DETAILED PROJECT REPORT
ON
REPLACEMENT OF CONVENTIONAL GRINDING MACHINE TO CNC GRINDING MACHINE (BANGALORE MACHINE TOOL CLUSTER)











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Bureau of Energy Efficiency

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REPLACEMENT OF CONVENTIONAL GRINDING MACHINE
WITH CNC GRINDING MACHINE
OR NEW CNC GRINDING MACHINE

BANGALORE MACHINE TOOL CLUSTER

BEE, 2010

Detailed Project Report on Replacement of Conventional Grinding Machine to CNC Grinding Machine

Bangalore Machine Tool cluster, Karnataka (India)

New Delhi: Bureau of Energy Efficiency;

Detail Project Report No.:

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Acknowledgement

We are sincerely thankful to the Bureau of Energy Efficiency, Ministry of Power, for giving us the opportunity to implement the 'BEE SME project in Bangalore Machine Tool cluster'. We express our sincere gratitude to all concerned officials for their support and guidance during the conduct of this exercise.

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Petroleum Conservation Research Association is also thankful to "Karnataka Small Scale Industries Association, Bangalore, Peenya Industrial Association, Bangalore and Bangalore Machine Tool manufacturers Association, Bangalore" for their valuable inputs, co-operation, support and identification of the units for energy use and technology audit studies and facilitating the implementation of BEE SME program in Bangalore Machine tools cluster.

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

PCRA is also thankful to all the SME owners, plant in charges and all workers of the SME units for their support during the energy use and technology audit studies and in implementation of the project objectives.

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
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 recommendation made in the cluster manual is listed below:

Grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material. Information in this section is organized according to the subcategory links in the menu bar to the left. In grinding, an abrasive material rubs against the metal part and removes tiny pieces of material. The abrasive material is typically on the surface of a wheel or belt and abrades material in a way similar to sanding. On a microscopic scale, the chip formation in grinding is the same as that found in other machining processes.

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 axis 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:

	Particular	***Unit***	***Value***
1	Project cost	` (in lakh)	45.61
2	Electricity saving	kWh	51384.4
3	Monetary benefit	` (in lakh)	33.73
4	Simple payback period	Year	1.35
5	NPV	` (in lakh)	55.32
6	IRR	%age	89.79
7	ROI	%age	27.61
8	DSCR	ratio	3.05
9	CO2 reduction	Tonne/annum	38.54
10	Procurement and implementation schedule	week	15

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.

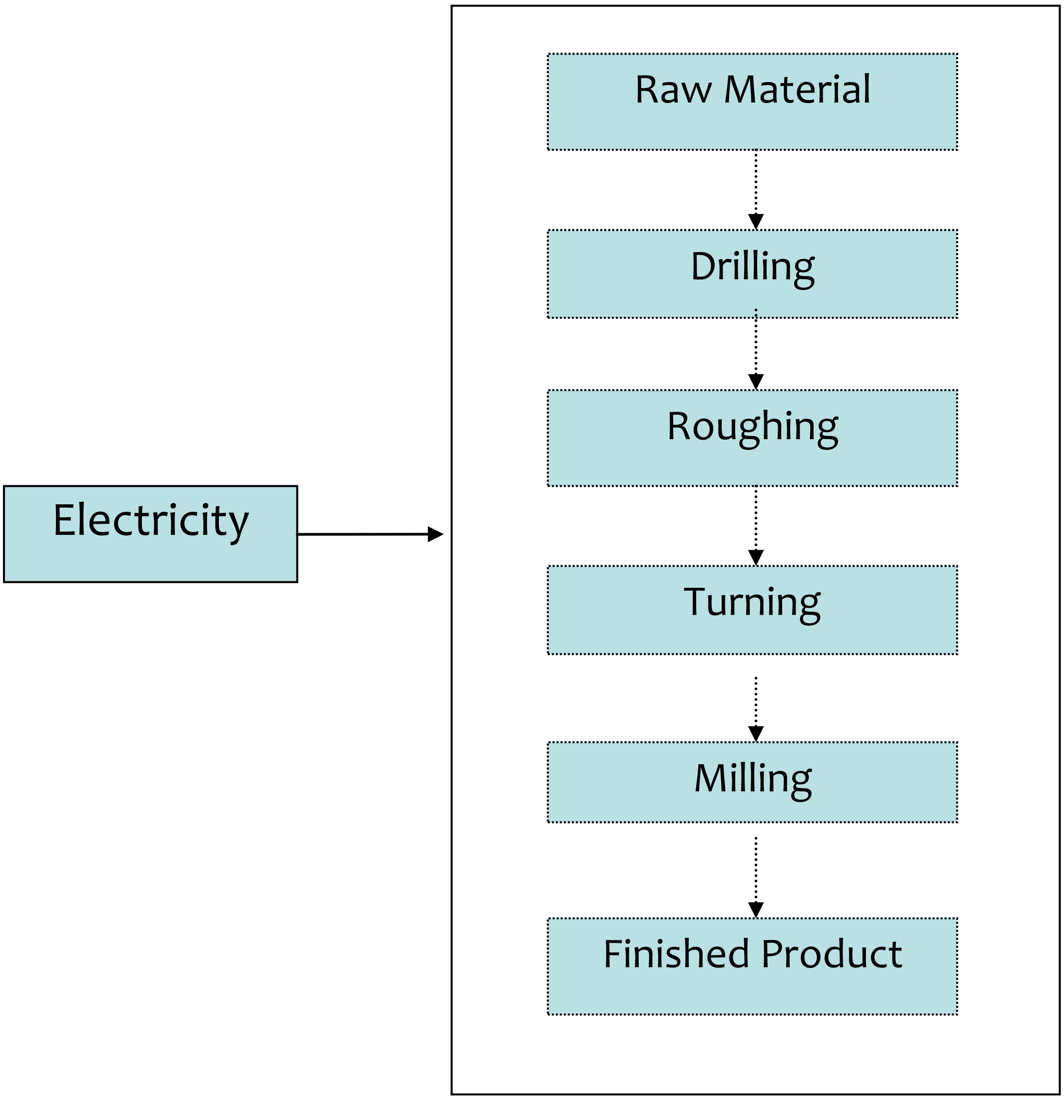
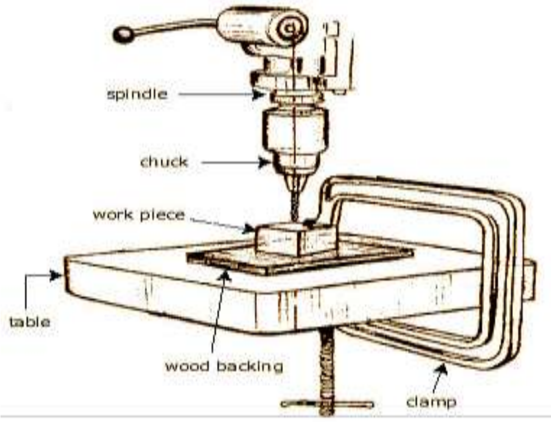


Figure 1.1 Process flow chart of typical Machine Tools Unit

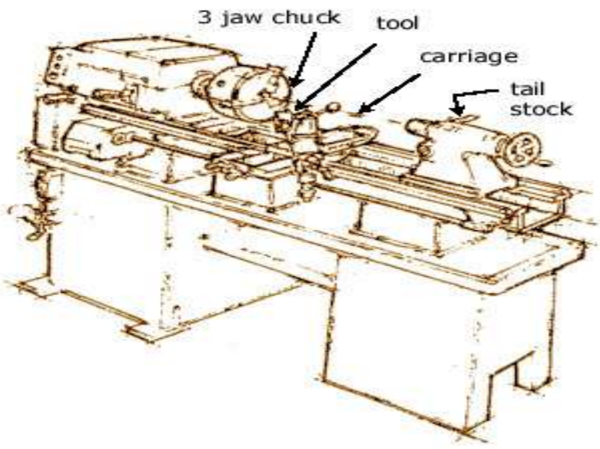
Drilling Process

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.

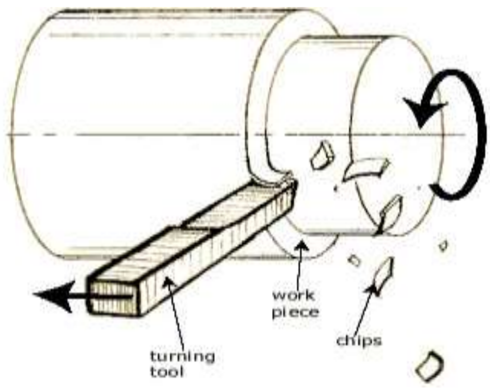
Drilling may affect the mechanical properties of the work piece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the work piece to become more susceptible to corrosion at the stressed surface.

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.

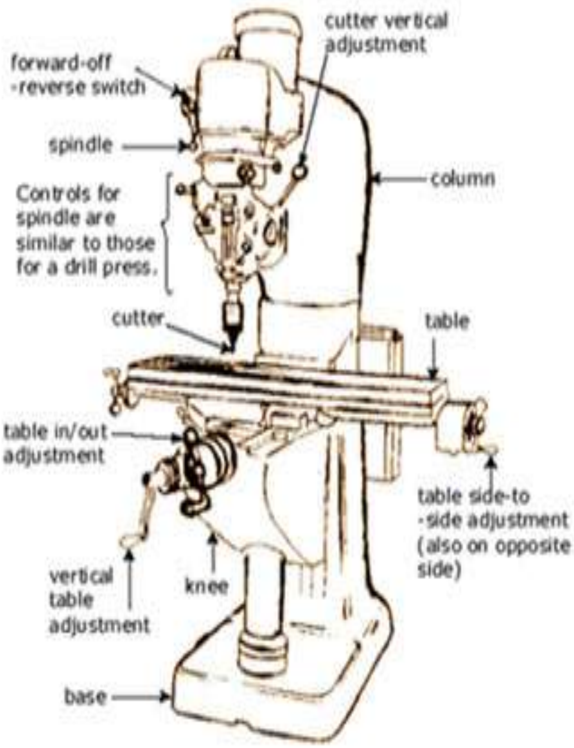
There are various types of boring. The boring bar may be supported on both ends (which only works if the existing hole is a through hole), or it may be supported at one end. Lineboring (line boring, line-boring) implies the former. Backboring (back boring, back-boring) is the process of reaching through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

- ***Knurling***

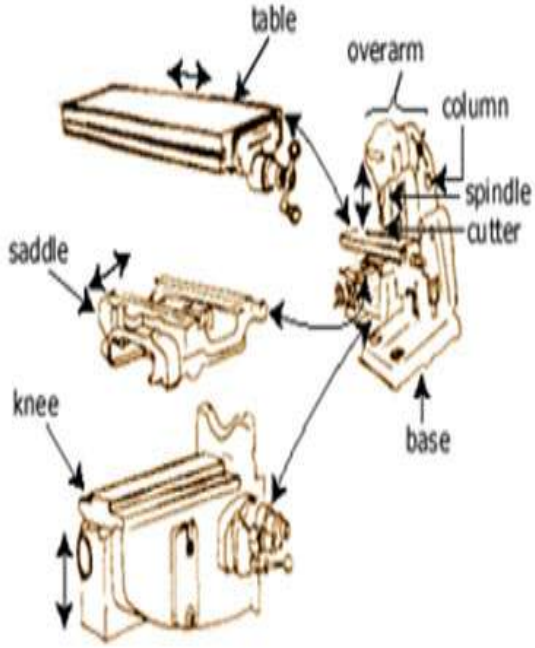
The cutting of a serrated pattern onto the surface of a part to use as a hand grip using a special purpose knurling tool.Threading both standard and non-standard screw threads can be turned on a lathe using an appropriate cutting tool. (Usually having a 60, or 55° nose angle) Either externally, or within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

