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Optimization and Analysis of Multi Tool Arbor

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ABSTRACT

The growth of Indian manufacturing sector depends largely on its productivity and quality. Productivity depends upon many factors, one of the major factors being manufacturing efficiency with which the operation activities are carried out in the organization. Productivity can be improved by reducing the total machining time, combining the operations etc. In case of mass production where variety of jobs is less and quantity to be produced is huge, it is very essential to produce the job at a faster rate. This is not possible if we carry out the production by using general purpose machines. The best way to improve the production rate(productivity) along with quality is by use of special purpose machine. Usefulness and performance of the existing radial drilling machine will be increased by designing and development of multi spindle drilling head attachment. Machining time plays a pivotal role in the field of manufacturing. Thus increasing the size and shape of the machining tool, will no longer provides solution to meet today's demand. However, CNC helps to meet desired function but not suitable for many small scale industries which serves as a backbone of our country. The Main function of this project is to reduce machining time and provide assistance to productivity. By incorporating multiple arbor tool adaptable longitudinally. The longitudinal adaptation is achieved by mating gears. we can minimize the machining time in the conventional setup. Catia is the standard in 3d product design, featuring industry-leading productivity tools that promote best practices in design.

Keywords : Arbor Tool, 3D Modeling, CNC machining, Catia

I. INTRODUCTION

A machine tool is a machine for shaping or machining metal or other rigid materials, usually by cutting, boring, grinding, shearing, or other forms of deformation. Machine tools employ some sort of tool that does the cutting or shaping. All machine tools have some means of constraining the work piece and provide a guided movement of the parts of the machine. Thus the relative movement between the work piece and the cutting tool (which is called the tool path) is controlled or constrained by the machine to at least some extent, rather than being entirely "offhand" or "freehand".

The precise definition of the term machine tool varies among users, as discussed below. While all machine tools are "machines that help people to make things", not all factory machines are machine tools.Today machine tools are typically powered other than by human muscle (e.g., electrically, hydraulically, or via line shaft), used to make manufactured parts (components) in various ways that include cutting or certain other kinds of deformation with their inherent precision, machine tools enabled the economical production of interchangeable parts.

A. **Nomenclature and Key Concepts, Interrelated**

Many historians of technology consider that true machine tools were born when the toolpath first became guided by the machine itself in some way, at least to some extent, so that direct, freehand human guidance of the toolpath (with hands, feet, or mouth) was no longer the only guidance used in the cutting or forming process. In this view of the definition, the term, arising at a time when all tools up till then had been hand tools, simply provided a label for "tools that were machines instead of hand tools". Early lathes, those prior to the late medieval period, and modern woodworking lathes and potter's wheels may or may not fall under this definition, depending on how one views the headstockspindle itself; but the earliest historical records of a lathe with direct mechanical control of the cutting tool's path are of a screw-cutting lathe dating to about 1483. This lathe "produced screw threads out of wood and employed a true compound slide rest".

The mechanical tool path guidance grew out of various root concepts:

First is the spindle concept itself, which constraints work piece or tool movement to rotation around a fixed axis. This ancient concept predates machine tools per se; the earliest lathes and potter's wheels incorporated it for the work piece, but the movement of the tool itself on these machines was entirely freehand.The machine slide, which has many forms, such as dovetail ways, box ways, or cylindrical column ways. Machine slides constrain tool or work piece movement linearly. If a stop is added, the length of the line can also be accurately controlled. (Machine slides are essentially a subset of linear bearings, although the language used to classify these various machine elements includes connotative boundaries; some users in some contexts would contradistinguish elements in ways that others might not).Tracing, which involves following the contours of a model or template and transferring the resulting motion to the tool path.Cam operation, which is related in principle to tracing but can be a step or two removed from the traced element's matching the reproduced element's final shape. For example, several cams, no one of which directly matches the desired output shape, can actuate a complex tool path by creating component vectors that add up to a net tool path.

