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Design and Manufacturing of an Open Sleeve in Aerospace and Mechanical Industry

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Abstract: In this project we are going to explain that with the incorporation of CNC machining into its manufacturing capabilities, we may gain the capability to effectively produce lower volume, higher complexity component parts. Due to the volume and longevity of demand for this Sleeve used in aircraft engine ignition systems, we took this product to be designed, developed, tested and refined the processes required to complete all operations required, except for the plating, on a Multiple Spindle Automatic Screw Machine. The MSATOS is designed in CATIA/UG and then manufacturing in CNC. The strength may be evaluated after testing the part in testing machine.

Keywords: Open Sleeve, Multi Spindle Automatic Screw Machine, CNC Manufacturing etc.

Hardware/Equipment Requirements: CNC Lathe.

Software Requirements: CATIA V5 and MCAD.

I. INTRODUCTION

A. CNC Machining

Numerical control is the automation of machine tools that are operated by precisely programmed commands encoded on a storage medium, as opposed to controlled manually by hand wheels or levers, or mechanically automated by cams alone. Most NC today is computer (or computerized) numerical control (CNC) in which computers play an integral part of the control .Computer Numerical Control (CNC) is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data. CNC can control the motions of the work piece or tool, the input parameters such as feed, depth of cut, speed, and the functions such as turning spindle on/off, turning coolant on/off. All computer controlled machines are able to accurately and repeatedly control motion in various directions. Each of these directions of motion is called an axis. Depending on the machine type there are commonly two to five axes. Additionally, a CNC axis may be either a linear axis in which movement is in a straight line or a rotary axis with motion following a circular path. Since the program is the controlling point for product manufacture, the machine becomes versatile and can be used for any part. All the functions of a NC machine tool are therefore controlled electronically, hydraulically or pneumatically. In NC machine tools, one or more of the following functions may be automatic.

Starting and stopping of machine tool spindle.
Controlling the spindle speed.
Positioning the tool tip at desired locations and guiding it along desired paths by automatic control of motion of slides.
Controlling the rate of movement of tool tip (feed rate)
Changing of tools in the spindle.

Functions of a machine tool The purpose of a machine tool is to cut away surplus material, usually metal from the material supplied to leave a work piece of the required shape and size, produced to an acceptable degree of accuracy and surface finish. The machine tool should possess certain capabilities in order to fulfil these requirements. It must be

Able to hold the work piece and cutting tool securely.
Endowed the sufficient power to enable the tool to cut the work piece material at economical rates.
Capable of displacing the tool and work piece relative to one another to produce the required work piece shape. The displacements must be controlled with a degree of precision which will ensure the desired accuracy of surface finish and size.

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Concept of numerical control

Formerly, the machine tool operator guided a cutting tool around a work piece by manipulating hand wheels and dials to get a finished or somewhat finished part. In his procedure many judgments of speeds, feeds, mathematics and sometimes even tool configuration were his responsibility. The number of judgments the machinist had to make usually depended on the type of stock he worked in and the kind of organization that prevailed. If his judgment was an error, it resulted in rejects or at best parts to be reworked or repaired in some fashion. Decisions concerning the efficient and correct use of the machine tool then depended on the craftsmanship, knowledge and skill of the machinist himself. It is rare that two expert operators produced identical parts using identical procedure and identical judgment of speeds, feeds and tooling. In fact even one craftsman may not proceed in same manner the second time around. . Process planners and programmers have now the responsibilities for these matters. It must be understood that NC does not alter the capabilities of the machine tool. The With NC the correct and most efficient use of a machine no longer rests with the operator. Actual machine tool with a capable operator can do nothing more than it was capable of doing before a MCU was joined to it. New metal removing principles are not involved. Cutting speeds, feeds and tooling principles must still be adhered to. The advantage is idle time is reduced and the actual utilization rate is much higher (compresses into one or two years that a conventional machine receives in ten years).

B. Historical Development

In 1947 was the year in which Numerical control was born. It began because of an urgent need. John C Parsons of the parson's corporation, Michigan, a manufacturer of helicopter rotor blades could not make his templates fast enough. so he invented a way of coupling computer equipment with a jig borer. The US air force realized in 1949 that parts for its planes and missiles were becoming more complex. Also the designs were constantly being improved; changes in drawings were frequently made. Thus in their search for methods of speeding up production, an air force study contract was awarded to the Parson's Corporation. The servomechanisms lab of MIT was the subcontractor. In 1951, the MIT took over the complete job and in 1952; a prototype of NC machine was successfully demonstrated. The term "Numerical Control" was coined at MIT. In 1955 seven companies had tape controlled machines. In 1960, there were 100 NC machines at the machine tool shown in Chicago and a majority of them were relatively simple point to point application. During these years the electronics industry was busy. First miniature electronic tubes were developed, then solid state circuitry and then modular or integrated circuits. Thus the reliability of the controls has been greatly increased and they have become most compact and less expensive. Today there are several hundred sizes and varieties of machines, many options and many varieties of control system available.

Features of CNC Computer NC systems include additional features beyond what is feasible with conventional hard-wired NC. These features, many of which are standard on most CNC Machine Control units (MCU), include the following:

1) *Storage of more than one part program:* With improvements in computer storage technology, newer CNC controllers have sufficient capacity to store multiple programs. Controller manufacturers generally offer one or more memory expansions as options to the MCU
2) *Various forms of program input :* Whereas conventional (hard-wired) MCUs are limited to punched tape as the input medium for entering part programs, CNC controllers generally possess multiple data entry capabilities, such as punched tape, magnetic tape, floppy diskettes, RS-232 communications with external computers, and manual data input (operator entry of program).
3) *Program editing at the machine tool:* CNC permits a part program to be edited while it resides in the MCU computer memory. Hence, a part program can be tested and corrected entirely at the machine site, rather than being returned to the programming office for corrections. In addition to part program corrections, editing also permits cutting conditions in the machining cycle to be optimized. After the program has been corrected and optimized, the revised version can be stored on punched tape or other media for future use.