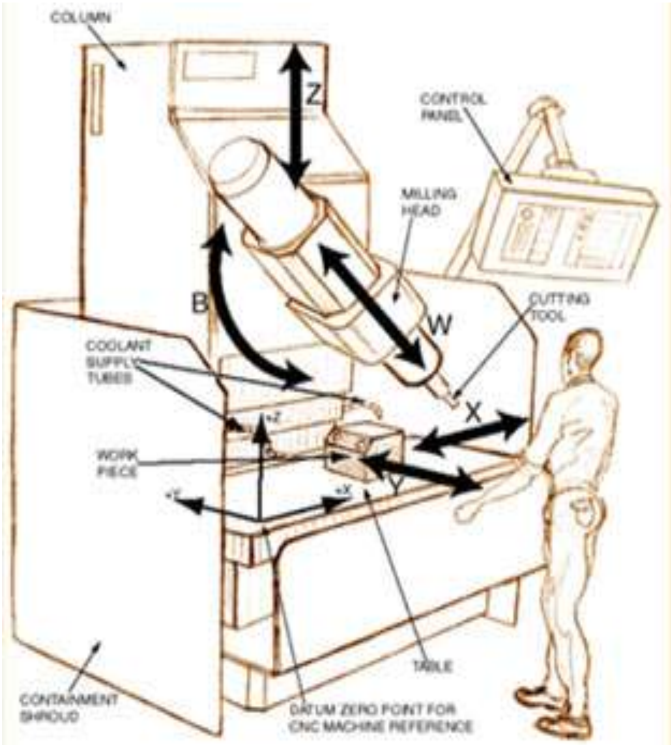
Milling is the most common form of machining, a material removal process, which can create a variety of features on a part by cutting away the unwanted material. The milling process requires a milling machine, work piece, fixture, and cutter. The work piece is a piece of pre-shaped material that is secured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



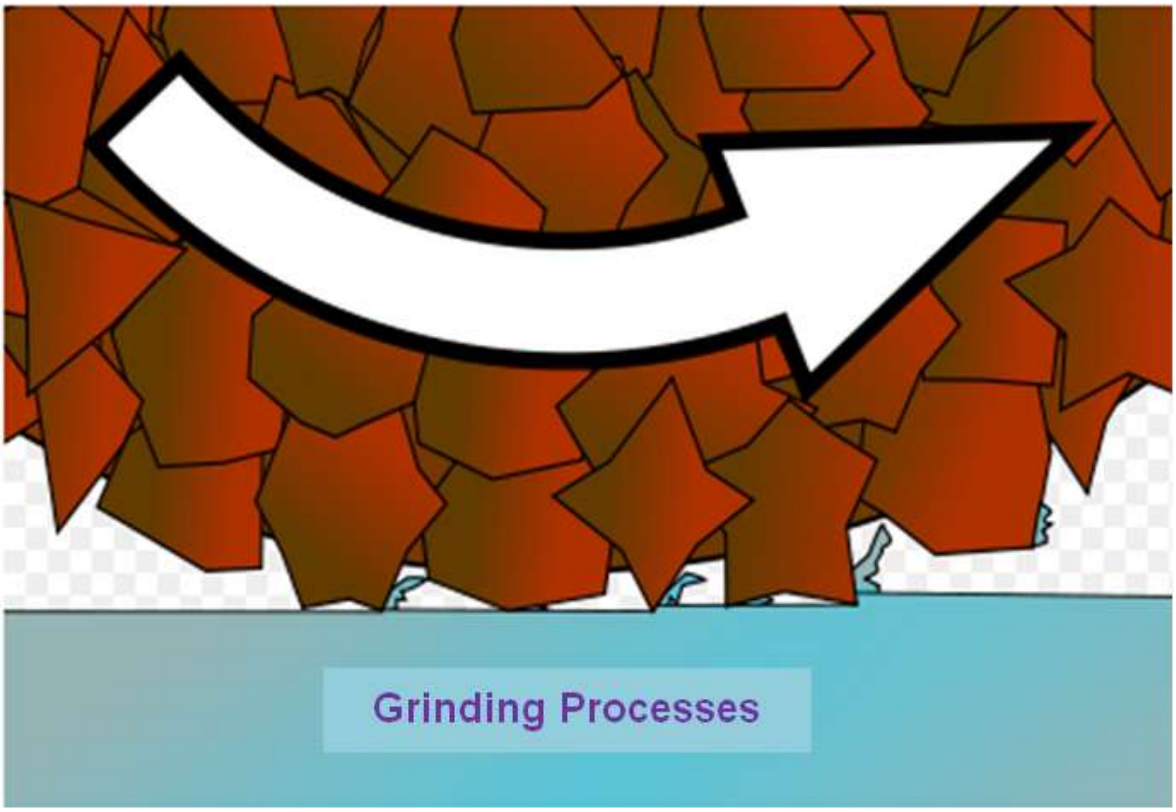
Milling is as fundamental as drilling among powered metal cutting processes. Milling is versatile for a basic machining process, but because the milling set up has so many degrees of freedom, milling is usually less accurate than turning or grinding unless especially rigid fixturing is implemented. For 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 Machines: Computer Numerical Control (CNC) Milling is the most common form of CNC. CNC machines are traditionally programmed using a set of commands known as G-codes. G-codes represent specific CNC functions in alphanumeric format.

Grinding practice is a large and diverse area of manufacturing and tool making. It can produce very fine finishes and very accurate dimensions; yet in mass production contexts it can also rough out large volumes of metal quite rapidly. It is usually better suited to the machining of very hard materials than is "regular" machining (that is, cutting larger chips with cutting tools such as tool bits or milling cutters), and until recent decades it was the only practical way to machine such materials as hardened steels. Compared to "regular" machining, it is usually better suited to taking very shallow cuts, such as reducing a shaft's diameter by half a thousand of an inch (thou) or 12.7 um.



Grinding is a subset of cutting, as grinding is a true metal-cutting process. Each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip that is analogous to what would conventionally be called a "cut" chip (turning, milling, drilling, tapping, etc.). However, among people who work in the machining fields, the term *cutting* is often understood to refer to the macroscopic cutting operations, and *grinding* is often mentally categorized as a "separate" process. This is why the terms are usually used in contradistinction in shop-floor practice, even though, strictly speaking, grinding is a subset of cutting.

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.

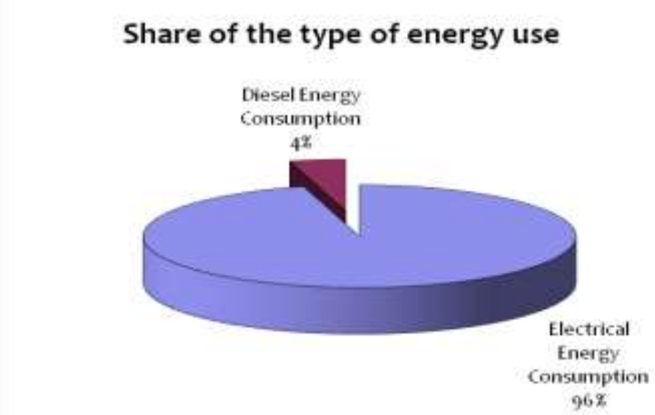


Figure 1.2: Share of Energy Type used in the Machine Tool Units

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

Grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material. Information in this section is organized according to the subcategory links in the menu bar to the left. In grinding, an abrasive material rubs against the metal part and removes tiny pieces of material. The abrasive material is typically on the surface of a wheel or belt and abrades material in a way similar to sanding. On a microscopic scale, the chip formation in grinding is the same as that found in other machining processes. The abrasive action of grinding generates excessive heat so that flooding of the cutting area with fluid is necessary. The grinding machine, often shortened to grinder, is a machine tool used for grinding, which is a type of machining using an abrasive wheel as the cutting tool. Each grain of abrasive on the wheel's surface cuts a small chip from the workpiece via shear deformation. The grinding machine consists of a power driven grinding wheel spinning at the required speed (which is determined by the wheel's diameter and manufacturer's rating, usually by a formula) and a bed with a fixture to guide and hold the work-piece. The grinding head can be controlled to travel across a fixed work piece or the workpiece can be moved whilst the grind head stays in a fixed position. Very fine control of the grinding head or table's position is possible using a vernier calibrated hand wheel, or using the features of numerical controls. Grinding machines remove material from the workpiece by abrasion, which can generate substantial amounts of heat; they therefore incorporate a coolant to cool the workpiece so that it does not overheat and go outside its tolerance. The coolant also benefits the machinist as the heat generated may cause burns in some cases. In very high-precision grinding machines (most cylindrical and surface grinders) the final grinding stages are usually set up so that they remove about 200 nm (less than 1/100000 in) per pass - this generates so little heat that even with no coolant, the temperature rise is negligible.

Table 1.2 Energy Consumption Pattern of Existing Technology

Particular	Unit	Case
Annual electricity Consumption	kWh	127212
Annual Fuel (HSD) consumption	Lts	00
Annual Energy Consumption	GJ	458.0
Average Specific Energy Consumption	GJ/T	3.51
Total Annual production	Tonnes	130.5
Reduction in Rejection rate out of replacement by CNC machine/ savings in amount	`	22136

1.3.1 Description of technology/equipment

The grinding machine consists of a power driven grinding wheel spinning at the required speed (which is determined by the wheel's diameter and manufacturer's rating, usually by a formula) and a bed with a fixture to guide and hold the work-piece. The grinding head can be controlled to travel across a fixed work piece or the workpiece can be moved whilst the grind head stays in a fixed position. Very fine control of the grinding head or tables position is possible using a vernier calibrated hand wheel, or using the features of numerical controls. Grinding machines remove material from the workpiece by abrasion, which can generate substantial amounts of heat; they therefore incorporate a coolant to cool the workpiece so that it does not overheat and go outside its tolerance. The coolant also benefits the machinist as the heat generated may cause burns in some cases. In very high-precision grinding machines (most cylindrical and surface grinders) the final grinding stages are usually set up so that they remove about

200 nm (less than 1/100000 in) per pass - this generates so little heat that even with no coolant, the temperature rise is negligible.

These machines include the:

- **Belt grinder**, which is usually used as a machining method to process metals and other materials, with the aid of coated abrasives. Sanding is the machining of wood; grinding is the common name for machining metals. Belt grinding is a versatile process suitable for all kind of applications like finishing, deburring, and stock removal.
- **Bench grinder**, which usually has two wheels of different grain sizes for roughing and finishing operations and is secured to a workbench. It is used for shaping tool bits or various tools that need to be made or repaired. Bench grinders are manually operated.
- **Cylindrical grinder** which includes the **center less grinder**. A cylindrical grinder may have multiple grinding wheels. The workpiece is rotated and fed past the wheel/s to form a cylinder. It is used to make precision rods.
- **Surface grinder** which includes the **wash grinder**. A surface grinder has a "head" which is lowered, and the workpiece is moved back and forth past the grinding wheel on a table that has a permanent magnet for use with magnetic stock. Surface grinders can be manually operated or have CNC controls.
- **Tool and cutter grinder** and the **D-bit grinder**. These usually can perform the minor function of the **drill bit** grinder, or other specialist tool room grinding operations.
- **Jig grinder**, which as the name implies, has a variety of uses when finishing jigs, dies, and fixtures. Its primary function is in the realm of grinding holes and pins. It can also be used for complex surface grinding to finish work started on a mill.
- **Gear grinder**, which is usually employed as the final machining process when manufacturing a high precision gear. The primary function of these machines is to remove the remaining few thousandths of an inch of material left by other manufacturing methods (such as gashing or hobbing).