Abstractly programmable tool path guidance began with mechanical solutions, such as in musical box cams and Jacquard looms. The convergence of programmable mechanical control with machine tool path control was delayed many decades, in part because the programmable control methods of musical boxes and looms lacked the rigidity for machine tool paths. Later, electromechanical solutions (such as servos) and soon electronic solutions (including computers) were added, leading to numerical control and computer numerical control. When considering the difference between freehand tool paths and machine-constrained toolpaths, the concepts of accuracy and precision, efficiency, and productivity become important in understanding why the machine-constrained option adds value. After all, humans are generally quite talented in their freehand movements; the drawings, paintings, and sculptures of artists such as Michelangelo or Leonardo da Vinci, and of countless other talented people, show that human freehand tool path has great potential. The value that machine tools added to these human talents is in the areas of rigidity (constraining the tool path despite thousands of Newtons (pounds) of force fighting against the constraint), accuracy and precision, efficiency, and productivity. With a machine tool, tool paths that no human muscle could constrain can be constrained; and tool paths that are technically possible with freehand methods, but would require tremendous time and skill to execute, can instead be executed quickly and easily, even by people with little freehand talent (because the machine takes care of it). The latter aspect of machine tools is often referred to by historians of technology as "building the skill into the tool", in contrast to the tool path-constraining skill being in the person who wields the tool. As an example, it is physically possible to make interchangeable screws, bolts, and nuts entirely with freehand tool paths. But it is economically practical to make them only with machine tools.

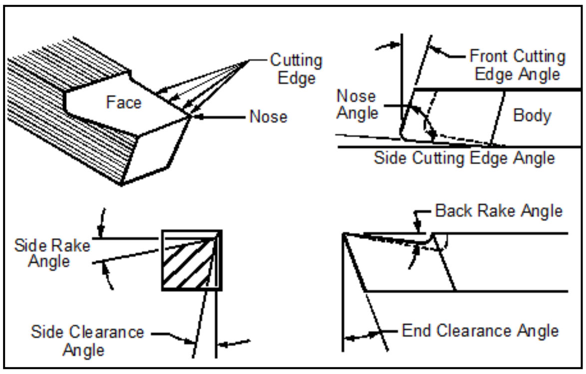

Figure 1: Types of Rake angles

In the 1930s, the U.S. National Bureau of Economic Research (NBER) referenced the definition of a machine tool as "any machine operating by other than hand power which employs a tool to work on metal". The narrowest colloquial sense of the term reserves it only for machines that perform metal cutting in other words, the many kinds of [conventional] machining and grinding.

These processes are a type of deformation that produces swarf. However, economists use a slightly broader sense that also includes metaldeformation of other types that squeeze the metal into shape without cutting off swarf, such as rolling, stamping with dies, shearing, swaging, riveting, and others. Thus presses are usually included in the economic definition of machine tools. For example, this is the breadth of definition used by Max Holland in his history of Burgmaster and Houdaille, which is also a history of the machine tool industry in general from the 1940s through the 1980s; he was reflecting the sense of the term used by Houdaille itself and other firms in the industry. Many reports on machine tool export and import and similar economic topics use this broader definition.

The colloquial sense implying [conventional] metal cutting is also growing obsolete because of changing technology over the decades. The many more recently developed processes labeled "machining", such as electrical discharge machining, electrochemical machining, electron beam machining, photochemical machining, and ultrasonic machining, or even plasma cutting and water jet cutting, are often performed by machines that could most logically be called machine tools. In addition, some of the newly developed additive manufacturing processes, which are not about cutting away material but rather about adding it, are done by machines that are likely to end up labeled, in some cases, as machine tools. In fact, machine tool builders are already developing machines that include both subtractive and additive manufacturing in one work envelopeand retrofits of existing machines are underway.