4) *Fixed cycles and programming subroutines:* The increased memory capacity and the ability to program the control computer provide the opportunity to store frequently used machining cycles as macros that can be called by the part program. Instead of writing the full instructions for the particular cycle into every program, a programmer includes a call statement in the part program to indicate that the macro cycle should be executed. These cycles often require that certain parameters be defined, for example, a bolt hole circle, in which the diameter of the bolt circle, the spacing of the bolt holes, and other parameters must be specified.
5) *Interpolation:* Some of the interpolation schemes are normally executed only on a CNC system because of computational requirements. Linear and circular interpolation is sometimes hard-wired into the control unit, but helical, parabolic, and cubic interpolations are usually executed by a stored program algorithm.
6) *Positioning features for setup:* Setting up the machine tool for a given work part involves installing and aligning a fixture on the machine tool table. This must be accomplished so that the machine axes are established with respect to the work part. The alignment task can be facilitated using certain features made possible by software options in the CNC system. Position set is one of the features. With position set, the operator is not required to locate the fixture on the machine table with extreme accuracy. Instead, the machine tool axes are referenced to the location of the fixture using a target point or set of target points on the work or fixture.
7) *Cutter length and size compensation:* In older style controls, cutter dimensions hade to be set precisely to agree with the tool path defined in the part program. Alternative methods for ensuring accurate tool path definition have been incorporated into the CNC controls. One method involves manually entering the actual tool dimensions into the MCU. These actual dimensions may differ from those originally programmed. Compensations are then automatically made in the computed tool path. Another method involves use of a tool length sensor built into the machine. In this technique, the cutter is mounted in the spindle and the sensor measures its length. This measured value is then used to correct the programmed tool path.
8) *Acceleration and deceleration calculations:* This feature is applicable when the cutter moves at high feed rates. It is designed to avoid tool marks on the work surface that would be generated due to machine tool dynamics when the cutter path changes abruptly. Instead, the feed rate is smoothly decelerated in anticipation of a tool path change and then accelerated back up to the programmed feed rate after the direction change.
9) *Communications interface:* With the trend toward interfacing and networking in plants today, most modern CNC controllers are equipped with a standard RS-232 or other communications interface to link the machine to other computers and computer driven devices. This is useful for various applications, such as
a) Downloading part programs from a central data file;
b) Collecting operational data such as work piece counts, cycle times, and machine utilization and
c) Interfacing with peripheral equipment, such as robots that unload and load parts.
10) *Diagnostics:* Many modern CNC systems possess a diagnostics capability that monitors certain aspects of the machine tool to detect malfunctions or signs of impending malfunctions or to diagnose system breakdowns.

C. The Machine Control Unit (MCU) for CNC

The MCU is the hardware that distinguishes CNC from conventional NC. The general configuration of the MCU in a CNC system is illustrated in Figure 2. The MCU consists of the following components and subsystems:

1) Central Processing Unit,
2) Memory,
3) Input/output Interface,
4) Controls for Machine Tool Axes and Spindle Speed, and
5) Sequence Controls for Other Machine Tool Functions. These subsystems are interconnected by means of a system bus, which communicates data and signals among the components of a network.
1) *Central Processing Unit:* The central processing unit (CPU) is the brain of the MCU. It manages the other components in the MCU based on software contained in main memory. The CPU can be divided into three sections:
a) Control section,
b) Arithmetic-logic unit, and
c) Immediate access memory. The control section retrieves commands and data from memory and generates signals to activate other components in the MCU. In short, it sequences, coordinates, and regulates all the activities of the MCU computer. The arithmetic-logic unit (ALU) consists of the circuitry to perform various calculations (addition, subtraction, and multiplication), counting, and logical functions required by software residing in memory. The immediate access memory provides a temporary storage of data being processed by the CPU. It is connected to main memory of the system data bus.

2) *Memory:* The immediate access memory in the CPU is not intended for storing CNC software. A much greater storage capacity is required for the various programs and data needed to operate the CNC system. As with most other computer systems, CNC memory can be divided into two categories:

a) Primary memory, and
b) Secondary memory.

Main memory (also known as primary storage) consists of ROM (read-only memory) and RAMS (random access memory) devices. Operating system software and machine interface programs are generally stored in ROM. These programs are usually installed by the manufacturer of the MCU. Numerical control part programs are stored in RAM devices. Current programs in RAM can be erased and replaced by new programs as jobs are changed. High-capacity secondary memory (also called auxiliary storage or secondary storage) devices are used to store large programs and data files, which are transferred to main memory as needed. Common among the secondary memory devices are hard disks and portable devices that have replaced most of the punched paper tape traditionally used to store part programs. Hard disks are high-capacity storage devices that are permanently installed in the CNC machine control unit. CNC secondary memory is used to store part programs, macros, and other software.

3) *Input/output Interface:* The I/O interface provides communication software between the various components of the CNC system, other computer systems, and the machine operator. As its name suggests, The I/O interface transmits and receives data and signals to and from external devices, several of which are illustrated in Figure 2. The operator control panel is the basic interface by which the machine operator communicates to the CNC system. This is used to enter commands related to part program editing, MCU operating mode (e.g., program control vs. manual control), speeds and feeds, cutting fluid pump on/off, and similar functions. Either an alphanumeric keypad or keyboard is usually included in the operator control panel. The I/O interface also includes a display (CRT or LED) for communication of data and information from the MCU to the machine operator. The display is used to indicate current status of the program as it is being executed and to warn the operator of any malfunctions in the CNC system. Also included in the I/O interface are one or more means of entering the part program into storage. As indicated previously, NC part programs are stored in a variety of ways. Programs can also be entered manually by the machine operator or stored at a central computer site and transmitted via local area network (LAN) to the CNC system. Whichever means is employed by the plant, a suitable device must be included in the I/O interface to allow input of the program into MCU memory. Memory

ROM – Operating System

RAM – Part Program Central Processing Unit (CPU) Input/output interface

Operator panel

Tape reader Machine tool controls

Position control

Spindle speed control Sequence controls

Coolant

Fixture clamping

Tool changer System bus

4) *Controls for Machine Tool Axes and Spindle Speed:* These are hardware components that control the position and velocity (feed rate) of each machine axis as well as the rotational speed of the machine tool spindle. The control signals generated by MCU must be converted to a form and power level suited to the particular position control systems used to drive the machine axes. Positioning systems can be classified as open loop or closed loop, and different hardware components are required in each case. Depending on the type of machine tool, the spindle is used to drive either

a) Work piece or
b) A rotating cutter.

Turning exemplifies the first case, whereas milling and drilling exemplify the second. Spindle speed is a programmed parameter for most CNC machine tools. Spindle speed components in the MCU usually consist of s drive control circuit and a feedback sensor interface. The particular hardware components depend on the type of spindle drive.

