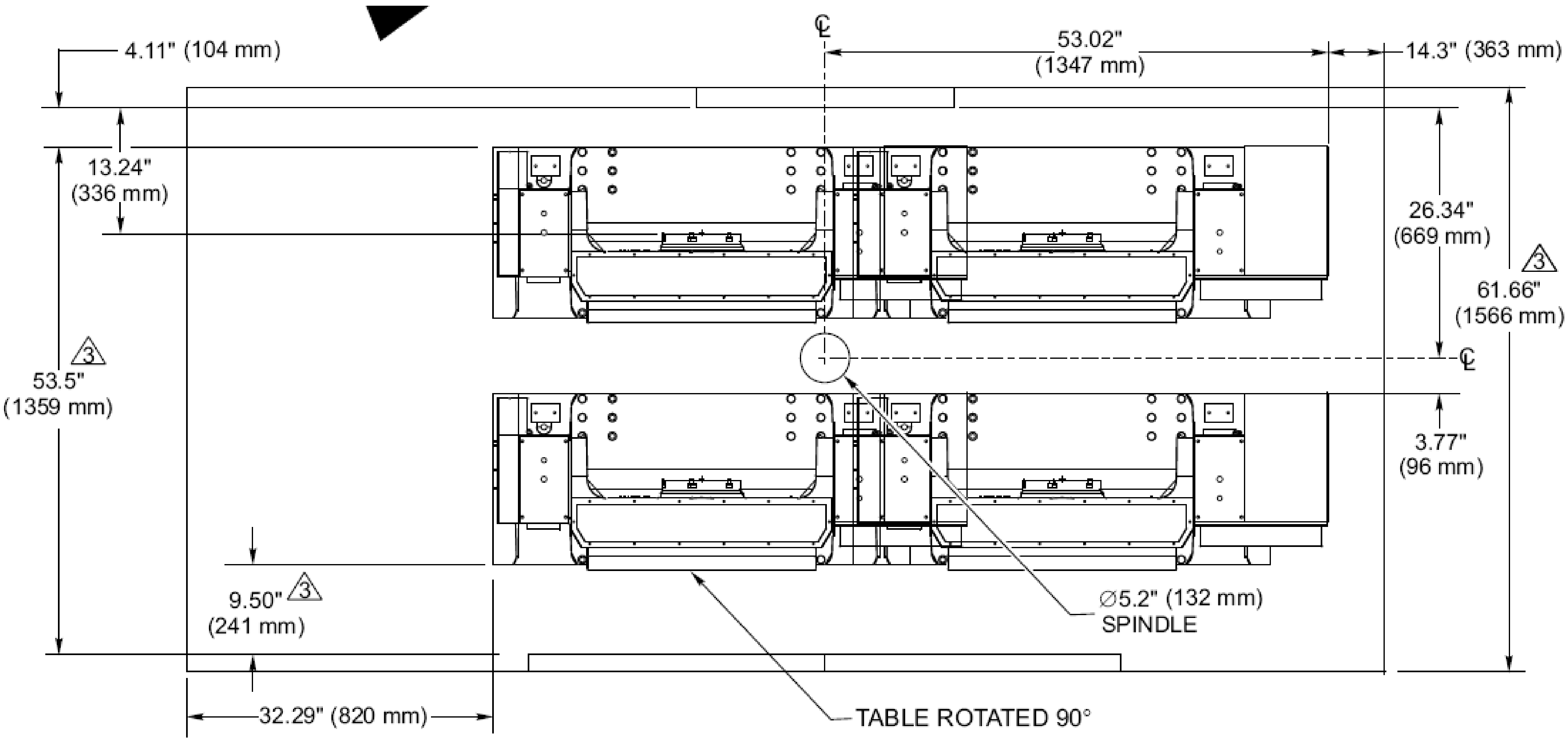
To evaluate the performance of milling, we can look at its rigidity. For example, the more rigid a mill is, the more precisely it drills and cuts. CNC mills normally have better & tougher engines for higher rigidity compared to manual counterparts. With CNC milling machine, we can improve the speed of cut compared to manual operation. It also reduced the rejection when rigidity results increased. Thus, in long run business, it will indeed save a lot of time and overhead due to less wastage happened. Another benefits is the accuracy of cut through CNC milling machine with a computer numerically controlled machine. In production line, it is very important to have all the parts produced exactly the same. However, nothing is perfect. CNC milling machine may also have a possibility of fault lies in the operator due to a mill can cut with absolute precision as close as.0001 of an inch.