1.3.2 Role in process

Grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material. Information in this section is organized according to the subcategory links in the menu bar to the left. In grinding, an abrasive material rubs against the metal part and removes tiny pieces of material. The abrasive material is typically on the surface of a wheel or belt and abrades material in a way similar to sanding. On a microscopic scale, the chip formation in grinding is the same as that found in other machining processes. The abrasive action of grinding generates excessive heat so that flooding of the cutting area with fluid is necessary. Reasons for grinding are:

1. The material is too hard to be machined economically. (The material may have been hardened in order to produce a low-wear finish, such as that in a bearing raceway.)
2. Tolerances required preclude machining. Grinding can produce flatness tolerances of less than ±0.0025 mm (±0.0001 in) on a 127 x 127 mm (5 x 5 in) steel surface if the surface is adequately supported.
3. Machining removes excessive material. At grinding machines of this kind the grinding wheel in many cases is directly connected to its drive motor. At such an arrangement apparently the risk is great that undesirably vibrations and shakings from the drive motor are propagated to the grinding wheel. A grinding wheel assembled with the drive motor also constitutes a great mass, whereby difficulties, for example with respect to the control of the grinding pressure, can arise. The grinding stand mounted on the cross travel carriage provides the possibility of continuous rotation of the grinding wheel, whereby an increase in the width of the groove is obtained. A positive locking of the grinding stand at the cross travel carriage after completion of the desired rotation of the grinding wheel provides optimum stability and low vibrations. These and other advantages are achieved thereby that the grinding machine shows the characterizing features defined in the attached claims.

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 Rs. 61590 per tonne.

Table 1.3 Energy Consumption Pattern of Machine Tools Cluster

Particular	*Unit*	*Value*
Specific Energy Consumption	kWh/Tonne	975
Average Energy Cost	` /Tonne	4875

Particular	Unit	Value
Cost of Material Rejection	` /tonne	35000
Other Cost (Man Power/Utility)	` /tonne	11350
Average Production cost	***` /tonne***	***51225***
Annual Production	Tonne	130.5
Annual Production Cost	` /annum	6684863

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.

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:

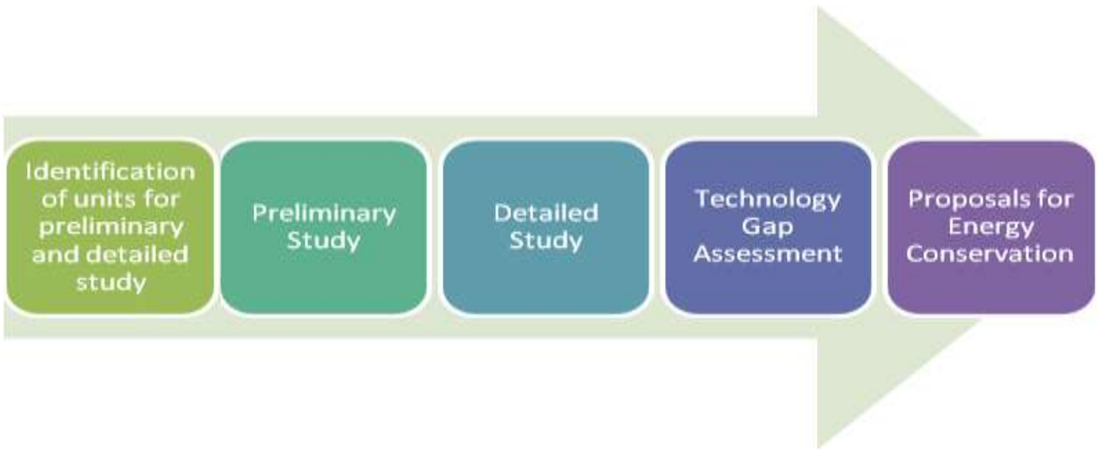


Figure 1.3 Energy auditing methodology

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

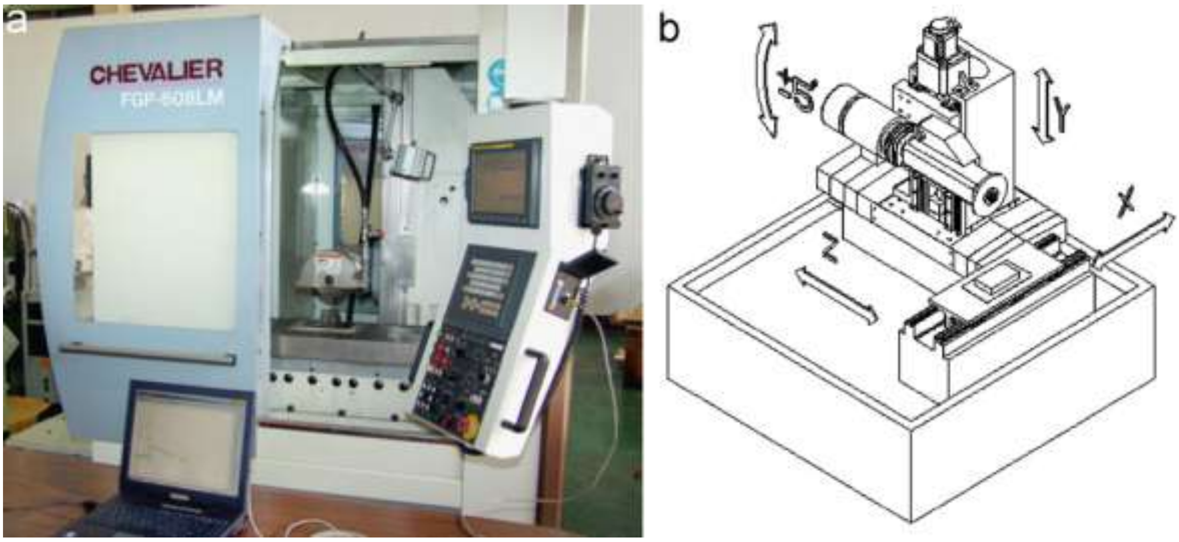
In new modern manufacturing industry, machine has become more efficient, complicated and fully automated. This type of new generation machines only required fewer man powers to operate because of automation functions. Thus this new feature, able to increase the volume of production but it requires new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

Grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material. Information in this section is organized according to the subcategory links in the menu bar to the left. In grinding, an abrasive material rubs against the metal part and removes tiny pieces of material. The abrasive material is typically on the surface of a wheel or belt and abrades material in a way similar to sanding. On a microscopic scale, the chip formation in grinding is the same as that found in other machining processes. The abrasive action of grinding generates excessive heat so that flooding of the cutting area with fluid is necessary.

1. The material is too hard to be machined economically. (The material may have been hardened in order to produce a low-wear finish, such as that in a bearing raceway.)
2. Tolerances required preclude machining. Grinding can produce flatness tolerances of less than ±0.0025 mm (±0.0001 in) on a 127 x 127 mm (5 x 5 in) steel surface if the surface is adequately supported.
3. Machining removes excessive material.

At grinding machines of this kind the grinding wheel in many cases is directly connected to its drive motor. At such an arrangement apparently the risk is great that undesirably vibrations and shakings from the drive motor are propagated to the grinding wheel. A grinding wheel assembled with the drive motor also constitutes a great mass, whereby difficulties, for example with respect to the control of the grinding pressure, can arise. The grinding stand mounted on the cross travel carriage provides the possibility of continuous rotation of the grinding wheel, whereby an increase in the width of the groove is obtained. A positive locking of the grinding stand at the cross travel carriage after completion of the desired rotation of the grinding wheel provides optimum stability and low vibrations. These and other advantages are achieved thereby that the grinding machine shows the characterizing features defined in the attached claims.

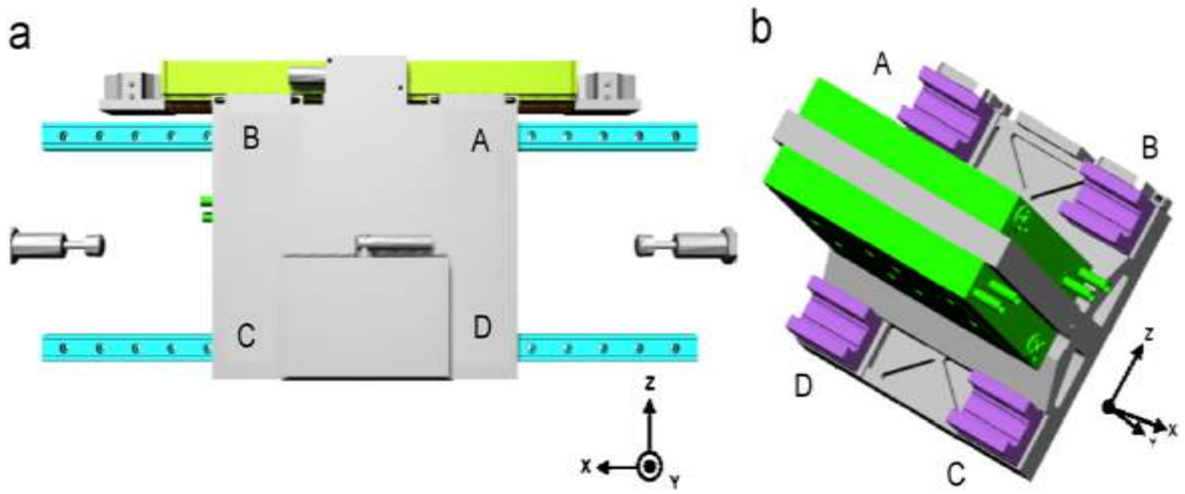
The new trend for designing high-end precision machines relies heavily on computer-aided design (CAD) tools to minimize the design effort and to speed up the design process. A very realistic representation of a machine and an examination of its dynamics behavior can be implemented within a software environment. Recent advancements in software technology have also enabled servo tuning to be included within a virtual-reality environment. Conventional approaches to machine design rely heavily on the designer's experience, and prototyping is expensive, which means that the ability to successfully develop prototypes in the virtual world provides many advantages for manufacturers. These efforts have aimed at establishing suitable mathematical models for the underlining machining process, with some actual controllers being based on these models. Basic tuning rules, based on the system responses, have been analyzed, but there have been very few reports on performing servo tuning within a virtual environment. An FEM model has been used for volumetric error estimation, and a design and tuning process has been attempted within a virtual solid-modeling environment. However, no