5) *Sequence Controls for Other Machine Tool Functions:* In addition to control of table position, feed rate, and spindle speed, several additional functions are accomplished under part program control. These auxiliary functions are generally on/off (binary) actuations, interlocks, and discrete numerical data. To avoid overloading the CPU, a programmable logic controller is sometimes used to manage the I/O interface for these auxiliary functions.

D. Classification Of CNC Machine Tools

1) *Based on the motion type 'Point-to-point & Contouring systems:* There are two main types of machine tools and the control systems required for use with them differ because of the basic differences in the functions of the machines to be controlled. They are known as point-to-point and contouring controls. Point-to-point systems Some machine tools for example drilling, boring and tapping machines etc, require the cutter and the work piece to be placed at a certain fixed relative positions at which they must remain while the cutter does its work. These machines are known as point-to-point machines and the control equipment for use with them are known as point-to-point control equipment. Feed rates need not to be programmed. In these machine tools, each axis is driven separately. In a point-to-point control system, the dimensional information that must be given to the machine tool will be a series of required position of the two slides. Servo systems can be used to move the slides and no attempt is made to move the slide until the cutter has been retracted back. Contouring systems (Continuous path systems) other type of machine tools involves motion of work piece with respect to the cutter while cutting operation is taking place. These machine tools include milling, routing machines etc. and are known as contouring machines and the controls required for their control are known as contouring control. Contouring machines can also be used as point-to-point machines, but it will be uneconomical to use them unless the work piece also requires having a contouring operation to be performed on it. These machines require simultaneous control of axes. In contouring machines, relative positions of the work piece and the tool should be continuously controlled. The control system must be able to accept information regarding velocities and positions of the machines slides. Feed rates should be programmed.
   a) Point-to-point system
   b) Contouring system
   c) Contouring systems
2) *Based on the control loops 'Open loop & Closed loop systems:* Open loop systems Programmed instructions are fed into the controller through an input device. These instructions are then converted to electrical pulses (signals) by the controller and sent to the servo amplifier to energize the servo motors. The primary drawback of the open-loop system is that there is no feedback system to check whether the program position and velocity has been achieved. If the system performance is affected by load, temperature, humidity, or lubrication then the actual output could deviate from the desired output. For these reasons the open -loop system is generally used in point-to-point systems where the accuracy requirements are not critical. Very few continuous-path systems utilize open-loop control. Open loop control system Closed loop control system Closed loop systems. The closed-loop system has a feedback subsystem to monitor the actual output and correct any discrepancy from the programmed input. These systems use position and velocity feedback. The feedback system could be either analog or digital. The analog systems measure the variation of physical variables such as position and velocity in terms of voltage levels. Digital systems monitor output variations by means of electrical pulses. To control the dynamic behaviour and the final position of the machine slides, a variety of position transducers are employed. Majority of CNC systems operate on servo mechanism, a closed loop principle. If a discrepancy is revealed between where the machine element should be and where it actually is, the sensing device signals the driving unit to make an adjustment, bringing the movable component to the required location. Closed-loop systems are very powerful and accurate because they are capable of monitoring operating conditions through feedback subsystems and automatically compensating for any variations in real-time. Closed loop system
3) *Based on the number of axes:* There will be two axes along which motion takes place. The saddle will be moving longitudinally on the bed (Z-axis) and the cross slide moves transversely on the saddle (along X-axis). In 3-axes machines, there will be one more axis, perpendicular to the above two axes. By the simultaneous control of all the 3 axes, complex surfaces can be machined. (3.2) 4 & 5 axes CNC machines (4 and 5 axes CNC machines provide multi-axis machining capabilities beyond the standard 3- axis CNC tool path movements. A 5-axis milling centre includes the three X, Y, Z axes, the A axis which is rotary tilting of the spindle and the B-axis, which can be a rotary index table.
4) *Importance of higher axes machining:* Reduced cycle time by machining complex components using a single setup. In addition to time savings, improved accuracy can also be achieved as positioning errors between setups are eliminated.

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Improved surface finish and tool life by tilting the tool to maintain optimum tool to part contact all the times.

Improved access to under cuts and deep pockets. By tilting the tool, the tool can be made normal to the work surface and the errors may be reduced as the major component of cutting force will be along the tool axis.

Higher axes machining has been widely used for machining sculptures surfaces in aerospace and automobile industry.

E. Limitations of CNC

1) High initial investment.
2) High maintenance requirement.
3) Not cost-effective for low production cost.

F. Advantages of CNC

1) Increased productivity.
2) High accuracy and repeatability.
3) Reduced production costs.
4) Reduced indirect operating costs.
5) Facilitation of complex machining operations.
6) Greater flexibility.
7) Improved production planning and control.
8) Lower operator skill requirement.
9) Facilitation of flexible automation.

Other advantages are:

Part program storage memory.
Part program editing.
Part program downloading and uploading.
Part program simulation using tool path.
Tool offset data and tool life management.
Additional part programming facilities.
Macros and subroutines.
Background tape preparation, etc.
Open Sleeve In An Aircraft:

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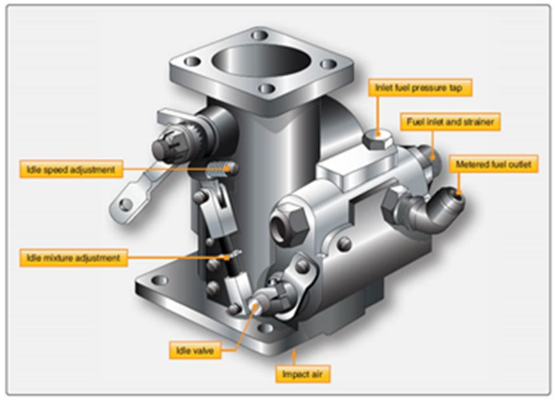

Figure 2-47. Bendix adjustment of idle mixture linkage.