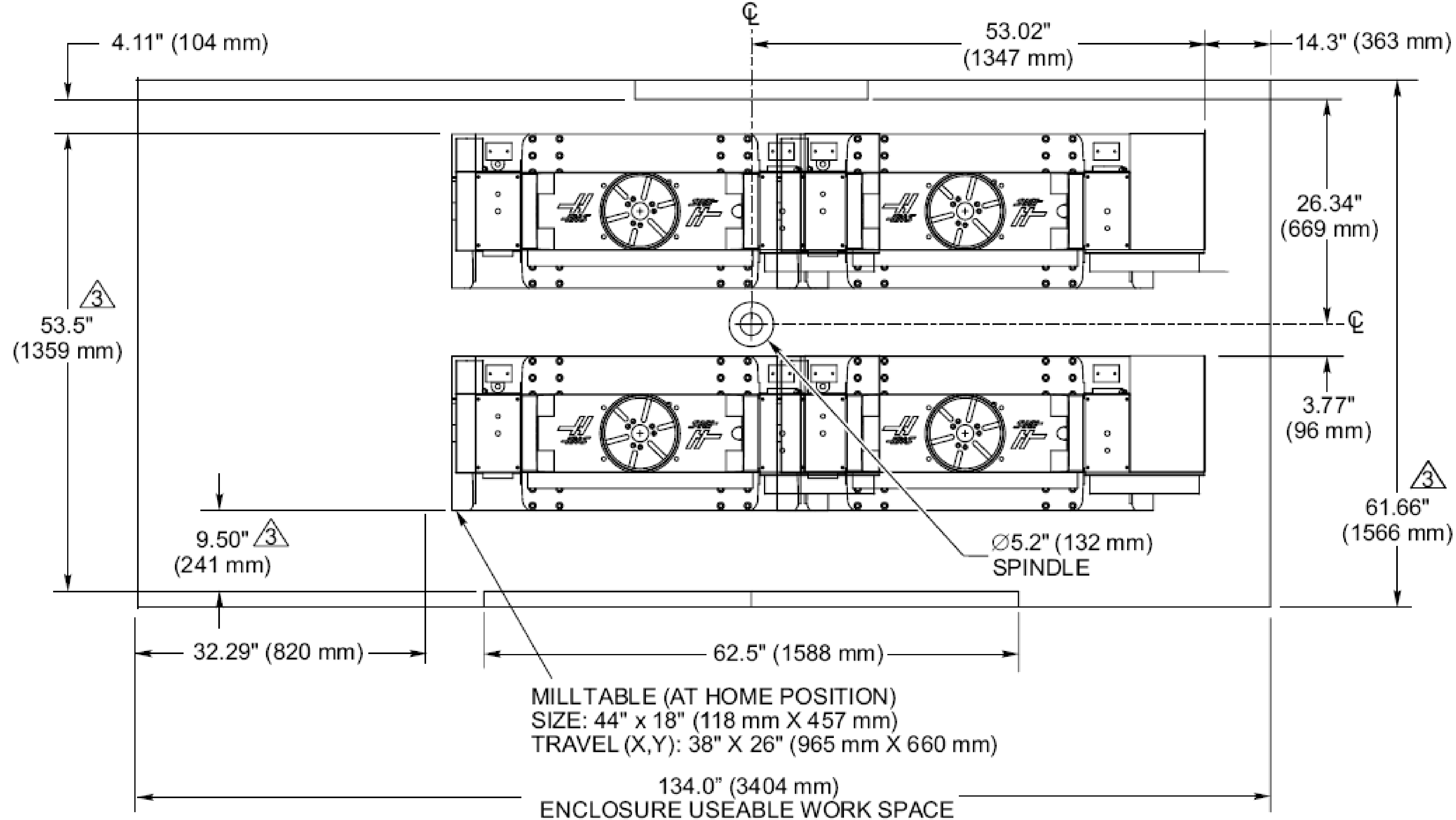
Annexure 3: Technical Drawing of CNC Milling Machines