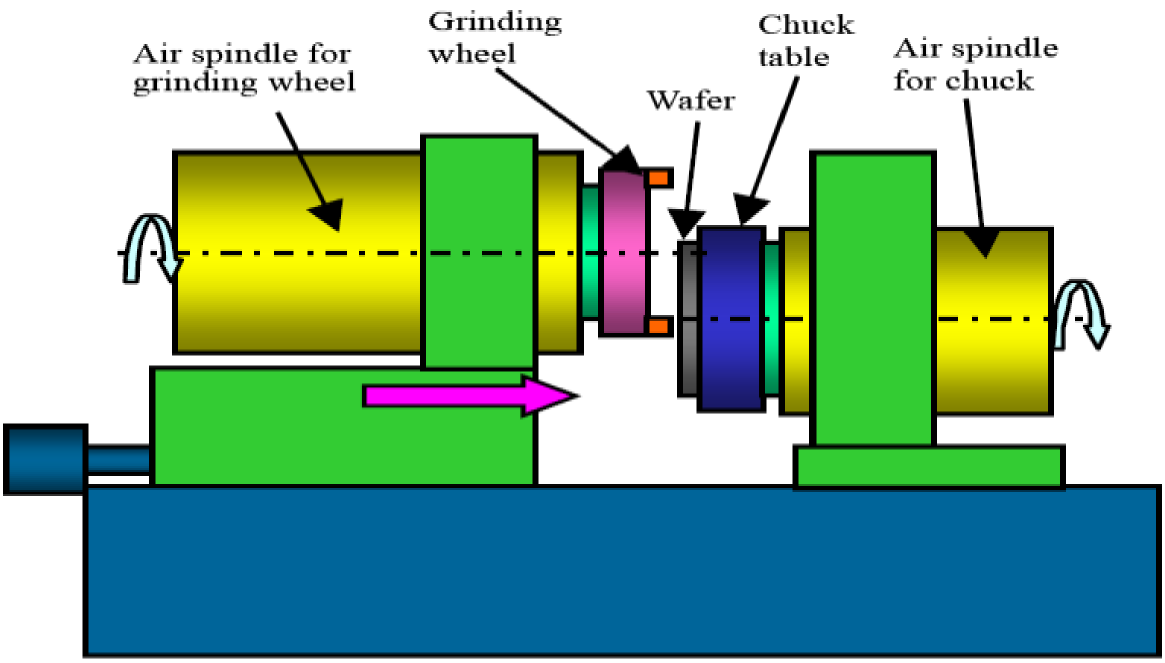


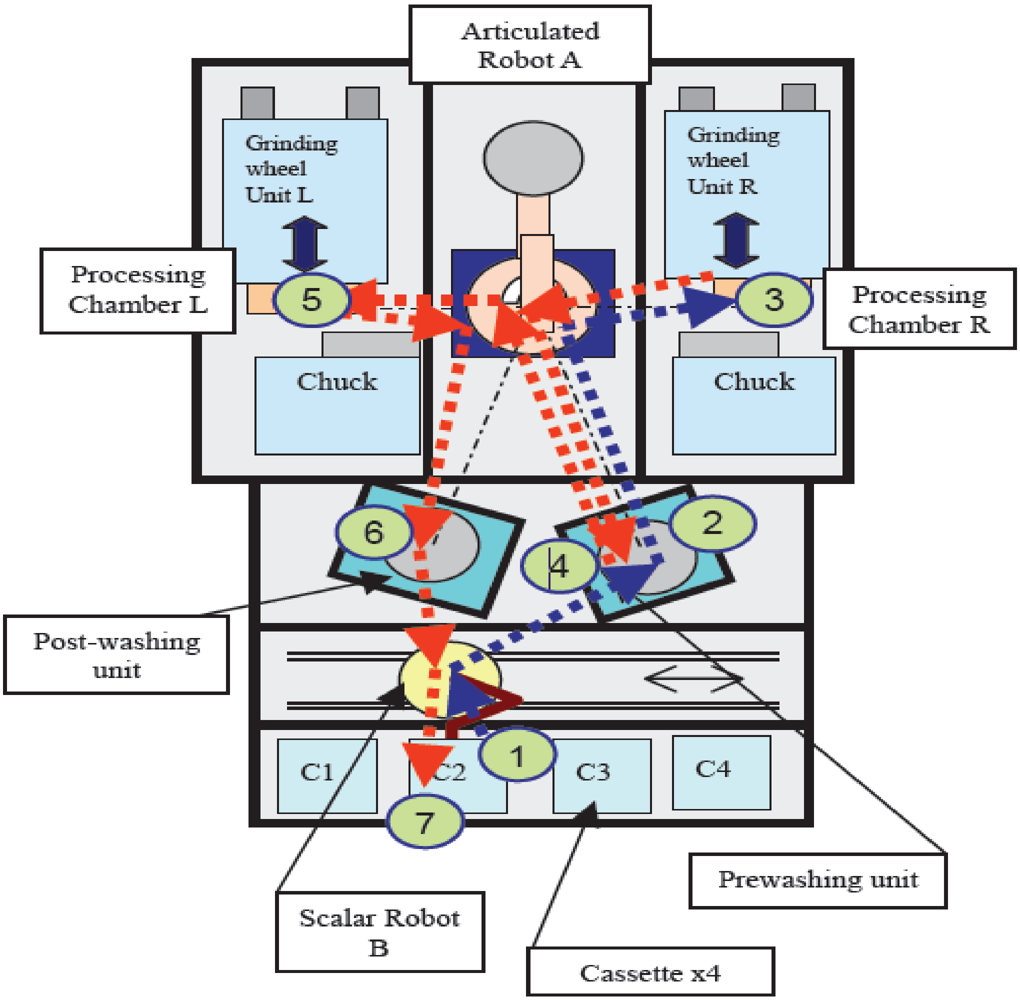
research effort has addressed the actual implementation of a controller interface. In this study we addressed the issue of interfacing between the actual controller and the virtual environment. The CAD/CAM environment allows engineers to perform mechanical design and servo tuning with a virtual-reality solid model. However, attempts to tune the solid-modeling process depend on the ability to convert the virtual environment parameters into the actual hardware parameters, and hence we also present a validation of our simulation results. A coefficient vector was used to represent the differences in the numerical representations, and an algorithm for identifying controller parameters has been developed. The target machine in this study The CNC grinding machine used in this study comprises three major components: the spindle, the moving worktable, and the base of the machine. The grinding wheel mounted on the spindle can move linearly in the y-direction and can rotate 751 about the x-axis. The grinding machine uses two sets of high-thrust linear motors to drive the worktable rapidly back and forth in the x-direction for high-speed grinding. The base of the machine not only supports the weight of the machine but also receives the reaction force from the linear motor.

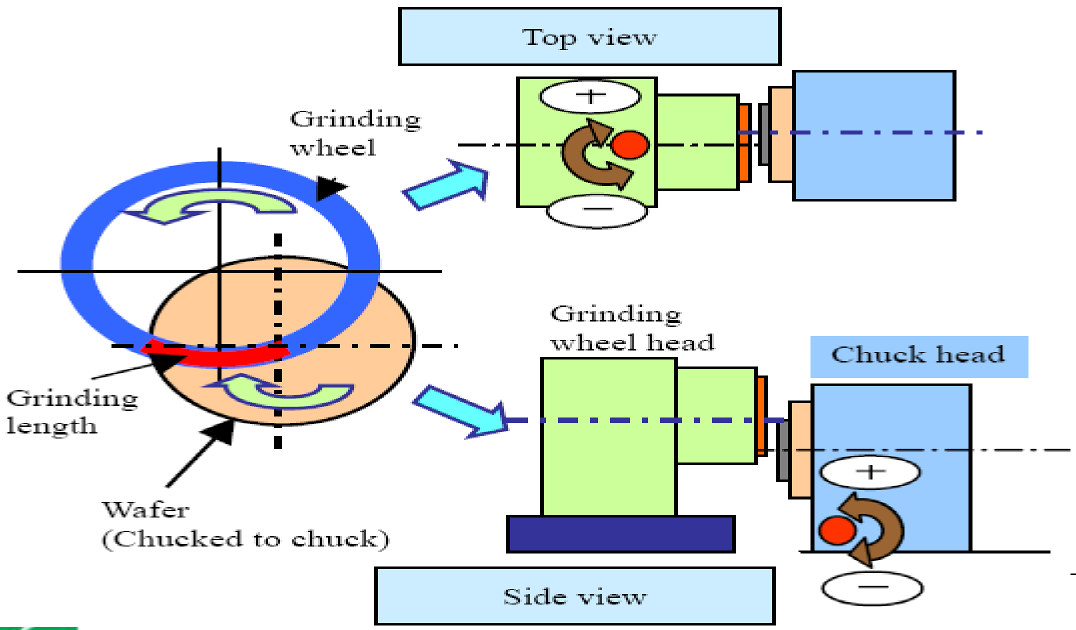
Design standards in all application areas are becoming increasingly more demanding. Expectations in terms of ergonomics, the air drag coefficient (CW value) or simply aesthetic appeal are creating a need for more complex surface geometries to be achieved in less time and with greater precision. The design 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 CNC Grinding Machines






Articulated Robot A
Grinding wheel Unit L
Grinding wheel Unit R
Processing Chamber L
Processing Chamber R
Chuck
Chuck
Post-washing unit
C1
C2
C3
C4
Prewashing unit
Scalar Robot B
Cassette x4
1
2
3
4
5
6
7


Top view
Grinding wheel
Grinding length
Wafer (Chucked to chuck)
Grinding wheel head
Chuck head
Side view

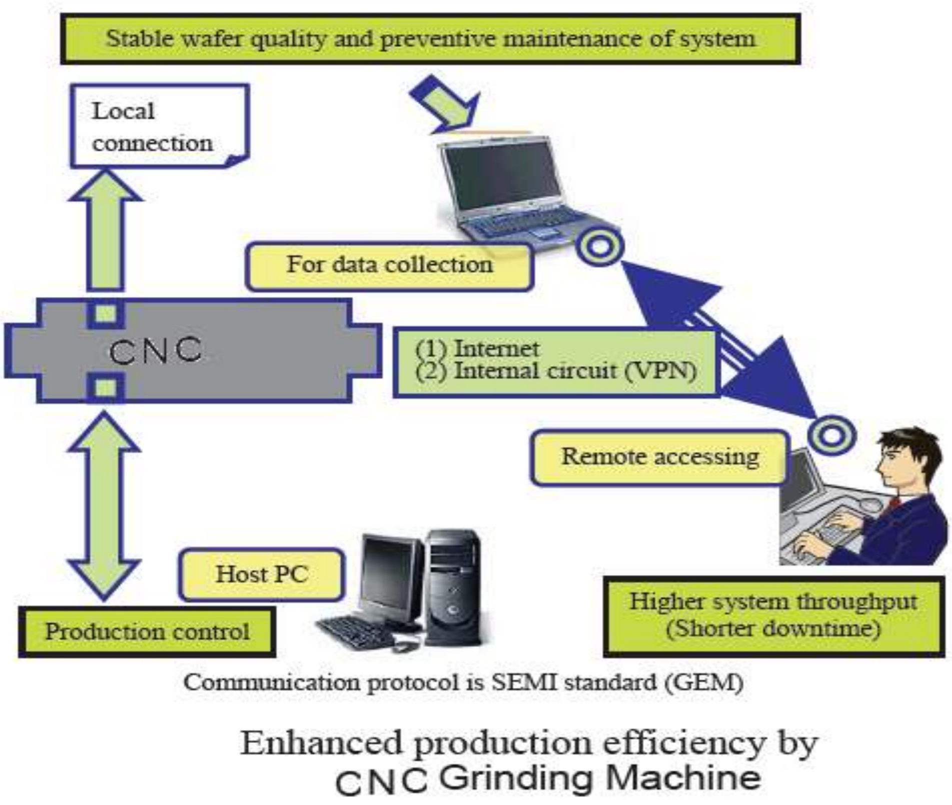


Figure 2.1 Process chain for CNC Grinding Machines

2.1.3 Technology specification

Salient Features:

- Grinding wheel spindle equipped with unique "Paragon" hydrostatic bearings for greater system stiffness, high accuracy & longevity.
- Hydrostatic lubrication on wheel head & table guideways.
- The machine bed, work head, wheel head are of Meehanite grade cast iron.
- The machine is developed based on the result of finite elements structure analysis & vibration analysis for achieving high rigidity, longer life & extremely low vibration level.
- Wheel head slide guideways is of hydrostatic.
- Machine tropicalised for stable continuous performance.
- Work head spindle runs on high precision preloaded antifriction bearing.
- Grinding wheel peripheral speed 45 M/sec.

- X & Z axis through CNC Servo drive controlled by Fanuc 2 axes CNC control model OG-C.
- Grinding wheelhead slide moves on C1 class ball screw, Heidenhain linear scale for closed loop feedback, A.C. servo motor results in achieving least input increment of 0.0001mm on dia.
- Hydraulic / manual operated tailstock. Tailstock has provision for micro taper correction. (optional)
- Machine equipped with sealed guard with auto door (optional).