II. LITERATURE REVIEW

A. Simplicity is the keynote of the only two types of sleeve-valve engines that have stood the test of time, namely, the double-sleeve, or Knight, engine and the single-sleeve, or Burt-McCollum, engine, the latter type being the subject of this paper. After noting the vicissitudes through which the single sleeve-valve engine has passed since its first introduction in 1911 and outlining the patent situation, the author describes the mechanical construction of the valve and the sleeve-driving mechanism, discusses the inherent advantages of the characteristic twisting-movement of sleeve-valves, points out the advantages of a detachable head for each cylinder, explains the principles underlying the determination of the size, shape and number of the ports and tabulates the average timing-practice of single-sleeve-valve engines. He states that the chief advantages of the single-sleeve-valve engine are sustained operating efficiency, good power-output and silent operation. Sleeve valves obviate the grinding-in of the valves, the ingress of unwanted air through worn valve-guides, the distortion or sticking of the valve, the adjustment of clearance, the breakage of valve springs, and frequent decarbonisation. Rapid opening of the ports, the type of port opening obtained, positive timing, unobstructed intake passages, and increased compression-ratio all contribute to good power-output. Other features of the single-sleeve-valve engine are said to be silence, favourable comparison in weight with that of the poppet-valve engine; added strength and rigidity due to the depth of engine body and shortness of the sleeve valve cylinder, when a separate cylinder-block is used, allowing the use of aluminium; lubrication by a pressure-feed system of orthodox design; and freedom from detonation on account of the absence of hot exhaust-valves. In the appendix is given a simple method for determining quickly the size and the arrangement of the ports in this type of engine.

B. The paper starts by giving a historical background of the sleeve-valve internal combustion engine from 1905 when Charles Y. Knight first began work; then carries on with the development by different groups until the Bristol Co. entered the field. Then follows a resume of Bristol single-cylinder research, and subsequent main-engine development, giving particulars of type tests together with flight-testing of the Bristol sleeve-valve engines. The author announces that more than 10,000 hr. of main-engine running and flying have been attained on the Bristol sleeve-valve types to date. The single sleeve valve has now passed from the experimental to the production stage with hundreds flowing through the Bristol factory, and the author sees ahead a vast field of research yet to be explored.

C. The growth of small scale industries are now increases as large scale industries commercializes their products for various operation and process hence main task ahead the small scale industries are satisfy and meet the time requirement of customers. Hence they uses special purpose machine as the cost is low as compared CNC machines. The use of SPM increase productivity

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and maintain the accuracy of same operation for number of times. This paper gives literature survey about multi-spindle drilling machine and focuses on previous development in, Multi-spindle drilling machines.

D. This paper discuss the case study and comparison of productivity of component using conventional radial drilling machine and special purpose machine(SPM) for drilling and tapping operation. In this case study, the SPM used for 8 multi drilling operation (7 of Ø6.75 and Ø12), linear tapping operation of Ø12 and angular tapping operation of Ø5.1 of TATA cylinder block. In this paper the following studies are carried out

E. Time saved by component handling (loading and unloading), using hydraulic clamping, Increase in productivity both qualitative and quantitative, Less human intervention, indirectly reduction in operator fatigue, Less rejection due to automatic controls, and Increase the profit of company.

F. The growth of Indian manufacturing sector depends largely on its productivity & 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 f 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 multispindle drilling head attachment. This paper deals with such development undertaken for similar job under consideration along with industrial case study. Keywords- Various methods, Design, Manufacturing, Statistical process control (Process capability).

III. SPECIFICATIONS AND PROPERTIES

A. Design Specifications

1	Length	60mm
2	Outer Diameter	50mm
3	Inner Diameter	40mm
4	Wall thickness	5mm
5	Pitch	1.5mm

B. Material properties

Al	Max97.5
Cr	Max0.1
Cu	Max0.1
Fe	Max0.35
Mg	0.45-0.9
Mn	Max0
Si	0.2-0.6
Ti	Max0.1
Density	2.7g/cc

IV. DESIGN AND METHODOLOGY

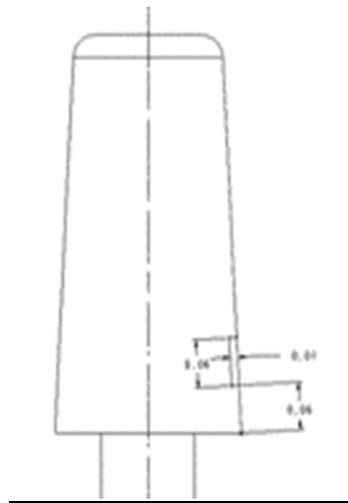
A. Introduction to ProE

There are three basic Pro/ENGINEER design steps from conception to completion:

Part creation
Assembly creation
Drawing creation

Each design step is treated as a separate Pro/ENGINEER mode, with its own characteristics, file extensions, and relations with the other modes. Remember that all information–dimensions, tolerances, and relational formulas–are passed from one mode to the next bidirectional. This means that if you change your design at any mode level, the change is automatically reflected at all mode levels. If you plan ahead and use the associative features correctly, you can save significant time in the design and engineering process.

1) Part Mode: The Dashboard and Sketcher In Part Mode, you create part files (.prt), the separate components that are joined together in an assembly file (.asm). Part mode lets you create and edit the features–the extrusions, cuts, blends, and rounds–that comprise each part being modelled. Most features start with a two dimensional outline, or section. When the section is defined, you assign a third dimension value to it in order to make it a 3D shape. You create the 2D section in a tool called Sketcher. As the name implies, Sketcher lets you roughly draw the section with lines, angles, or arcs, and then input the precise dimensional values later. You use an interface called the dashboard to create and edit 3D feature geometry. The dashboard presents feature-specific fields for input as you switch from feature to feature. Once a 3D feature is created, it can be edited directly in the graphics window.



2) *Assembly Mode:* After you have created the parts, you create an empty assembly file for the model, then assemble the individual parts within it, assigning the positions the parts will occupy in the final product. You can also define exploded views to better examine or display part relationships. In a slightly more advanced scenario, you would start the model as an assembly and create each part (and part file) from what is called a “skeleton part”. This is the key to top-down design, where an edit to one part can automatically affect the parts to which it is joined. You can also associate one part to another part in an ordinary assembly using assembly relations—these will retain associatively between dimensions as they change. In addition, with model analysis tools, you can measure an assembly's mass properties and volume to determine its overall weight, centre of gravity, and inertia. Determining interference between components throughout the entire assembly is also possible.
3) *Drawing Mode:* Drawing mode lets you create finished, precise mechanical drawings of the design, based directly on the dimensions recorded in the 3D part and assembly files. In fact, it is not necessary to add dimensions to objects as you may have done in other programs. Instead, in Pro/ENGINEER you selectively show and hide dimensions that have been passed from the 3D models. Any information objects—dimensions, notes, surface notes, geometric tolerances, cross sections, and so on—that have been created for the 3D model can be passed to the drawing mode. When these objects are passed from the 3D model, they remain associated, and may be edited to affect the 3D model from within the drawing.