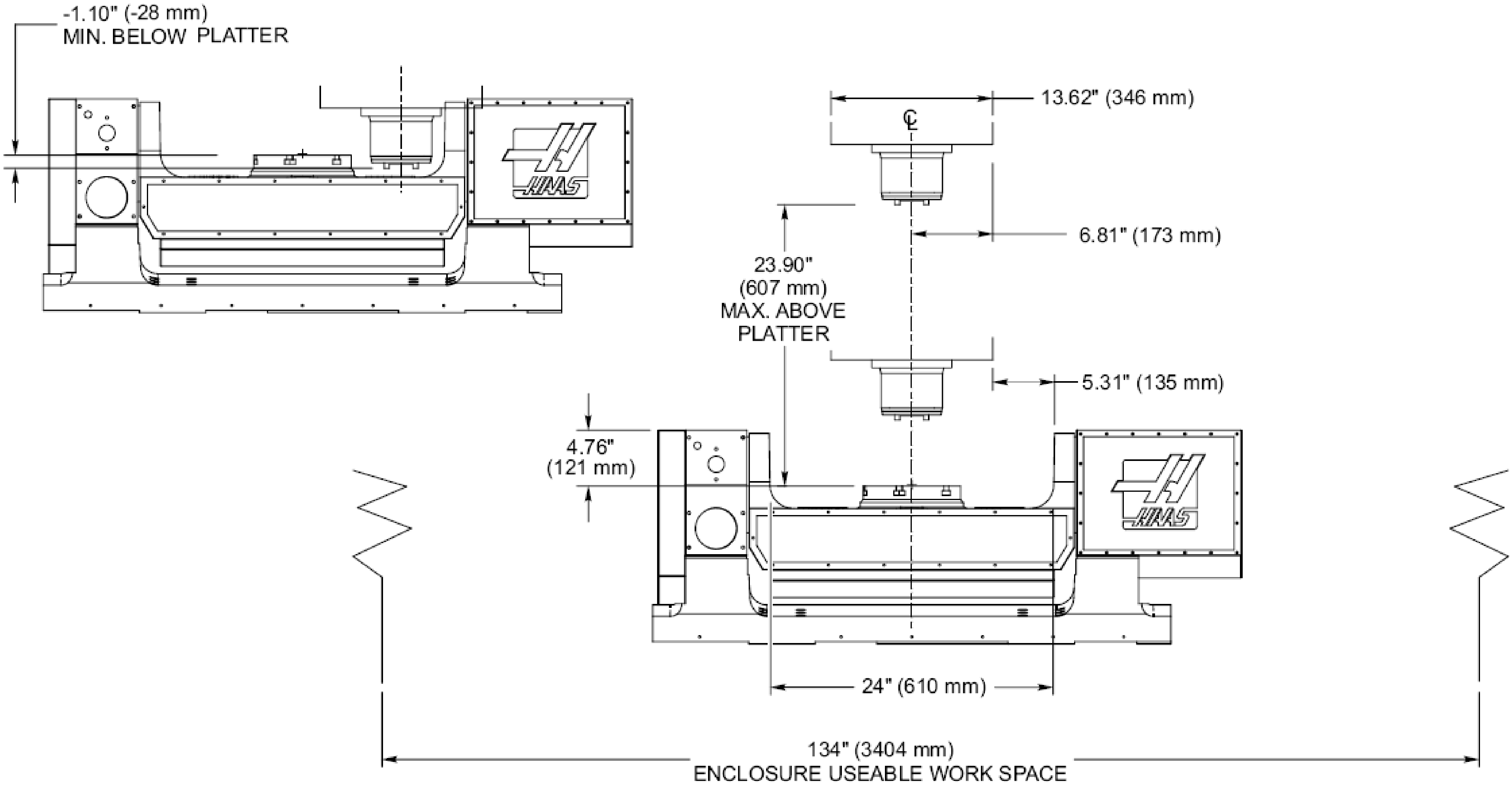
Shipping Position




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.
76-1/8"
(1933 mm)
80-1/4"
(2038 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)
∅5.2" (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)
53.5"
(1359 mm)
3.77"
(96 mm)
61.66"
(1566 mm)
9.50"
(241 mm)
∅5.2" (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

Annexure 4: Detailed financial calculations & analysis for financial indicators

Assumption

Name of the Technology	***CNC Milling 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)	71.31	Feasibility Study
Cost of modification in civil construction	` (in lakh)	1.60	Feasibility Study
Electrical work	` (in lakh)	0.50	Feasibility Study
Total Investment	` (in lakh)	73.41	Feasibility Study
Financing pattern			
Own Funds (Equity)	` (in lakh)	18.35	Feasibility Study
Loan Funds (Term Loan)	` (in lakh)	55.06	Feasibility Study
Loan Tenure	years	7	Assumed
Moratorium Period	Months	6	Assumed
Repayment Period	Months	90	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	1691.88	
Annual production	Tonne/Annum	47.25	
Cost	`/kWh	5	
Other savings	`/Tonne	52621.9	
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	55.06	3.00	52.06	6.38
2	52.06	6.00	46.06	4.93
3	46.06	6.60	39.46	4.31
4	39.46	7.20	32.26	3.62
5	32.26	8.20	24.06	2.87
6	24.06	9.10	14.96	2.00
7	14.96	9.80	5.16	1.06
8	5.16	5.16	0.00	0.15
		55.06		