Table 2.1 Equipment Speciation

DESCRIPTION	Unit	GU-2020 CNC
CAPACITY		
Swing over table	φ mm	200
Distance between centers	mm	200
Max. Grinding dia.	φ mm	100
Max. load held between centers	kg	30
Max Grinding wheel peripheral speed	m/s	33
Max Grind Wheel Dimensions	mm	355x50x127
CONTROL SYSTEM		FANUC
FEED SLIDE		
X-Axis minimum resolution increment	mm	0.0001
X-Axis rapid feed rate	m/min	8
Z-Axis minimum resolution increment	mm	0.0001
Z-Axis rapid feed rate	m/min	10
Z-axis can be swiveled manually in deg.	deg	-7.5 to 0.5
WORK HEAD		
Spindle Speed	RPM	0-1,200
Center	---	M.T.3
TAIL STOCK		
Hydraulic Sleeve retraction	mm	25
Center	---	M.T.3
TANK CAPACITY		
Hydraulic Tank	Ltr	32
Coolant Tank	Ltr	24
Wheel head lubrication	Ltr	80

DRIVEN MOTORS		
Wheel Spindle	HP	3
Wheel head feed (servo motor)	Kw	1.2
Table Feed (Servo motor)	Kw	1.2
Spindle Driver (Servo Motor)	Kw	1.2
Hydraulic Pump	HP	1.0
Wheel Spindle Lubricant	HP	¼
Coolant pump	HP	0.24
Internal Grinding	HP	1
OTHERS		
Machine Dimensions	Mm	2,700 x 3,150 x 2,140
Machine Weight	Kgs	2500

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	975
Average Energy Cost	` /Tonne	4875
Cost of Material Rejection	` /tonne	35000
Other Cost (Man Power/Utility)	` /tonne	11350
Average Production cost	`/tonne	51225

Grinding is the process of removing metal by the application of abrasives which are bonded to form a rotating wheel. When the moving abrasive particles contact the workpiece, they act as tiny cutting tools, each particle cutting a tiny chip from the workpiece. It is a common error to believe that grinding abrasive wheels remove material by a rubbing action; actually, the process is as much a cutting action as drilling, milling, and lathe turning. The grinding machine supports and rotates the grinding abrasive wheel and often supports and positions the workpiece in proper relation to the wheel. The grinding machine is used for roughing and finishing flat, cylindrical, and conical surfaces; finishing internal cylinders or bores; forming and sharpening cutting tools; snagging or removing rough projections from castings and stampings; and cleaning, polishing, and buffing surfaces. Once strictly finishing machines, modem production grinding machines are used for complete roughing and finishing of certain classes of work. From the simplest grinding machine to the most complex, grinding machines can be classified as utility grinding machines, cylindrical grinding machines. And surface grinding machines. The average machinist will be concerned mostly with floor-mounted and bench-mounted utility grinding machines, bufting machines. And reciprocating surface grinding machines.

- The wheel head travelling on a preloaded linear guide way system is driven by a hardened and ground lead screw and an AC servo motor providing high torque, speed and accurate positioning with a minimum increment of 0.0001” (0.001mm).A manual pulse generator(MPG) is standard for easy operation.
- Saddle continuous movement speed is controlled by a frequency converter for obtaining better grinding surface finish and dressing grinding wheel from table.
- The spindle of each machine is calibrated by a portable precision dynamic vibration measuring device. The final amplitude of spindle vibration shall be under 0.0012"/s(0.03mm/s).

- The spindle is supported by 4 class 7(P4) super precision angular contact ball bearings which have been accurately measured, selected and preloaded, and then assembled in a temperature controlled clean room. The spindle is permanently lubricated and requires no maintenance. Spindle motor, spindle shaft, and couplings are precisely balanced to ensure accuracy and superb finishes.
- The wheel head and column way system is composed of hardened and ground inserted steel guide ways and precision roller bearings. The wheel head and column guide ways are preloaded providing zero clearance for precise straight line movement. The low friction wheel head guide way system enables accurate feeds even at 0.000050"(0.001mm) increments while providing extended way life.
- The steel roller bearings used in all three axes guide ways are sieved by an automatic machine which assures the tolerance of the bearings within 0.00004"(0.001mm).
- The spindle of each machine is calibrated by a portable precision dynamic vibration measuring device. The final amplitude of spindle vibration shall be under 0.0012"/s(0.03mm/s

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 Grinding machine can be done in the 5-7 days, However the CNC Grinding machine is end to end solution of Grinding machineing 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 Grinding machine, 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

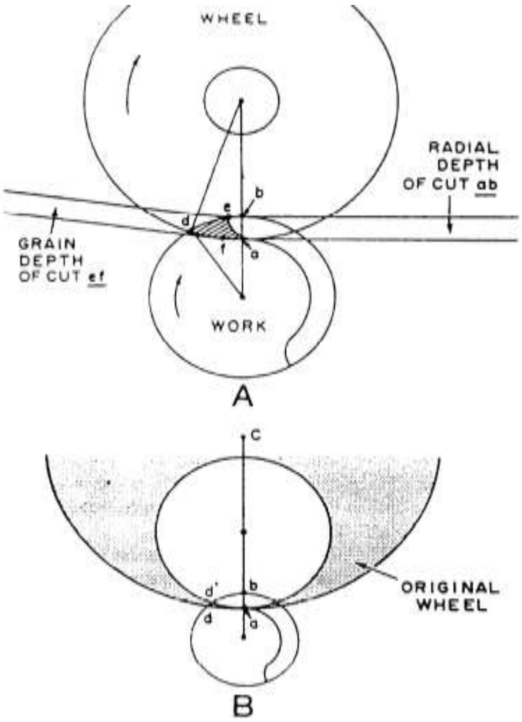
CNC Grinding machine is suitable for the units involved in the production of bulk quantity and large cross section job/product.

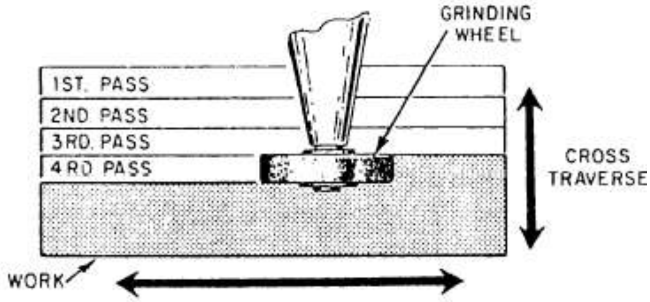
3 ECONOMIC BENEFITS FROM NEW ENERGY EFFICIENT TECHNOLOGY

3.1 Technical benefits

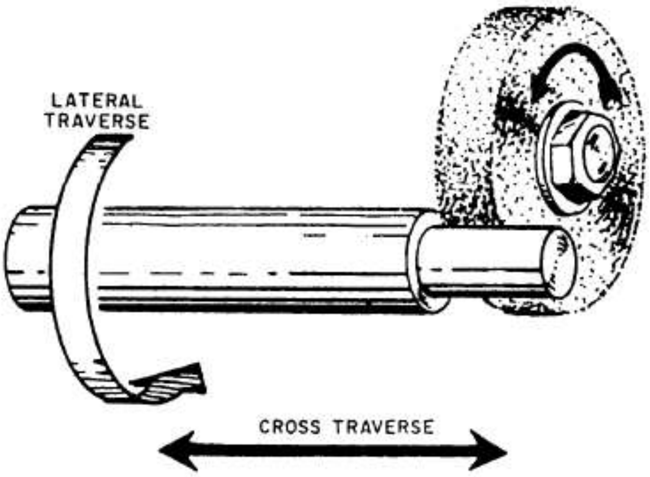
3.1.1 Fuel saving

Modern grinding machines are versatile and are used to perform work of extreme accuracy. They are used primarily to finish surfaces that have been machined in other machine tool operations. Surface grinders, cylindrical grinders, and tool and cutter grinders can perform practically all of the grinding operations required in machine tool production work. To perform these operations, you must know the construction and principles of operation of commonly used grinding machines. You gain proficiency in grinding through practical experience. Therefore, you should take every opportunity to watch or perform grinding operations from setup to completion. There are several classes of each type of grinder. The **SURFACE** grinder may have either a rotary or a reciprocating table and either a horizontal or a vertical spindle. **CYLINDRICAL** grinders may be classified as plain, center less, or internal grinders; the **TOOL AND CUTTER** grinder is basically a cylindrical grinder. Those generally found in Navy machine shops are the reciprocating table grinder, the horizontal spindle (planer type) surface grinder, the plain cylindrical grinder, and the tool and cutter grinder. Shops also may have a universal grinder, which is similar to a tool and cutter grinder except that it is designed for heavier work and usually has a power feed system and a coolant system.





Surface grinding a flat workpiece.



Surface grinding a cylindrical workpiece.

Energy & Cost saving including the energy, material rejection, man power cost and utility cost for a typical unit by installation of CNC

Grinding Machine are tabulated below:

Table 3.1 Energy savings estimation for CNC Grinding Machine

S. No	Particular	Unit	Conventional Grinding Machine	CNC Grinding Machine
1	Specific Energy Consumption	kWh/Tonne	975	750
2	Average Energy Cost	` /Tonne	4875	3750
3	Cost of Material Rejection	` /Tonne	35000	22136
4	Other Cost (Man Power/Utility)	` /tonne	11350	10569
5	***Average Production***	***` /tonne***	***51225***	***36455***
6	Annual Production	Tonne/annum	130.5	130.5
7	Annual Production Cost	` /annum	6684862.5	4757377.5
8	Reduction in Production Cost	` /Tonne	14770	
9	Annual Production Rate	Tonne/annum	130.5	
9	Annual cost reduction	` /Annum	1927485	

***Note:-** *As in the proposed DPR Conventional Grinding machine is replaced by CNC Grinding Machine, it is assumed that it improves the overall productivity by 1.75 times i.e. 130.5 Tonnes/Annum in earlier case to 228.375 Tonnes/Annum after implementation. Accordingly, the energy saving could be achieved.Consequnetly, the O&M cost of machinery shall increase to 5 % with annual Escalation of 5 %.*

3.1.2 Improvement in product quality

CNC Grinding Machine The truth of the highest precision the on-going consequent development has led to the introduction of this extremely compact CNC machine which is based on a visionary modular concept. The new design of the hydrostatic guide ways is meeting even the extremes requirements on universal as well as on production grinding. The objective rigorously striven for had been to develop a compact machine which can be used for the grinding of any kind of components with a length of up to 400 mm. The CNC Grinding Machine is based on platforms for the table slide and wheel head supports, and also for applications where the table slide is the direct starting basis. The new machine models are offered in their standard configuration. Application- and customer-specific versions of workpieces can also be processed. The new very rigid hydrostatic guide ways provide the basis for higher performance and dynamics in the X- and Z-axes. Further, the productivity and precision on unround grinding are significantly enhanced. Stronger drives for the axes of the CNC Grinding machines are permitting rapid speeds of up to 30 m/min. on the longitudinal axis, and of 15 m/min. on the infeed axis, both movements with higher accelerations. A complete cooling system is ensuring an even thermal economy for the machine. The hydrostatics, wheel head, internal grinding spindles and the heat exchanger of the electrical cabinet are included in this cooling cycle.

- Extremely fine correction possibilities
- Excellent dimensional accuracy on interpolating the X- and Z-axes, both for contour grinding and form dressing
- Even after years of use, no wear on the guide ways
- Excellent damping and extremely smooth operation
- The infrastructure is modular in design, easy to service and easily accessible, with all important functions being monitored
- Connecting plates for steady-rests / dressing spindles / measuring units
- Prepared for the use of oil as a coolant

3.1.3 Increase in production

Development of CNC grinding 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 grid or drill each material component manually. Apart from that the possibility of human error increases. CNC grinding machines not merely help in grinding 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 grinding machine is basically used to machine solid materials. Used with sharp cutting tools, it can be employed to get desired geometry. CNC grinding bits is one of the most important components used in CNC grinding machines. Basically used for grinding work, they are available in different sizes and shapes to provide desired result.