The natural language use of the terms varies, with subtle connotative boundaries. Many speakers resist using the term "machine tool" to refer to woodworking machinery (joiners, table saws, routing stations, and so on), but it is difficult to maintain any true logical dividing line, and therefore many speakers are fine with a broad definition. It is common to hear machinists refer to their machine tools simply as "machines". Usually the mass noun "machinery" encompasses them, but sometimes it is used to imply only those machines that are being excluded from the definition of "machine tool".

Nomenclature of single point cutting tool:

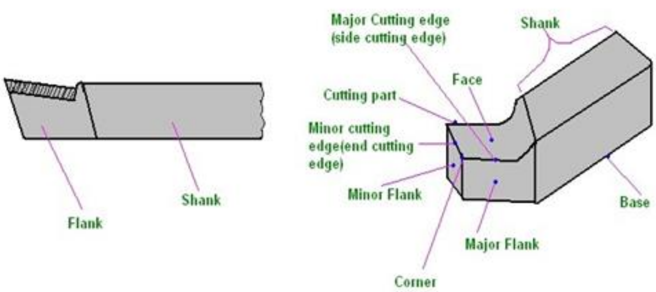

Figure 2: Nomenclature of single point cutting tool.

This is why the machines in a food-processing plant, such as conveyors, mixers, vessels, dividers, and so on, may be labelled "machinery", while the machines in the factory's tool and die department are instead called "machine tools" in contradistinction. As for the 1930s NBER definition quoted above, one could argue that its specificity to metal is obsolete, as it is quite common today for particular lathes, milling machines, and machining centers (definitely machine tools) to work exclusively on plastic cutting jobs throughout their whole working lifespan. Thus the NBER definition above could be expanded to say "which employs a tool to work on metal or other materials of high hardness". And its specificity to "operating by other than hand power" is also problematic, as machine tools can be powered by people if appropriately set up, such as with a treadle (for a lathe) or a hand lever (for a shaper).Hand-powered shapers are clearly "the 'same thing' as shapers with electric motors except smaller", and it is trivial to power a micro lathe with a hand-cranked belt pulley instead of an electric motor. Thus one can question whether power source is truly a key distinguishing concept; but for economics purposes, the NBER's definition made sense, because most of the commercial value of the existence of machine tools comes about via those that are powered by electricity, hydraulics, and so on. Such are the vagaries of natural language and controlled vocabulary, both of which have their places in the business world. Fig. 2 Nomenclature of Single Point Cutting Tool.

Machine Tool Type

B. **Turning and Related Operations**

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helical tool path by moving more or less linearly while the work piece rotates. The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear (in the nonmathematical sense). Usually the term "turning" is reserved for the generation of external surfaces by this cutting action, whereas this same essential cutting action when applied to internal surfaces (that is, holes, of one kind or another) is called "boring". Thus the phrase "turning and boring" categorizes the larger family of (essentially similar) processes. The cutting of faces on the work piece (that is, surfaces perpendicular to its rotating axis), whether with a turning or boring tool, is called "facing", and may be lumped into either category as a subset. Turning can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using an automated lathe which does not. Today the most common type of such automation is computer numerical control, better known as CNC. (CNC is also commonly used with many other types of machining besides turning.)

When turning, a piece of relatively rigid material (such as wood, metal, plastic, or stone) is rotated and a cutting tool is traversed along 1, 2, or 3 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 since the advent of CNC it has become unusual to use non-computerized tool path control for this purpose.

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.

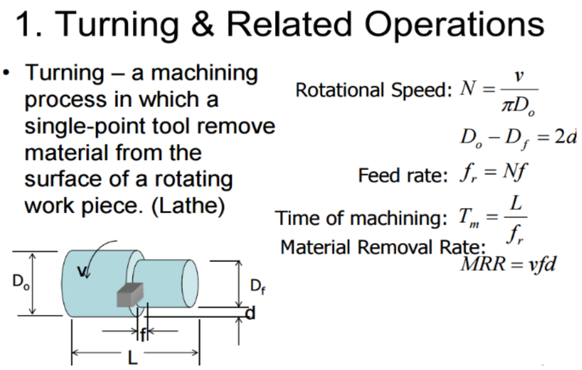

Figure 3: Turning and related operations.