WDV Depreciation

Particulars / years	*1*	*2*
Plant and Machinery		
Cost	73.41	14.68
Depreciation	58.73	11.75
WDV	14.68	2.94

Projected Profitability

Particulars / Years	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Revenue through Savings										
Total Revenue (A)	28.86	28.86	28.86	28.86	28.86	28.86	28.86	28.86	28.86	28.86
Expenses										
O & M Expenses	3.67	3.85	4.05	4.25	4.46	4.68	4.92	5.16	5.42	5.69
Total Expenses (B)	3.67	3.85	4.05	4.25	4.46	4.68	4.92	5.16	5.42	5.69
PBDIT (A)-(B)	25.19	25.01	24.81	24.61	24.40	24.18	23.94	23.70	23.44	23.17

Particulars / Years	1	2	3	4	5	6	7	8	9	10
Interest	6.38	4.93	4.31	3.62	2.87	2.00	1.06	0.15	-	-
PBDT	18.81	20.07	20.51	20.99	21.53	22.18	22.89	23.54	23.44	23.17
Depreciation	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
PBT	14.94	16.20	16.63	17.12	17.65	18.30	19.01	19.67	19.56	19.29
Income tax	-	2.83	6.97	7.14	7.32	7.54	7.78	8.00	7.97	7.87
Profit after tax (PAT)	14.94	13.37	9.66	9.98	10.33	10.77	11.23	11.66	11.60	11.42

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

Particulars / Years	1	2	3	4	5	6	7	8	9	10
Profit before tax	14.94	16.20	16.63	17.12	17.65	18.30	19.01	19.67	19.56	19.29
Add: Book depreciation	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
Less: WDV depreciation	58.73	11.75	-	-	-	-	-	-	-	-
Taxable profit	(39.92)	8.33	20.51	20.99	21.53	22.18	22.89	23.54	23.44	23.17
Income Tax	-	2.83	6.97	7.14	7.32	7.54	7.78	8.00	7.97	7.87

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

Particulars / Years	1	2	3	4	5	6	7	8	9	10
Liabilities										
Share Capital (D)	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35
Reserves & Surplus (E)	14.94	28.30	37.96	47.95	58.28	69.05	80.28	91.94	103.54	114.95
Term Loans (F)	52.06	46.06	39.46	32.26	24.06	14.96	5.16	0.00	0.00	0.00
Total Liabilities D)+(E)+(F)	85.35	92.71	95.78	98.56	100.69	102.36	103.79	110.29	121.89	133.30
Assets										
Gross Fixed Assets	73.41	73.41	73.41	73.41	73.41	73.41	73.41	73.41	73.41	73.41
Less: Accm. Depreciation	3.88	7.75	11.63	15.50	19.38	23.26	27.13	31.01	34.89	38.76
Net Fixed Assets	69.54	65.66	61.78	57.91	54.03	50.15	46.28	42.40	38.53	34.65
Cash & Bank Balance	15.81	27.05	33.99	40.65	46.66	52.20	57.51	67.89	83.36	98.65
Total Assets	85.35	92.71	95.78	98.56	100.69	102.36	103.79	110.29	121.89	133.30
Net Worth	33.29	46.66	56.32	66.30	76.63	87.40	98.63	110.29	121.89	133.30
Dept equity ratio	2.84	2.51	2.15	1.76	1.31	0.82	0.28	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	18.35	-	-	-	-	-	-	-	-	-	-
Term Loan	55.06										
Profit After tax		14.94	13.37	9.66	9.98	10.33	10.77	11.23	11.66	11.60	11.42
Depreciation		3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
Total Sources	73.41	18.81	17.24	13.54	13.86	14.21	14.64	15.11	15.54	15.47	15.29
Application											
Capital Expenditure	73.41										
Repayment of Loan	-	3.00	6.00	6.60	7.20	8.20	9.10	9.80	5.16	-	-
Total Application	73.41	3.00	6.00	6.60	7.20	8.20	9.10	9.80	5.16	-	-
Net Surplus	-	15.81	11.24	6.94	6.66	6.01	5.54	5.31	10.38	15.47	15.29
Add: Opening Balance	-	-	15.81	27.05	33.99	40.65	46.66	52.20	57.51	67.89	83.36
Closing Balance	-	15.81	27.05	33.99	40.65	46.66	52.20	57.51	67.89	83.36	98.65