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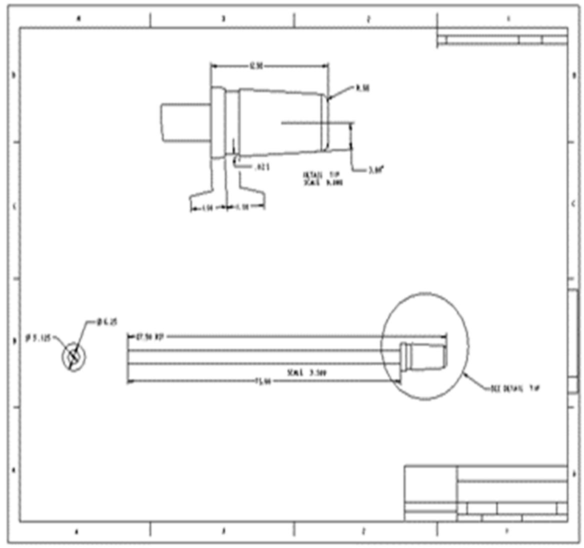
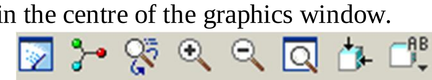


Spin, Pan, and Zoom

The middle mouse button is the key to model manipulation as you move the mouse:
Spin—Press and hold the middle mouse button
Pan—Press and hold the middle mouse button + SHIFT
Zoom—Press and hold the middle mouse button + CTRL + vertical drag, or
spin the mouse wheel Another useful shortcut is CTRL+d.
This returns the part to a default orientation in the centre of the graphics window.



a) Redraw current view

b) Spin centre
c) Orient mode
d) Zoom In area
e) Zoom Out
f) Re-enter
g) Orientation dialog box

Additional specialized controls are available in Orient mode. To enter, click View > Orientation > Orient Mode. The pointer changes to a black movement spin centre and a triangular or square vector handle is constantly visible. Right-click and choose one of the following controls from the Orient mode shortcut menu:

Dynamic—The usual spin, pan, and zoom controls.
Anchored—Movement is anchored around a specific point. Click once to determine the anchor point, then move the mouse as usual.
Delayed—The view changes after the vector handle is moved and released. This avoids constant repaint for large assemblies.
Velocity—Movement continues as long as the mouse button is pressed, even though the mouse drag has stopped. Right-click and choose Exit Orient Mode to exit Orient mode completely.

4) *Axes, and Coordinate Systems:* When you start a new part, three datum planes and a coordinate system are added for you. The datum planes are automatically named Front, Top, and Right. The coordinate system indicates the x-, y-, and z-axes. The positive z-axis is perpendicular to the front datum plane. If you orient the datum's so the Front plane is flat to the screen, the z-axis is perpendicular to the screen. Datum's are points of reference in space that Pro/E uses to calculate distances. Datum's can be actual points, planes, or curves, but they have no value for thickness. You will create and place them frequently for a variety of uses in both Part and Assembly modes. Like solid features, datum's are added to the Model Tree as you create them. They are named numerically by default, for example DTM1, DTM2 (for datum planes) or PNT1, PNT2, (for datum points). You can rename them to better describe their purpose after they are added. Datum points and coordinate systems are similar in that they are both points either fixed or offset from a surface or vertex. You can use datum points separately or combine them into a

patterned array that behaves as one feature. These arrays can be saved as ASCII files and reused in other designs. Coordinate systems are points that define an x-, y-, and z-direction. Each part that you create is based on a coordinate system, and you may use coordinate systems within parts or assemblies to define the direction of other components. Coordinate systems are used, for example, in cabling connector parts to define the direction that an auto routed wire or cable will exit the connector. You can add datum's at any time from the main menu, using Insert > Model Datum, or you can click the datum creation toolbar buttons on the right side of the graphics window. To redefine datum's, you can select them from the Model Tree, then right-click and choose Edit Definition from the right mouse button shortcut menu. You can also add datum's "on the fly" or in the middle of other processes. Datum's that you add to create specific features remain with the feature's section, and are not displayed in the 3D model.

5) *Defining Parts in Sketcher:* The Sketcher is best described as a sub mode of Part mode, a 2D drafting board within the 3D environment. You will use it to create most of the geometric shapes you use in a part. The associative details, such as geometric constraints or relations between dimensions that you build into a sketch or section act as a foundation for all other additions and edits to follow. The more you can foresee areas of potential change to the design, the more associative detail you can build in to handle the effects of the changes. If you don't build in the required intelligence to handle future edits, you will have to spend time fixing problems as they arise. Learning to use the Sketcher correctly and effectively is crucial to learning to use Pro/ENGINEER.
6) *The Sketcher Principle:* In Pro/ENGINEER, 3D objects begin as 2D outlines. After the 2D outline is defined with x and y dimensions, it is given a z dimension, or depth, to make it three-dimensional. You literally "sketch" an imprecise or exaggerated 2D profile of the part you want to create. Sketcher adds weak dimensions, complete with arrows and witness lines, as you draw. When the sketch is finished, you enter the precise lengths, angles, and radii (strong dimensions) as needed. The section is then regenerated to the real values. Geometry may be constrained to grow or shrink with the size of related lines. There is no need to count grid lines or use on-screen rulers, as you would with a simpler drafting program.
7) *Sketcher Tools:* The basis of Sketcher geometry tools are the line, circle, and arc creation functions common to most drawing programs. These are arranged on a toolbar to the side of the graphics window. Fly-out menus from the side of an icon mean there are more varieties of the same function to be used. If you move the pointer over an icon, a Tooltip explains its function.
8) *Sketching Plane and Sketcher References:* One of the first things you identify in setting up a sketch is the sketching plane. This is the surface on which you will draw. A sketching plane may be an existing part surface, or it may be a datum plane. The selected plane or surface is rotated flat to the screen in Sketcher. You can use the usual rotation commands to rotate the sketch in 3D space for inspection, but usually sections are laid out flat, as though on a 2D drafting table. When the sketching plane is established, Sketcher needs existing planes and edges from which to dimension the new section. By default, Sketcher automatically selects two reference planes or edges, a horizontal and a vertical, to start a sketch. As you add to the sketch, you may need to add more references. In Sketcher, use the Sketch > References dialog box to add existing edges as references. Added edges are marked by a coloured, dotted line.
9) *Adding or Editing Dimensions:* When your sketched outline is finished; it will be dimensioned with default weak dimensions. As pointed out before, these are the dimensions that Sketcher adds automatically when you draw. They are displayed as gray lines. Because you are just sketching, they will not be the exact placements or values that you need. To enter strong values for a single dimension in Sketcher, click the weak dimension value itself and type directly into the text box. The dimension is then converted to a strong dimension, shown in normal line width, and the line or angle is adjusted to the new value. If Sketcher hasn't automatically given you a dimension or angle you want, you can use the Add Dimension icon on the Sketcher toolbar to add one, and then enter a value for it.
10) *Sketcher Geometric Constraints:* The work with dimensions to define a section. A constraint states that one line has a definite geometric relationship to another. For example, if you wanted a line in your new section to be parallel to and equal in length to an existing line, you could add those two constraints to the line in the section, rather than entering new dimensions. Constraints are represented on the screen by small symbols on the constrained line. In the next figure, the radius of the right circle is constrained to be the same as the radius of the left circle. The two centre points are constrained to be equidistant from a centreline. Thus, you only need to dimension the original, left circle. The right one will mirror it automatically.