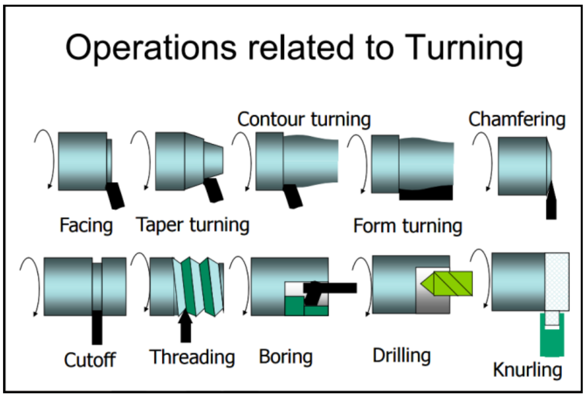

Figure 4: Operations related to turnings

C. Drilling and Related Operations

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the work piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work piece, cutting off chips (swarf) from the hole as it is drilled. Exceptionally, specially-shaped bits can cut holes of non-circular cross-section; a square cross-section is possible.

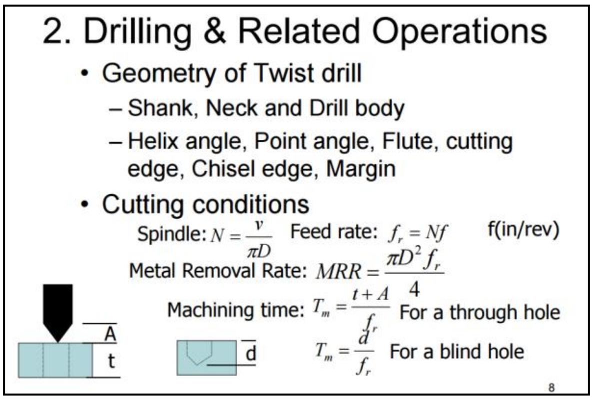

Figure. 5: Drilling & Related Operations

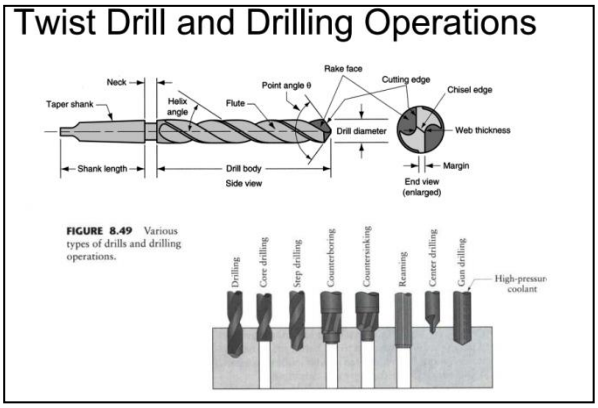

Figure. 6: Twist Drill & Drilling Operations

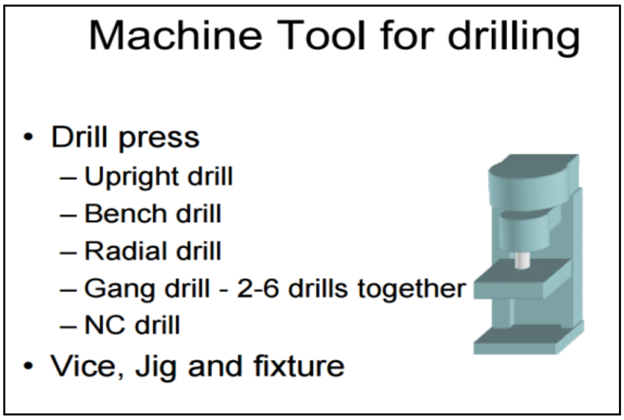

Figure.7: Machine Tool for Drilling

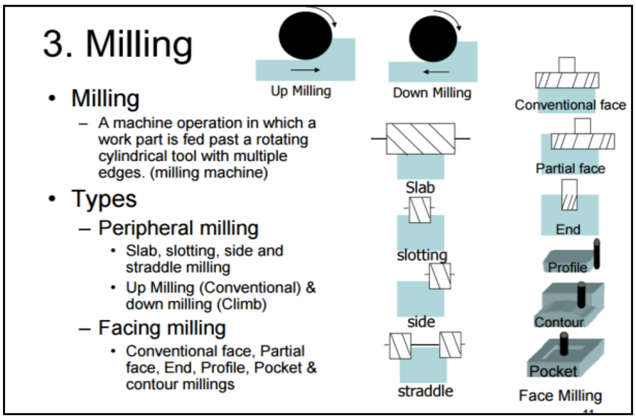

Figure.8: Types Of Milling Operations

D. Milling Machine

Milling is the machining process of using rotary cutters to remove material from a workpiece by advancing (or feeding) in a direction at an angle with the axis of the tool.It covers a wide variety of different operations and machines, on scales from small individual parts t It is one of the most commonly used processes in industry and machine shops today for machining parts to precise sizes and shapes.Milling can be done with a wide range of machine tools. The original class of machine tools for milling was the milling machine (often called a mill). After the advent of computer numerical control (CNC), milling machines evolved into machining centers (milling machines with automatic tool changers, tool magazines or carousels, CNC control, coolant systems, and enclosures), generally classified as vertical machining centers (VMCs) and horizontal machining centers (HMCs). The integration of milling into turningenvironments and of turning into milling environments, begun with live tooling for lathes and the occasional use of mills for turning operations, led to a new class of machine tools, multitasking machines (MTMs), which are purpose-built to provide for a default machining strategy of using any combination of milling and turning within the same work envelope.In face milling, the cutting action occurs primarily at the end corners of the milling cutter. Face milling is used to cut flat surfaces (faces) into the workpiece, or to cut flat-bottomed cavities.