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

Particulars / months	0	1	2	3	4	5	6	7	8	9	10
Profit after Tax		14.94	13.37	9.66	9.98	10.33	10.77	11.23	11.66	11.60	11.42
Depreciation		3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
Interest on Term Loan		6.38	4.93	4.31	3.62	2.87	2.00	1.06	0.15	-	-
Cash outflow	(73.41)	-	-	-	-	-	-	-	-	-	-
Salvage value											34.65
Net Cash flow	(73.41)	25.19	22.18	17.84	17.48	17.08	16.64	16.16	15.69	15.47	49.94
IRR	25.30%										
NPV	54.59										

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

Particulars / Years	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Variable Expenses										
Operation & Maintenance Exp (75%)	2.75	2.89	3.04	3.19	3.35	3.51	3.69	3.87	4.07	4.27
Sub Total (G)	2.75	2.89	3.04	3.19	3.35	3.51	3.69	3.87	4.07	4.27
Fixed Expenses										
Operation & Maintenance Exp (25%)	0.92	0.96	1.01	1.06	1.12	1.17	1.23	1.29	1.36	1.42
Interest on Term Loan	6.38	4.93	4.31	3.62	2.87	2.00	1.06	0.15	0.00	0.00
Depreciation *(H)*	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
Sub Total (I)	11.17	9.77	9.19	8.56	7.86	7.04	6.16	5.32	5.23	5.30
Sales (J)	28.86	28.86	28.86	28.86	28.86	28.86	28.86	28.86	28.86	28.86
Contribution (K)	26.11	25.97	25.83	25.67	25.51	25.35	25.17	24.99	24.79	24.59
Break Even Point (L= G/I) (%)	42.79%	37.63%	35.60%	33.33%	30.82%	27.79%	24.48%	21.29%	21.10%	21.55%
Cash Break Even {(I)-(H)} (%)	27.95%	22.70%	20.59%	18.23%	15.63%	12.49%	9.08%	5.78%	5.47%	5.79%
Break Even Sales (J)*(L)	12.35	10.86	10.27	9.62	8.90	8.02	7.07	6.14	6.09	6.22

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

Particulars / Years	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Total*
Net Profit Before Taxes	14.94	16.20	16.63	17.12	17.65	18.30	19.01	19.67	19.56	19.29	178.37
Net Worth	33.29	46.66	56.32	66.30	76.63	87.40	98.63	110.29	121.89	133.30	830.71

ROI	21.47%

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

Particulars / Years	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Total*
Cash Inflow											
Profit after Tax	14.94	13.37	9.66	9.98	10.33	10.77	11.23	11.66	11.60	11.42	91.94

Depreciation	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	31.01
Interest on Term Loan	6.38	4.93	4.31	3.62	2.87	2.00	1.06	0.15	0.00	0.00	25.31
Total (M)	25.19	22.18	17.84	17.48	17.08	16.64	16.16	15.69	15.47	15.29	148.26

Debt

Interest on Term Loan	6.38	4.93	4.31	3.62	2.87	2.00	1.06	0.15	0.00	0.00	25.31
Repayment of Term Loan	3.00	6.00	6.60	7.20	8.20	9.10	9.80	5.16	0.00	0.00	55.06
Total (N)	9.38	10.93	10.91	10.82	11.07	11.10	10.86	5.31	0.00	0.00	80.37
Average DSCR (M/N)	1.84										

Note: - As the proposed machinery is CNC MILLING machine 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

HAAS BUILD-A-QUOTE

HAAS AUTOMATION INC.
2800 STURGIS ROAD
OXNARD CA 93030
USA

MY CURRENT SELECTION

Selection		Qty	Price
MDC-500	Mill/Drill Center 20" x 14" x 20"	1	95,995.00 USD
Tooling Taper	BT-Style Tool Changer Grippers	1	**Included In Price**
	BT-Style Tool Changer Grippers	1	**Included In Price**
Through-Spindle Coolant	Through-Spindle Coolant, 300 psi (21 bar)	1	6,295.00 USD
Additional Axis	Dual 4th-Axis Drives, MDC	1	5,695.00 USD
	4th-Axis Drive and Wiring	1	2,095.00 USD
Probe System	Intuitive Probing, Renishaw	1	5,595.00 USD

Total Price **115,675.00** USD

Haas Build-a-Quote is for example only. Prices, specifications,availability and specific configurations may change without notice. Despite our best efforts, a small numberof items may contain pricing, typography,or photography errors. Correct prices and configurations are valid only at the time your order is placed with your Haas Factory Outlet distributor.

Shipping, delivery, transportation and rigging charges are not included in this quote.
Haas Automation 800-331-6746. www.HaasCNC.com | **CI CHENNAI**
Caution: Federal, State, Local taxes are not included in the quote price.

Regardless of location, Haas Automation offers this quotation without including required taxes. Your local Haas Factory Outlet can help determine tax requirements.

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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