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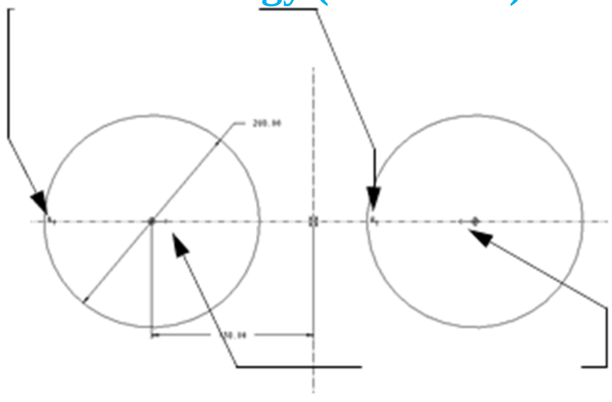
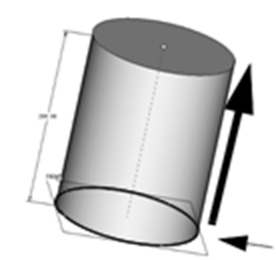


Use theConstraintpalettetoapplygeometricconstraintsintheSketchertool

11) *Going from Section to 3D :* When a section gains depth, or a z-dimension, it becomes a 3D geometric entity called an extrusion. The extrusion may add or remove material. In other words it may be a solid, or it may be a cut. For an example of a solid, imagine a 2D circle extruding outward to create a cylinder. An extrusion created as a cut removes material from any solid it passes through. For example, a bolt hole through a plate may be a circular section placed on the surface of the plate as a cut, and extruded through the plate. An extrusion must be defined as a solid or cut when created (otherwise it stays a 2D sketch), although the sketch may be used for both a solid and a cut. Depth can be added directly to a section, or the section can be revolved, where the depth of the cut or solid is added in degrees around an axis, as shown in the next figure.



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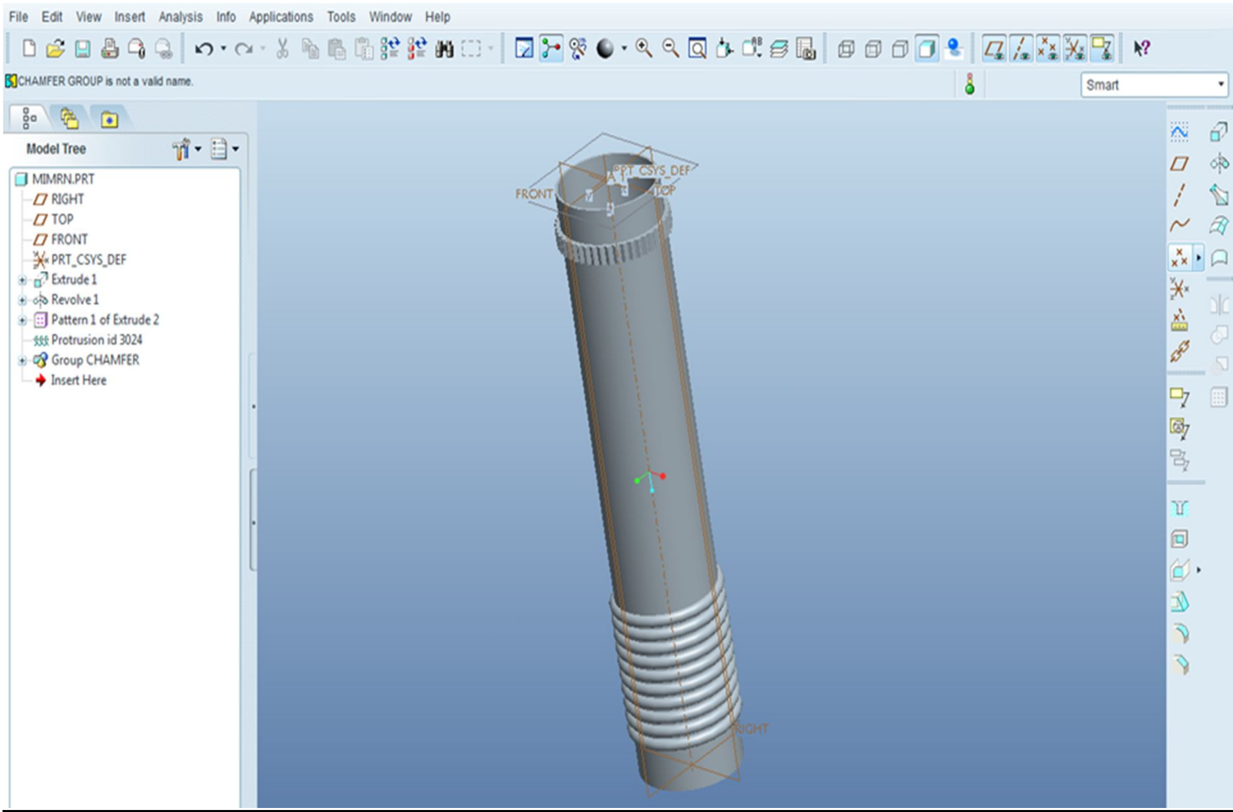
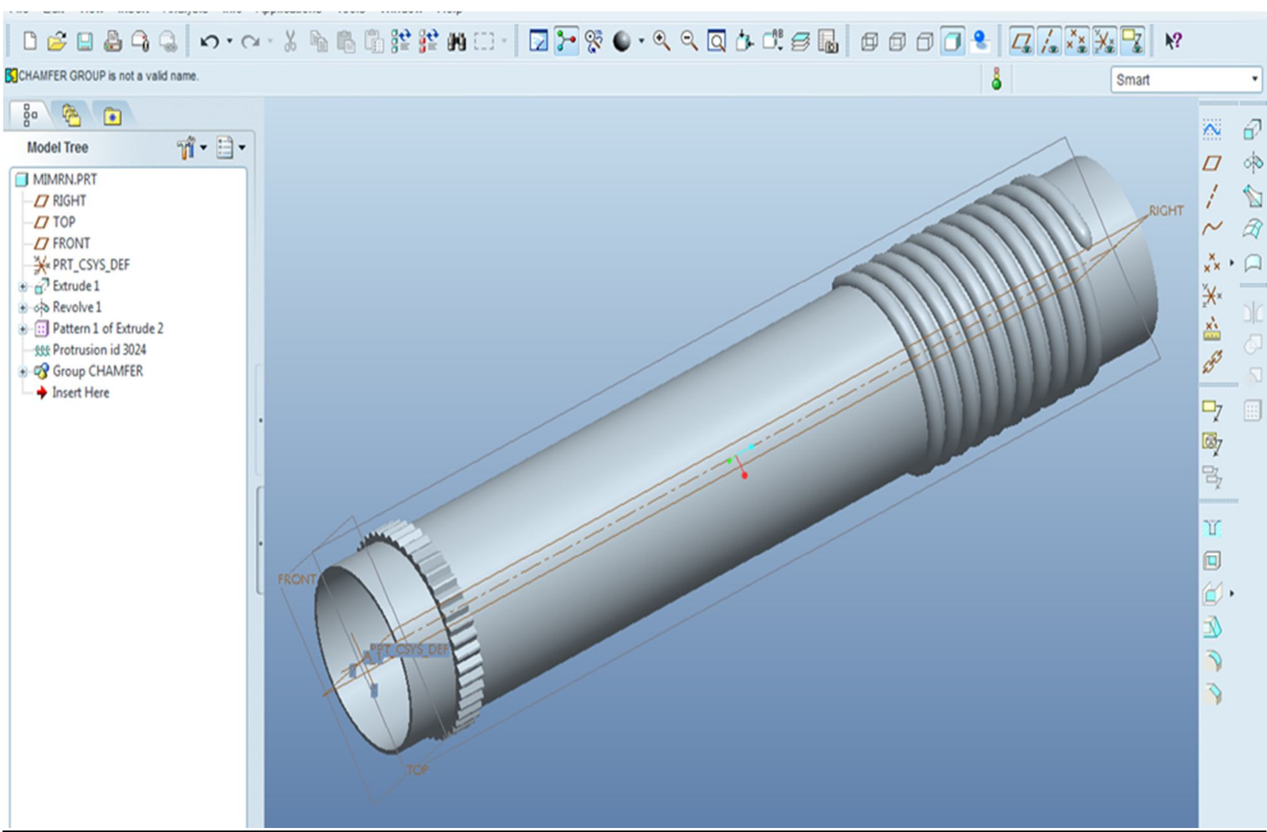
B. Design of an Open Sleeve