3.1.4 Reduction in raw material consumption

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 grinding 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 CNC grinding machine will result in reduction of the utility system like grinding 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 grinding machine has been estimated around ` 33.73 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 CO_2, NOx, etc

There are significant reductions to be achieved in Green House Gas emission by adoption of advance CNC technology like CNC grinding Machine in machine tools industries. Reduction in electricity consumption translates into GHG reductions is estimated to be 38.54 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 grinding Machine are provided in Table 4.1 below:

Table 4.1 Cost of equipment

S. No.	Particulars	Cost
1.	Cost of CNC Grinding Machine	` 4,241,000

4.1.2 Other costs

Table 4.2 Cost of civil work and consultancy

S. NO.	Particulars	Cost
1.	Erection and Commissioning , Cost of consultancy, Installation	` 2,70,000
2.	Civil Works	` 40,000
	Total in Rupees	` 310,000/-

Total project cost works out to be ` 45.61 lakh.

4.2 Arrangements of funds

4.2.1 Entrepreneur's contribution

Entrepreneur will contribute 25% of the total project cost & financial institutes can extend loan of 75%.

4.2.2 Loan amount.

The term loan is 75% of the total project cost, with repayment of 5 years excluding moratorium period of 6 months considered for the estimation purpose.

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 1.35 years.

4.3.3 Net Present Value (NPV)

Net Present Value of new project would work out ` 89.79 lakh.

4.3.4 Internal rate of return (IRR)

The after tax internal rate of return of the project works out to be 55.32 %. Thus the project is financially viable.

4.3.5 Return on investment (ROI)

The average return on investment of the project activity works out at 27.61 %.

Table 4.4 Financial indicator of proposed technology

Particulars	Unit	Value
Simple Pay Back period	years	1.35
IRR	%age	55.32
NPV	` in lakh	89.79
ROI	%age	27.61
DSCR	ratio	3.05

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.

Electricity saving increase by 5%

Electricity saving decrease by 5%

Table 4.5 Sensitivity analysis

Particulars	IRR	NPV	ROI	DSCR
Normal	55.32%	89.79	27.61%	3.05
5% increase in Electricity saving	55.58%	90.28	27.63%	3.06
5% decrease in Electricity saving	55.07%	89.30	27.60%	3.03

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

4.5 Procurement and implementation schedule

The installation of CNC grinding Machine can be done in the 7 – 9 days, However the CNC grinding machine is end to end solution of grinding production process, implementation will not affect production. Thus implementation of this technology will not affect the process.The Total time required will be about 15 weeks

Table 4.5 Implementation Schedule

S. No.	Activities	Weeks						
		1	2	-	-	13	14	15
1	Order Placement							
2	Delivery							
3	Erection & Commissioning							
4	Trial Operation							
5	Training							

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*	*Value*
Specific Energy Consumption	kWh/Tonne	975
Average Energy Cost	` /Tonne	4875
Cost of Material Rejection	` /tonne	35000
Other Cost (Man Power/Utility)	` /tonne	11350
Average Production cost	` /tonne	51225
Annual Production	Tonne	130.5
Annual Production Cost	` /annum	6684863

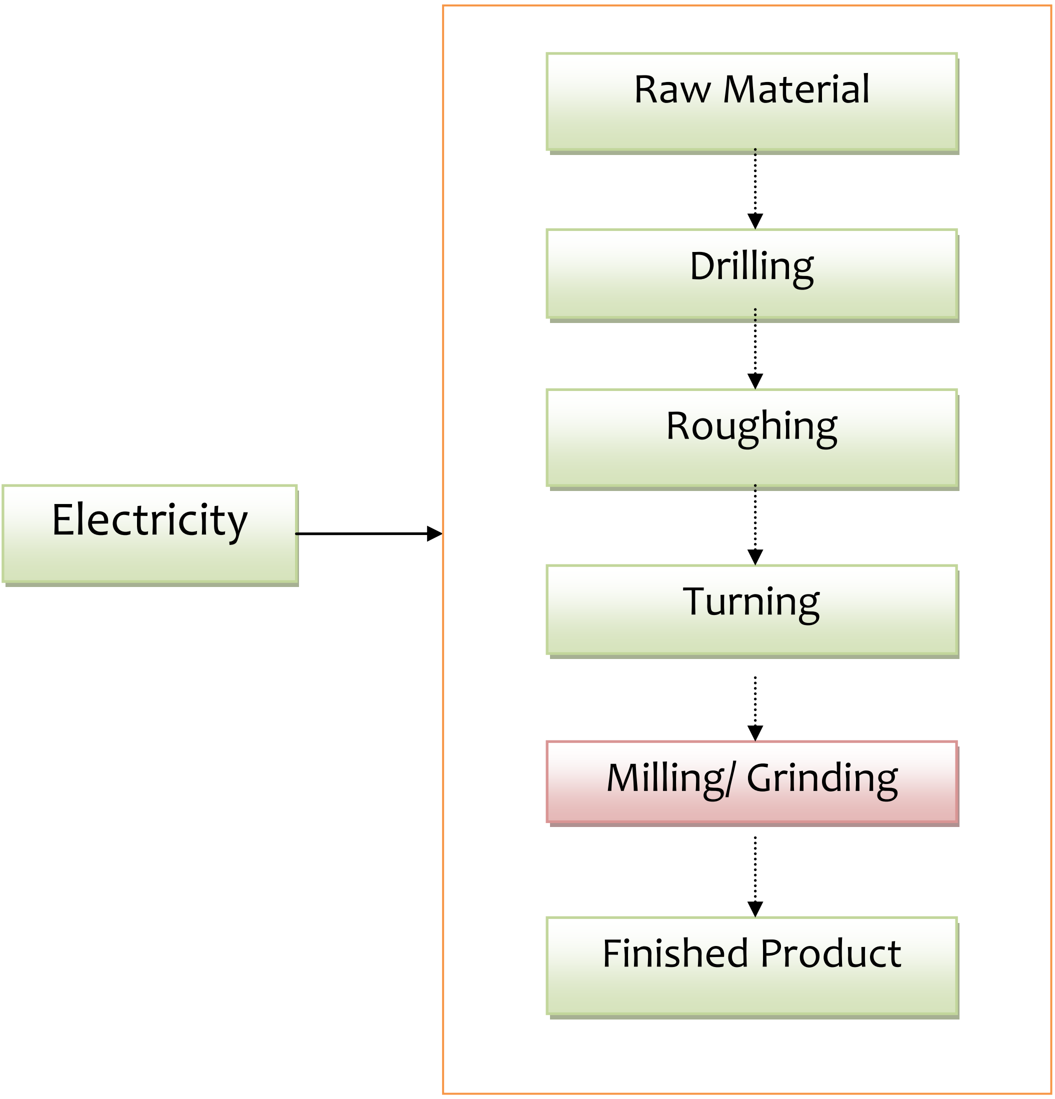
S. No	*Particular*	*Unit*	Conventional Grinding Machine	CNC Grinding Machine
1	Specific Energy Consumption	kWh/Tonne	975	750
2	Average Energy Cost	` /Tonne	4875	3750
3	Cost of Material Rejection	` /Tonne	35000	22136
4	Other Cost (Man Power/Utility)	` /tonne	11350	10569
5	***Average Production***	***` /tonne***	***51225***	***36455***
6	Annual Production	Tonne/annum	130.5	130.5
7	Annual Production Cost	` /annum	6684862.5	4757377.5
8	Reduction in Production Cost	` /Tonne		14770

9	Annual Production Rate	Tonne/annum	130.5
10	Annual cost reduction	` /Annum	1927485

***Note:-** *As in the proposed DPR Conventional Grinding machine is replaced by CNC Grinding Machine, it is assumed that it improves the overall productivity by 1.75 times i.e. 130.5 Tonnes/Annum in earlier case to 228.375 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 %.*

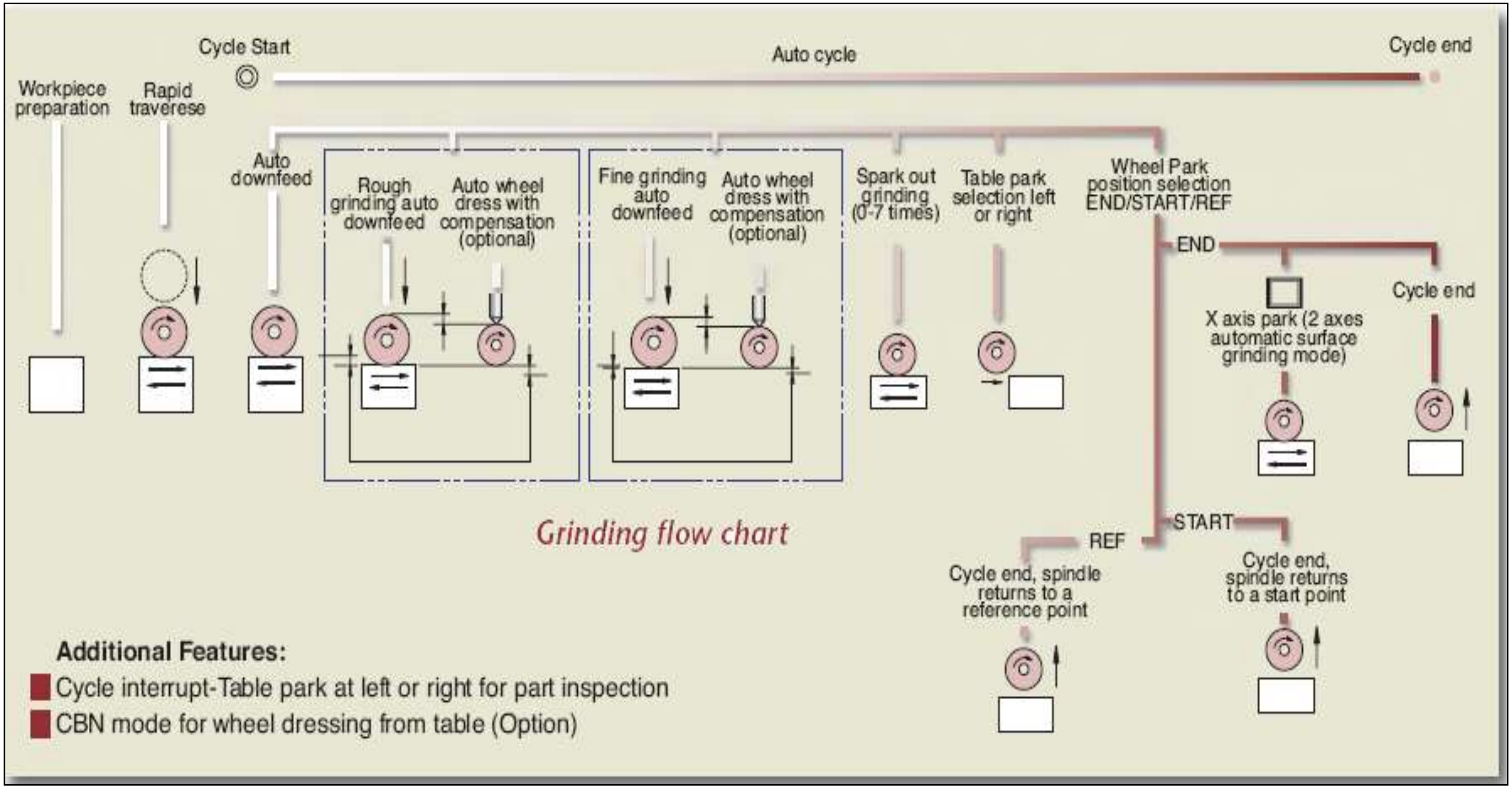
S. No	***Particular***	***Unit***	**Conventional Grinding Machine**	**CNC Grinding Machine**
	Average Production	***` /tonne***	***51225***	***36455***
	Annual Production	Tonne/annum	130.5	228.375
	Annual Production Cost	` /annum	6684862.5	4757377.5
	Annual cost reduction	` /Annum	3373099	