In peripheral milling, the cutting action occurs primarily along the circumference of the cutter, so that the cross section of the milled surface ends up receiving the shape of the cutter. In this case the blades of the cutter can be seen as scooping out material from the work piece. Peripheral milling is well suited to the cutting of deep slots, threads, and gear teeth.

E. **Definition of a mechanism**

A gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape. Two or more meshing gears, working in a sequence, are called a gear train or a transmission.

(i) **Gear Mechanism**

A gear can mesh with a linear toothed part, called a rack, thereby producing translation instead of rotation. Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with teeth projecting radially. Though the teeth are not straight-sided (but usually of special form to achieve a constant drive ratio, mainly in volute but less commonly cycloidal), the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears mesh together correctly only if fitted to parallel shafts

Figure 9:. Gear mechanism

(ii) **Problem Definition**

To design and development of MULTI TOOL ARBOR, a structured which is designed for the purpose of multi-operations i.e. drilling, cutting andshaping. This machine performs multipurpose operation at same time with required speed & this machine is operated by motor which is run with the help of current. This model of the multi OPERATIONAL machine is may be used in industries and domestic OPERATION which can perform mechanical operation like drilling, boring & milling etc.

(iii) **Research Methodology**

Following is the research methodology adopted for solving the problem discussed above.

Collection of required INPUT data.3D Modeling using CATIA software.