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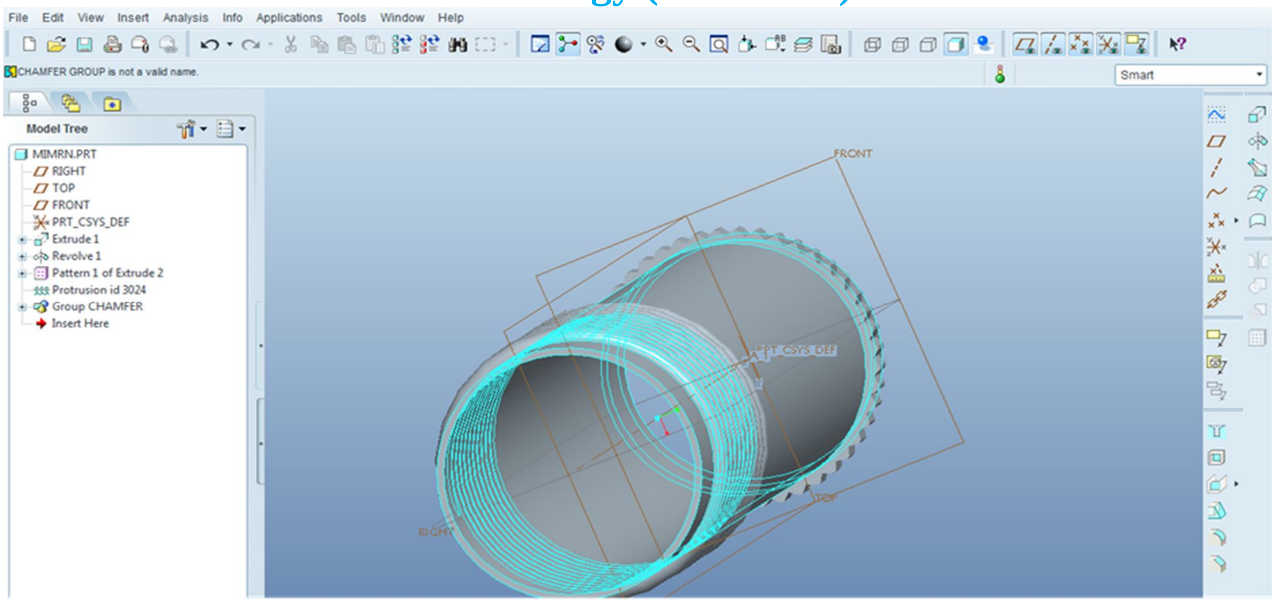