Annexure 2: Process flow diagram

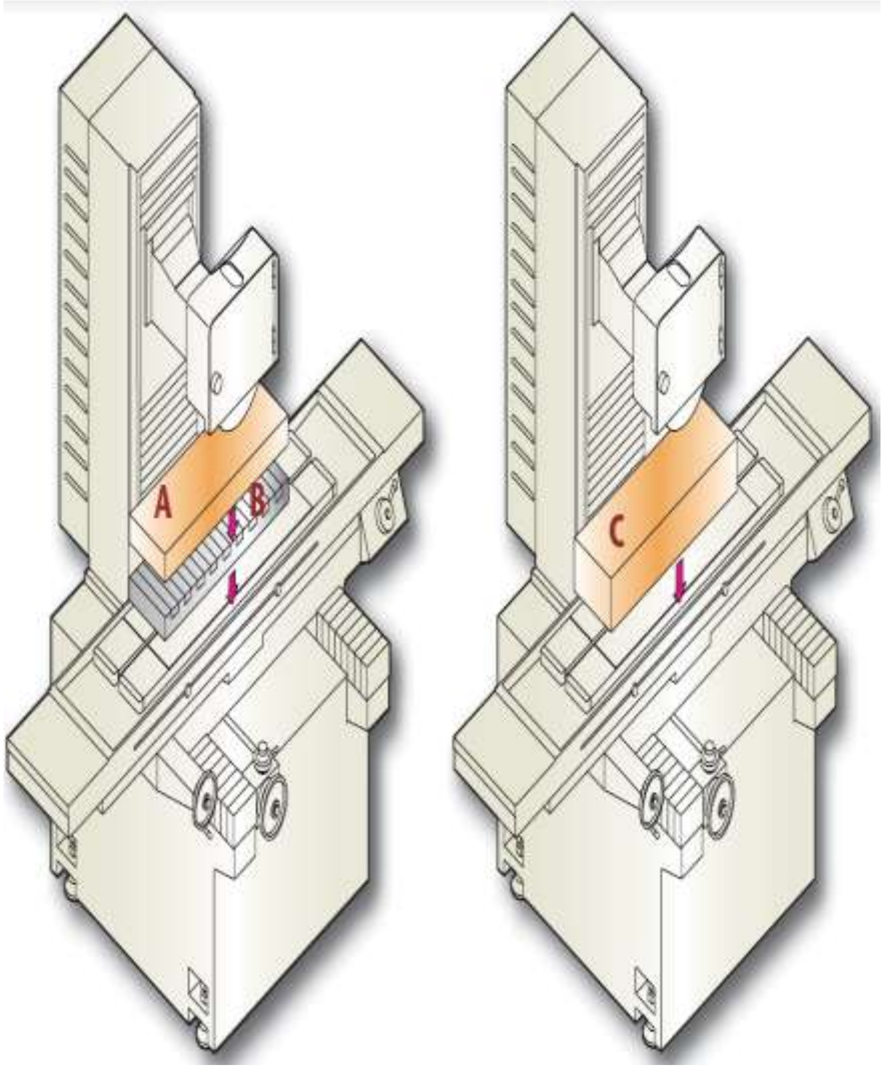


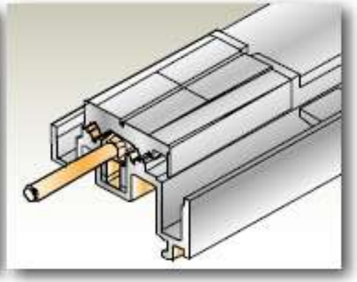
To evaluate the performance of CNC grinding machine, we can look at its rigidity. For example, the more rigid a grinding machine is, the more precisely it grinding machineing process. CNC grinding machine normally have better & tougher engines for higher rigidity compared to manual counterparts. With CNC grinding 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 grinding 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 grinding 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.

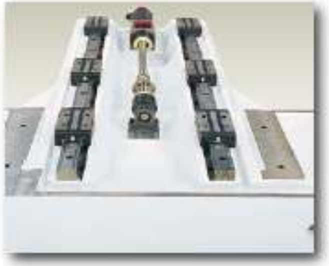
Annexure 3: Technical Drawing of CNC Grinding Machine

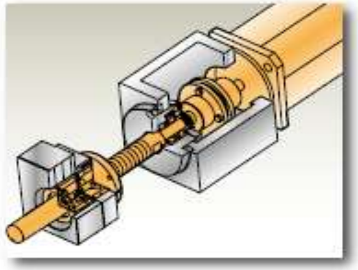



Control Station
Crossfeed Transmission
Micro Crossfeed Device


A
B
C







DISPLAY AND CONTROL PANEL

1. All executing function are well indicated. Main power, machine zero,end of program,magnetic chuck voltage,dressing,lubrication conditions are all shown by indicating LEDS.
2. The 8.4" TFT LCD color monitor position,program and working condition as well as self-displayed on the screen for the operator's convenience.
3. One piece soft-key keyboard not only dustproof and waterproof but also offers maintenance free features.
4. Easy to operate switch coped with indicating lights, to assure positive operations.
5. For the operator's convenience,not only the magnetic force can be adjusted but also the demagnetizing time.(operation)
6. Well deveoped testing functions can verify NC program thoroughly to ensure accident-free operation.
7. With MPG,feedrate override switches and JOG buttons,manual operation becomes easy and convenient.

Annexure 4: Detailed financial calculations & analysis for financial indicators

Assumption

Name of the Technology	***CNC Grinding 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)	42.41	Feasibility Study
Cost of modification in civil construction	` (in lakh)	0.50	Feasibility Study
Cost of consultancy, Installation & Erection & Commissioning	` (in lakh)	2.7	Feasibility Study
Total Investment	` (in lakh)	45.61	Feasibility Study
Financing pattern			
Own Funds (Equity)	` (in lakh)	11.40	Feasibility Study
Loan Funds (Term Loan)	` (in lakh)	34.21	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	225	
Annual production	Tonne/Annum	228.375	
Cost	` /kWh	5	
Other savings	` /Annum	13645	
St. line Depn.	%age	5.28	Indian Companies Act
IT Depreciation	%age	15.00	Income Tax Rules
Income Tax	%age	33.99	Income Tax

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

Years	***Opening Balance***	***Repayment***	***Closing Balance***	***Interest***
1	34.21	3.00	31.21	3.94
2	31.21	6.00	25.21	2.85
3	25.21	6.60	18.61	2.22
4	18.61	7.20	11.41	1.53
5	11.41	7.60	3.81	0.80
6	3.81	3.81	0.00	0.11
		34.21		

WDV Depreciation

Particulars / years	***1***	***2***	***3***	***4***	***5***
Plant and Machinery					
Cost	45.61	9.12			
Depreciation	36.49	7.30			
WDV	9.12	1.82			

Projected Profitability

Particulars / Years	1	2	3	4	5	6	7	8
Revenue through Savings								
Total Revenue (A)	33.73	33.73	33.73	33.73	33.73	33.73	33.73	33.73
Expenses								
O & M Expenses	2.28	2.39	2.51	2.64	2.77	2.91	3.06	3.21
Total Expenses (B)	2.28	2.39	2.51	2.64	2.77	2.91	3.06	3.21
PBDIT (A)-(B)	31.45	31.34	31.22	31.09	30.96	30.82	30.67	30.52
Interest	3.94	2.85	2.22	1.53	0.80	0.11	-	-
PBDT	27.51	28.49	29.00	29.56	30.16	30.71	30.67	30.52
Depreciation	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41
PBT	25.10	26.08	26.59	27.15	27.75	28.30	28.27	28.11
Income tax	-	7.20	9.86	10.05	10.25	10.44	10.43	10.37
Profit after tax (PAT)	25.10	18.88	16.73	17.10	17.50	17.86	17.84	17.74

Computation of Tax

Particulars / Years	1	2	3	4	5	6	7	8
Profit before tax	25.10	26.08	26.59	27.15	27.75	28.30	28.27	28.11
Add: Book depreciation	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41
Less: WDV depreciation	36.49	7.30	-	-	-	-	-	-
Taxable profit	(8.98)	21.19	29.00	29.56	30.16	30.71	30.67	30.52
Income Tax	-	7.20	9.86	10.05	10.25	10.44	10.43	10.37

Projected Balance Sheet

Particulars / Years	1	2	3	4	5	6	7	8
Liabilities								
Share Capital (D)	11.40	11.40	11.40	11.40	11.40	11.40	11.40	11.40
Reserves & Surplus (E)	25.10	43.98	60.71	77.82	95.31	113.18	131.02	148.76
Term Loans (F)	31.21	25.21	18.61	11.41	3.81	0.00	0.00	0.00
Total Liabilities D)+(E)+(F)	67.71	80.59	90.72	100.63	110.52	124.58	142.42	160.16
Assets								
Gross Fixed Assets	45.61	45.61	45.61	45.61	45.61	45.61	45.61	45.61
Less: Accm. Depreciation	2.41	4.82	7.22	9.63	12.04	14.45	16.86	19.27
Net Fixed Assets	43.20	40.79	38.39	35.98	33.57	31.16	28.75	26.34
Cash & Bank Balance	24.51	39.80	52.34	64.65	76.96	93.41	113.66	133.81
Total Assets	67.71	80.59	90.72	100.63	110.52	124.58	142.42	160.16
Net Worth	36.51	55.38	72.12	89.22	106.72	124.58	142.42	160.16
Dept equity ratio	2.74	2.21	1.63	1.00	0.33	0.00	0.00	0.00

Projected Cash Flow: *` (in lakh)*

Particulars / Years	0	1	2	3	4	5	6	7	8
Sources									
Share Capital	11.40	-	-	-	-	-	-	-	-
Term Loan	34.21								
Profit After tax		25.10	18.88	16.73	17.10	17.50	17.86	17.84	17.74
Depreciation		2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41
Total Sources	45.61	27.51	21.29	19.14	19.51	19.91	20.27	20.25	20.15
Application									
Capital Expenditure	45.61								
Repayment of Loan	-	3.00	6.00	6.60	7.20	7.60	3.81	-	-

Total Application	45.61	3.00	6.00	6.60	7.20	7.60	3.81	-	-
Net Surplus	-	24.51	15.29	12.54	12.31	12.31	16.46	20.25	20.15
Add: Opening Balance	-	-	24.51	39.80	52.34	64.65	76.96	93.41	113.66
Closing Balance	-	24.51	39.80	52.34	64.65	76.96	93.41	113.66	133.81

Calculation of Internal Rate of Return

Particulars / months	***0***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Profit after Tax		25.10	18.88	16.73	17.10	17.50	17.86	17.84	17.74
Depreciation		2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41
Interest on Term Loan		3.94	2.85	2.22	1.53	0.80	0.11	-	-
Cash outflow	(45.61)	-	-	-	-	-	-	-	-
Salvage value									26.34
Net Cash flow	(45.61)	31.45	24.13	21.36	21.04	20.71	20.38	20.25	46.49
IRR	55.32%								
NPV	89.79								

Break Even Point

`(in lakh)

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Variable Expenses								
Operation & Maintenance Exp (75%)	1.71	1.80	1.89	1.98	2.08	2.18	2.29	2.41
Sub Total (G)	1.71	1.80	1.89	1.98	2.08	2.18	2.29	2.41
Fixed Expenses								
Operation & Maintenance Exp (25%)	0.57	0.60	0.63	0.66	0.69	0.73	0.76	0.80
Interest on Term Loan	3.94	2.85	2.22	1.53	0.80	0.11	0.00	0.00
Depreciation *(H)*	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41
Sub Total (I)	6.92	5.85	5.26	4.60	3.90	3.25	3.17	3.21
Sales (J)	33.73	33.73	33.73	33.73	33.73	33.73	33.7	33.7
Contribution (K)	32.02	31.94	31.85	31.75	31.65	31.55	31.44	31.32
Break Even Point (L= G/I) (%)	21.61%	18.33%	16.51%	14.49%	12.33%	10.30%	10.09%	10.25%
Cash Break Even {(I)-(H)} (%)	14.08%	10.79%	8.95%	6.91%	4.72%	2.67%	2.43%	2.56%
Break Even Sales (J)*(L)	7.29	6.18	5.57	4.89	4.16	3.47	3.40	3.46

Return on Investment

`(in lakh)

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***Total***
Net Profit Before Taxes	25.10	26.08	26.59	27.15	27.75	28.30	28.27	28.11	217.35
Net Worth	36.51	55.38	72.12	89.22	106.72	124.58	142.42	160.16	787.09
ROI	27.61%								

Debt Service Coverage Ratio

`(in lakh)

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***Total***
Cash Inflow									
Profit after Tax	25.10	18.88	16.73	17.10	17.50	17.86	17.84	17.74	113.18
Depreciation	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	14.45
Interest on Term Loan	3.94	2.85	2.22	1.53	0.80	0.11	0.00	0.00	11.46

Total (M)	31.45	24.13	21.36	21.04	20.71	20.38	20.25	20.15	139.08

Debt

Interest on Term Loan	3.94	2.85	2.22	1.53	0.80	0.11	0.00	0.00
Repayment of Term Loan	3.00	6.00	6.60	7.20	7.60	3.81	0.00	0.00
Total (N)	6.94	8.85	8.82	8.73	8.40	3.92	0.00	0.00
Average DSCR (M/N)	3.05							

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).