II. DESIGN IMPLEMENTATION USING CATIA

Computer aided design (cad) is defined as any activity that involves the effective use of the computer to create, modify, analyze, or document an engineering design. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as cad system. The term CAD/CAM system is also used if it supports manufacturing as well as design applications CATIA is a suite of programs that are used in the design, analysis, and manufacturing of a virtually unlimited range of product. CATIA is a parametric, feature-based solid modeling system, “Feature based” means that you can create part and assembly by defining feature like pad, rib, slots, holes, rounds, and so on, instead of specifying low-level geometry like lines, arcs, and circle& features are specifying by setting values and attributes of element such as reference planes or surfaces direction of creation, pattern parameters, shape, dimensions and others.“Parametric” means that the physical shape of the part or assembly is driven by the values assigned to the attributes (primarily dimensions) of its features. Parametric may define or modify a feature’s dimensions or other attributes at any time.

For example, if your design intent is such that a hole is centered on a block, you can relate the dimensional location of the hole to the block dimensions using a numerical formula; if the block dimensions change, the centered hole position will be recomputed automatically. Solid Modeling” means that the computer model to create it able to contain all the information that a real solid object would have. The most useful thing about the solid modeling is that it is impossible to create a computer model that is ambiguous or physically non-realizable.

There are six core CATIA concepts. Those are: (i) Solid Modeling, (ii) Feature Based, (iii) Parametric, (iv) Parent / Child Relationships, (v) Associative, (vi) Model Centric.

A. Features of CATIA

CATIA is a one-stop for any manufacturing industry. It offers effective feature, incorporated for a wide variety of purpose. Some of the important features are as follows: (a) Simple and powerful tool, (b) Parametric design, (c) Feature-based approach, (d) Parent child relationship, (e) Associative and model centric.

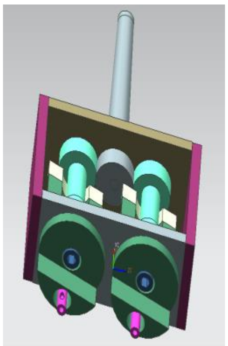

Figure 10: 3D-Model Development Using CATIA

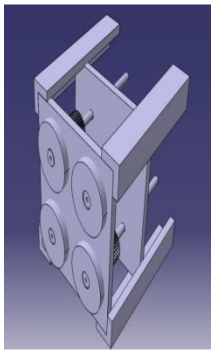

Figure 11.1: Proposed Model in CATIA-different views

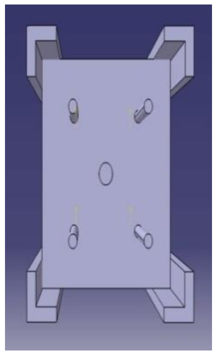

Figure 11.2: Proposed Model In CATIA-Different Views

B. Material Data

Nylon is one of the most widely used engineering thermoplastics. It offers an excellent combination of mechanical performance and cost. There are many nylon grades available today, the most common being nylon 6/6 and nylon 6. The properties of both nylon products are very similar; and typically, they can be used interchangeably. However, there are some advantages and limitations to each material both nylon 6/6 and nylon 6. Cast nylon 6 (polycaprolactam) has similar mechanical properties to extruded nylon 6/6; however, it cast nylon 6 has some distinct advantages. Cast nylon 6 is often less expensive to produce, especially for large geometries, large cross-sections, etc. The casting process of cast nylon 6 results in less stress than the extrusion process, thus providing better dimensional stability. Custom irregular shaped parts can be cast to "near-net" geometries thereby reducing machining time.

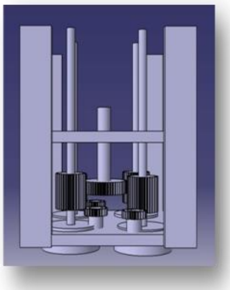

Figure 11.3: 3D-VIEW

Figure 12: Actual model.

Figure 13: Cast Nylon

III. RESULTS AND DISCUSSION

A. **Designing of Shaft**

(i) **Combined Bending And Torsion:**

In practice the shaft in general are subjected to combination of the bending and twisting stresses. Following stresses are normally adopted in shaft design: Maximum tensile stress = 60 N/mm², Maximum bending stress = 70 N/mm², Maximum shear stress = 40 N/mm², N1D1 = N2 D2, N2 = N1D1/D2, = 1440*40 / 80.

We have selected exactly ½ the diameter of driven pulley to reduce the RPM to ½ and increase TORQUE.= 720 RPM.

(ii) **Torque Calculation**

Power of motor = ½ hp = 373 watts. P = 2 π N T / 60 = 2 *3.14 * 720 * T / 60 ;

T=373 *60 / 4521.6= 4.94 N-M= 4940 N-mm. Considering 25 % overload T_{max} = 6175 N-mm

(iii) **Calculation of Maximum Bending Moment:**

M_{max} = force due to belt tension x distance=12000 N – mm

Equivalent Bending moment of shaft; Me = ½ *[M +(M2 +T2)1/2]= 12747 N-mm

Considering bending failure of shaft, Me = 3.14 / 32 * fb D3d = 12.25 ≈ 15 mm

(iv) **Design Of Pulley Shaft:**

Let M = bending moment; T = twisting moment' Maximum HP (i.e. h.p. of motor) to be transmitted by pulley = 0.5 HP ; N =460 rpm. (by experiment minimum rpm required for drilling) ; Angle of deflection = 0.250 ; Θ = 0.00436 rad. ; Length of the spindle = 15 cm.

Modulus of rigidity; G = 0.84 x 106 kg/cm2 (Plain carbon steel) ;Let T = torque transmitted by shaft ; T =P x 60/2 π N= 597 N.mm.

(v) **To Find The Diameter Of Shaft:**

Let d = diameter of the shaft ; Then using relation, T/J=G Θ/L ; d4 = 29.4 cm ; d = 2.23 cm. ;

.d = 22 mm. ;Hence the diameter of shaft = 25 mm.

(vi) **Shear Stress Induced In Spindle:**

Let's select, C –30 as a material for spindle. Then, бy = 400 N/mm² (yield stress from PSG data book.). Factor of safety, fos = 3 ;[бy] =400/3= 133 N/mm² ; Induced shear stress,

fs = 0.577 x [бy]= 76 N/mm².

Then using relation, Torque, T =π/16x fs x d3 ;fs = 194.6 kg /cm2fs

= 19.46 N/mm²fs < 76 N/mm² ;Hence design is safe.

(vii) **Selection of Ball Bearing:**

Figure 14: Selected bearing OD = 28 mm

(viii) **Theoretical Calculations:**

A face milling cutter of 150 mm diameter is used to give a cut on a block 500mm*500mm. The cutting speed is 50 m/main and feed 0.2mm/revolution. Calculate the time required to complete one cut. Conventional model. (2) Multiple arbor model.

(ix) **Conventional Model:**

Tool diameter, (D) =150mm ; Block Size =500*500mm ;

Cutting speed, (S) =50m/min ; Feed rate, (F) =0.2mm/rev

Solution

N = 1000*S/_D= 1000*50/ (_*150)= 106.1rpm

Length of the Job, (L) = 500mm ;Width of the Job, (W) = 500mm ; Since D < W

Approach = 0.50D= 0.5*150=75mm

Over travel = 7mm ;Added Table Travel = Approach + Over travel= 75+7 = 82mm

Milling Time/Cut = {Length of the Job + Added table travel} / {(Feed/rev) * rpm}

= 500+82/ (0.2*106.1)= 27.43min

(a) **Multiple Arbor Model**

N is similar to conventional, without change in the speed.

Length of the job (L) = 500mm ;Width of the job (W) = 500mm

Tool diameter (D) = d + d = 150*2 = 300mm ;Since, D<W

Approach = 0.50D= 0.5*300 = 150mm

Over travel = 4mm

Added table travel = Approach + Over travel = 154mm

Milling Time/Cut = {Length of the Job + Added table travel}/ {2*(Feed/rev) * rpm}

= 500+154/ (2*0.2*106.1)= 15.40min

Advantage of time over conventional model = Milling Time/Cut (Conventional) - Milling Time/Cut (Improved)= 27.43 – 15.40= 12.03min

(b) **Small Gear:**

Material: - Cast Nylon ;

Raw material: - ø40 X 15 mm 2Nos.