Annexure5: Details of procurement and implementation plan

S. No.	Activities	Weeks						
		1	2	-	-	13	14	15
1	Order Placement							
2	Delivery							
3	Erection & Commissioning							
4	Trial Operation							
5	Training							

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

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PARAGON
GU2020 CNC
UNIVERSAL CYLINDRICAL GRINDING MACHINE

QTN.NO.IMTPL/BLR/PARAGON/146/11 FEB 16, 2011

Petroleum Conservation Research Association,
302, Kaveri Apartments, 4th Main Road,
G.M.Palya, New Thippasandra Post,
Bangalore-560 075

MANUFACTURER: PARAGON MACHINERY CO. LTD., TAIWAN
MODEL: 'PARAGON' CNC PLUNGE WHEEL HEAD CYLINDRICAL GRINDING MACHINE GU-2020 CNC

SALIENT FEATURES:

- Grinding wheel spindle equipped with unique "Paragon" hydrostatic bearings for greater system stiffness, high accuracy & longevity.
- Hydrostatic lubrication on wheel head & table guideways.
- The machine bed, work head, wheel head are of Meehanite grade cast iron.
- The machine is developed based on the result of finite elements structure analysis & vibration analysis for achieving high rigidity, longer life & extremely low vibration level.
- Wheel head slide guideways is of hydrostatic.
- Machine tropicalised for stable continuous performance.
- Work head spindle runs on high precision preloaded antifriction bearing.
- Grinding wheel peripheral speed 45 M/sec.
- X & Z axis through CNC Servo drive controlled by Fanuc 2 axes CNC control model OG-C.
- Grinding wheelhead slide moves on C1 class ball screw, Heidenhain linear scale for closed loop feedback, A.C. servo motor results in achieving least input increment of 0.0001mm on dia.
- Hydraulic / manual operated tailstock. Tailstock has provision for micro taper correction. (optional)
- Machine equipped with sealed guard with auto door (optional).

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MAIN SPECIFICATIONS:

DESCRIPTION	Unit	GU-2020 CNC
CAPACITY		
Swing over table	φ mm	200
Distance between centers	mm	200
Max. Grinding dia.	φ mm	100
Max. load held between centers	kg	30
Max Grinding wheel peripheral speed	m/s	33
Max Grind Wheel Dimensions	mm	355x50x127
CONTROL SYSTEM		FANUC
FEED SLIDE		
X-Axis minimum resolution increment	mm	0.0001
X-Axis rapid feed rate	m/min	8
Z-Axis minimum resolution increment	mm	0.0001
Z-Axis rapid feed rate	m/min	10
Z-axis can be swiveled manually in deg.	deg	-7.5 to 0.5
WORK HEAD		
Spindle Speed	RPM	0-1,200
Center	---	M.T.3
TAIL STOCK		
Hydraulic Sleeve retraction	mm	25
Center	---	M.T.3
TANK CAPACITY		
Hydraulic Tank	Ltr	32
Coolant Tank	Ltr	24
Wheel head lubrication	Ltr	80

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DRIVEN MOTORS		
Wheel Spindle	HP	3
Wheel head feed (servo motor)	Kw	1.2
Table Feed (Servo motor)	Kw	1.2
Spindle Driver (Servo Motor)	Kw	1.2
Hydraulic Pump	HP	1.0
Wheel Spindle Lubricant	HP	¼
Coolant pump	HP	0.24
Internal Grinding	HP	1
OTHERS		
Machine Dimensions	Mm	2,700 x 3,150 x 2,140
Machine Weight	Kgs	2500

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1) **MACHINE BED** :

The machine bed is made of high quality – "MEEHANITE" cast iron. Machine slides, bed are heat treated and precision ground.

2) **GRINDING WHEELHEAD :**

The Wheel head is an integrated assembly for the optimum rigidity.

The Grinding wheel spindle is made of high grade Nickel Chromium Molybdenum steel SNCM –439 (JIS), heat treated, including sub-zero treatment to ensure trouble free performance throughout the life. Grinding spindle mounted on Hydrostatic which has successfully developed after research of many years. Hydrostatic bearing arrangement is a closed loop system unlike Hydrodynamic bearings of open loop system. Hydrostatic bearing arrangement ensures no metal to metal friction, no overheat & no oil leakage as no oil seal is used. The arrangement facilitate smooth running of spindle, light, high accuracy and longer life. Grinding wheel peripheral speed 45 Mts/sec.

3) **WORKHEAD:**

The work spindle is supported by two high quality accurate angular-contact ball bearings with permanent lubrication. Precisely aligned workhead providing solid support to assure accurate grinding. Combination live and dead spindle facility. Infinitely variable spindle speeds. A regulator for infinitely variable speed can be supplied as an option.

4) **TAILSTOCK** :

The tailstock is precisely aligned providing solid support to assure accurate grinding with precision axial movement of centre in the precisely machined sleeve.

5) **HYDRAULIC OIL COOLING FAN :**

Basically, it reduces the oil temperature which in turn keeps the spindle in stabilized condition.

6) **PRESSURE SWITCH :**

A pressure switch is provided in the grinding wheel spindle lubrication system so that the spindle will not rotate if the lubrication pressure is reduced. This prevents the spindle from dry running & also prevents from further damage.

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STANDARD ACCESSORIES :

- FANUC 2 AXIS CNC CONTROL # Oi-TC
- Linear Scales for X-axis
- Coolant system with Pump
- Electric cabinet heat exchanger
- Tail stock mounted dressing holder
- Grinding wheel + Flange
- Hydraulic Tank with Pump

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PRICE OFFER			
SR. NO.	DESCRIPTION OF ITEM	QTY	PRICE IN US$ FOB TAIWAN
1.0	PARAGON PLUNG WHEEL HEAD CNC CYLINDRICAL GRINDING MACHINE MODEL GU 2020 CNC Including Standard Accessories With Fanuc 2 Axes CNC control Oi-TC.(Swing over table :200mm:distance b/w centers:200mm)	1 Set	102,000
	*WHEELHEAD SPINDLE BEARING: HYDROSTATIC BEARING		
	*HYDROSTATIC GUIDEWAYS		
	*WORKHEAD MOTOR: SERVO MOTOR		
	*1 PCE GRINDING WHEEL(DIA. 355X25X127MM)(2700M/MIN) * GRINDING WHEEL MOTOR: 2.2 KW *1 PCE GRINDING WHEEL FLANGE *1 SET COOLANT TANK + PUMP (THIS WILL BE EXEMPTED WHILE PAPER FILTER IS ADOPTED) *1 SET HYDRAULIC POWER PACK *1 PCE DIAMOND TOOL FOR DRESSING *1 PCE TOOL BOX WITH TOOLS *1 PCE TRICOLOR WORK LIGHT *1 PCE WORKHEAD CENTER#MT 3 *1 PCE TAILSTOCK CENTER#MT 3 *WITHOUT SEALED MACHINE GUARD ** MACHINE NET WEIGHT: 2100 KG		

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OPTIONAL ACCESSORIES:

2.0	1) MAGNETIC COOLANT SEPARATOR 60L/MIN 2) PAPER FILTER 60L/MIN 3) MARPOSS AUTO. IN-PROCESS GAUGE #UNIMAR S10 + P1 (MEASURING RANGE: DIA 8-90MM) 4) WHEEL BALANCING STAND & ARBOR. 5) SEALED MACHINE GUARD	1 Set 1 Set 1 Set 1 Set 1 Set	1,100 1,600 12,000 1,000 8,000
3.0	Charges for Supervision of Errection and Commission by **PARAGON** Engineer		5,000
	Alternatively Charges for Supervision of Errection and Commission by **INTELMAC** Engineer in **INR**		**50,000 INR**

For **INTELMAC MACHINE TOOLS PVT LTD**

Kirankumar Dixit

093439 08030

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TERMS AND CONDITIONS OF SALES

1. **PRICES**

   PRICES QUOTED ARE FOB TAIWAN BASIS.30% DISCOUNT HAS BEEN QUOTED

2. **DELIVERY**

   3-3 MONTHS FROM EX-WORKS ON RECEIPT OF YOUR FIRM ORDER ALONG WITH LETTER OF CREDIT.

3. **PLACE OF SHIPMENT**

   FOB TAIWAN PORT

4. **TERMS OF PAYMENT**

   YOU HAVE TO OPEN CONFIRMED, IRREVOCABLE L/C FOR 100% OF ORDER VALUE WITH A PROVISION TO DRAW 30% ADVANCE IMMEDIATELY AFTER RECEIPT OF ORDER ACKNOWLEDGEMENT.

   THE ORDER AND LETTER OF CREDIT IS TO BE OPENED IN THE NAME OF PARAGON MACHINERY CO. LTD., TAIWAN.

5. **INSURANCE :**

   TO BE ARRANGED BY YOU.

6. **WARRANTY**

   15 MONTHS FROM THE DATE OF SHIPMENT OR 12 MONTHS FROM THE DATE OF INSTALLATION & COMMISSIONING, WHICHEVER IS EARLIER.

   DURING WARRANTY ANY PARTS THAT MAY BE FOUND FAULTY AND NEED REPLACEMENT WILL BE SUPPLIED FREE OF COST BY US . HOWEVER, THE COSTS OF CLEARANCE FROM CUSTOMS INCLUDING DUTIES, TAXES, GOVT. LEVIES ETC. ARE TO BE BORNE BY THE PURCHASER.

7. **FORCE MAJEURE**

   THE INTERNATIONAL FORCE MAJEURE CONDITION WILL APPLY TO THIS OFFER.

8. **ARBITRATION**

   ANY DISPUTES LEADING TO ARBITRATION WILL BE REFERRED TO INTERNATIONAL ARBITRATION COURT.

9. **VALIDITY**

   THIS OFFER IS VALID FOR ORDERING WITHIN 30 DAYS FROM THE DATE OF THIS OFFER.

10. **ERECTION AND COMMISSIONING**

    THE QUOTED PRICES DO NOT INCLUDE CHARGES TOWARDS SUPERVISION OF ERECTION & COMMISSIONING. THESE ARE QUOTED SEPARATELY.

For **INTELMAC MACHINE TOOLS PVT LTD**

Kirankumar Dixit

093439 08030

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