Module= 1.25

No of teeth = 24

Figure 15: Small gear

(c) **Process of Operations**

The process sheet for the component main spindle gear is as shown below, which shows the stepwise manufacturing process & machine require to manufacture the part.

Material: - Cast Nylon.

Raw material Shaft ø 60 * 30mm

TABLE I

LIST OF OPERATIONS

S.No	Operation	Machine	Measuring devices	Tool	Time, min
1	Turning Φ 57 mm	Lathe	Vernier caliper	Side tool	5
2	Step turning Φ 50 mm	Lathe	Vernier caliper	Side tool	5
3	Face cut 10 mm deep	Milling	Height gauge	Face mill cutter	8
4	Face cut 35 mm deep	Milling	Height gauge	Face mill cutter	10
5	Milling 20 mm deep	Milling	Height gauge	End mill cutter	15
6	Milling cut 22 mm thick	Milling	Vernier caliper	End mill cutter	15
7	Readies Milling R 10	Milling	---	End mill cutter Φ 20	10
8	Center hole Φ 8 mm	Jig & boring	Vernier caliper	End mill cutter	9

9	Step hole Φ 17 mm	Jig & boring	Vernier caliper	End mill cutter	5
10	Hole Φ 10 mm	Jig & boring	Vernier caliper	End mill cutter	10
11	Step hole Φ 17 mm	Jig & boring	Vernier caliper	End mill cutter	8

(d) **Main Body Specifications:**

The process sheet for the component main spindle gear is as shown below, which shows the step-wise manufacturing process & machine require to manufacture the parts
Material: - Cast Nylon
Raw material Shaft ø80 * 30 mm ;Raw Material Sheet 210*200mm
(e) **Gear Specifications:**

Material: - Cast Nylon
Raw material: - ø80 X 30 mm 1 Nos.
Big gear.
(f) **Main Body Diagram:**

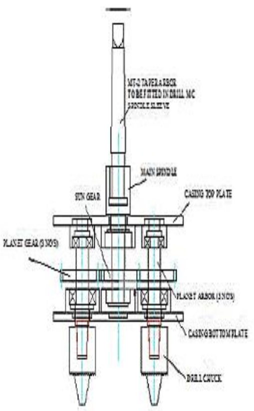

Figure 16: Multi tool spindle drilling

Figure 17: Main Gear

Module = 1.25
Number of teeth = 53

IV. CONCLUSION

After completing the major project on `MILT" TOOL ARBOR" we am much happy and would like to thank our professor. guides and the lectures of the concerned department who have guided us. While making project we have been able to learn a lot and understand the various aspects of -MUILTI TOOL ARBOR" we can use our knowledge, which we get during our study.

V. Future Implementation

We can perform various operations like cutting , drilling or shaping individually by introducing coupling (engagement & disengagement) between them. We can perform Grinding operation by introducing a grinding tool at the main shaft. We can perform boring operation by introducing a boring tool by replacing drilling tool. We can change the speed of motor by regulator.

VI. ACKNOWLEDGEMENT

Self Confidence, Hard Work, Commitment and planning are essential to carry out any task. Possessing these qualities are sheer waste, If any opportunity does not exist. So, we whole heartedly thank Y. Anuradha Head of the Department, Mechanical Engineering for her encouraging support and guidance in carrying out the project.
We thank our project guide M. Madhavi for providing us with an excellent project and guiding us in completing our project successfully. We would like to thank our principal Dr.G.Amarendar Rao and all the staff members of Mechanical Department for their kind co-operation and timely help during the course of our project. Finally we would like to thank our parents and friends who have always stood with us whenever we were in need of them.

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