V. PROCESS

A. Manufacturing process

A restoration sleeve for the remanufacture of cast iron engine blocks or aluminium blocks with cast iron liners includes a sleeve formed of cast iron and having a relatively thin wall, a selected length, an outer diameter to achieve a non-interference fit within an overbored cylinder, an inner diameter equal to the original specifications of the original manufacturer of the engine block, and a helical cross hatched inner surface finish. The sleeves are manufactured by placing an unfinished sleeve in a boring fixture, boring the inner surface to a selected diameter, transferring the bored sleeve to a honing fixture, and honing the inner surface to the required diameter and surface finish. An adhesive is applied to the restoration sleeve and the overbored block cylinders, and the sleeves are inserted into the overbored cylinders wherein the adhesive is allowed to cure to thereby adhesively retain the sleeves within the block. A fluorescent dye is used in the adhesive for inspection by ultraviolet light to insure continuous and complete application of the adhesive to the restoration sleeve and the bored cylinder surface. The present invention relates to the restoration of engines and, more particularly, to the remanufacture of cast iron block engines and resin impregnated aluminium block engines having cast iron cylinder liners using thin walled prefinished and semi-finished cylinder liners which are adhesively retained in a non-interference fit relationship within the rebored block cylinder or cylinder liners. Within a reciprocating engine, the space between each piston and its cylinder wall is sealed by several piston rings. Each ring is resiliently urged outward for sealing contact with the cylinder wall is maintained. During engine operation, sliding frictional contact between piston rings and cylinder walls wears the ring contact surfaces and cylinder walls. As wear progresses, compression is more difficult to maintain and, additionally, there is increased oil consumption and increased oil contamination from combustion products forced past the piston rings. In general, replacement parts and restoration methods are available for large engines and engines which are required to be highly reliable, such as aircraft engines. Many diesel engines are designed and built with replaceable cylinders, and replacement cylinder and piston sets are manufactured and made available for overhauling diesel engines. The same is often true of aircraft engines, particularly large engines. Smaller aircraft engines are usually restored using remanufactured cylinders wherein the inner cylinder surface is plated to build up wall thickness and then machined to the desired dimensions and tolerances. One aspect of such restoration operations is that each is very expensive and can only be justified economically in commercial operations or in situations in which the cost of replacement of the entire engine is prohibitive. In order to increase fuel economy by reducing overall vehicle weight, several automobile manufacturers have designed and produced engines wherein the cylinder block and heads, crankcase, and oil pan are formed of aluminium alloys. While such aluminium alloys perform adequately in a structural sense, they are too soft to stand up to high speed frictional loads and would wear quickly in such applications. To avoid this, other metals or materials are employed for components subject to friction, such as bearings. In particular, cast iron cylinder liners are employed for frictional sealing engagement with the piston rings. Such cylinder liners for aluminium block engines are referred to as "wet cylinder" liners because the engine coolant directly contacts the outer surfaces of such liners to carry away heat from engine combustion and piston friction.

Occasionally, during the operation of a piston engine, the piston rod can become separated from either the piston or the crankshaft. This is referred to as "throwing a rod" and can be very damaging to cylinder walls and to other components within the engine. The usual result is a gouging of the cylinder wall. If the gouge is not too deep, the cylinder can often be repaired by boring out the affected cylinder and the insertion of a replacement cylinder which is then bored and honed to the required dimensions within the block. Because it is necessary for all the cylinders of an engine to have the same volumetric displacement for engine balance purposes and since it is not economical to bore out and reline the remaining cylinders, the usual procedure is to redimension all the cylinders, including the repaired cylinder, to a greater radius than the original dimensions and to install oversized pistons. In older engines which were not computer controlled and wherein emission standards were not so strict, such repair methods were usually adequate. However, such relining of cylinders of modern engines which changes the displacement of the engine causes operational problems since the control computer and pollution controls are set up for controlling the operation of an engine with a given displacement. Modern engine control computers can often detect differences in pollution control device performance resulting from as little as a one or two inch increases in displacement. Such a detected fault can cause a permanently illuminated "check engine" indicator, making such a rebuilt engine difficult to guarantee. Solution of this problem can require the expense of replacing pollution control devices, such as the catalytic converter. The conventional liner insertion process is to force a liner into the rebored cylinder using a hydraulic press. This results in an "interference" fit wherein the outer surfaces of the liner frictionally engage the inner surfaces of the rebored cylinder. Thus, an interference fit of a liner within a cylinder generates a radially outward pressure of the liner wall against the cylinder surface. In an engine block not originally designed for relining of the cylinders, an interference fit of a liner can stress and even distort the block. The cumulative distortion of relining all the cylinders in a block can result in rendering the block nonrebuildable. Because conventional automobile engines with cast iron blocks are manufactured in mass quantities, it is currently not economical to restore the worn cylinders of an engine block to their original specifications. In engines for which cylinder replacement is designed from the outset, the cylinder structures are relatively thick walled. This facilitates machining and honing of the inner cylinder surface since the cylinder structures are self-supporting and stiff enough that there is virtually no distortion of the cylinder wall during machining operations. This allows quick and accurate dimensioning and finishing of the inner cylinder surface. Such engines and replacement cylinders are also designed for relatively convenient replacement of worn cylinders without machining of the cylinder block. In the case of diesel engines, an upper lip of the cylinder engages a shoulder groove in the block while the lower end engages a similar shoulder. The cylinder is then held in place by the cylinder head. Adhesives are often used to seal between the upper and lower rims of the cylinder and the block to retain coolant within the water jacket of the cylinder block which otherwise would likely leak out of the water jacket and probably into the oil pan, contaminating the oil. Conventional automobile engines with cast iron blocks are not designed for cylinder replacement. The cylinder structure is cast as an integral part of the cylinder block and machined to the required cylinder dimensions. When cylinder repair is required, relatively thin walled cylinder liners are used. In such a case, machining of the cylinder liner occurs with the liner located within the block. The liner wall is, thus, supported by the portion of the original cylinder wall which remains. Because of the relative thinness of the walls of such liners and the difficulty of accurately machining and finishing the inner surface thereof, it has heretofore been considered impractical to supply such liners in a semi-finished or prefinished condition, which would otherwise economize the restoration of such engine blocks to their original displacement specifications. There is another type of aluminium block engine with an aluminium head which is formed by a lost foam casting process and which is resin impregnated for liquid retention. The engine uses relatively thick walled cast iron cylinder liners interference fit within the aluminium cylinder bores which are cryogenically cold shrunk prior to insertion. Currently, such engines are provided in Saturn automobiles (General Motors) and may be provided in other cars in the future. It is reported that the cylinder liners of such engines can be over bored a maximum of 0.015 inch diametrically for rebuilding purposes. However, in a conventional engine rebuilding process, an overbore on the order of 0.020 inch is typical. Additionally, such a maximum allowable overbore would only for the engine to be rebuilt one time. Thus, as designed, such an engine cannot be rebuilt using conventional techniques. A theoretical alternative to conventional rebuilding techniques is to heat the block to 400°-450° F. and drive the old liners out. The differential thermal expansion rates of aluminium and iron loosens the grip of the aluminium cylinder bores on the iron liners. New iron liners, with the original manufacturer's specified diameter, could then be inserted using a cold shrink process. However, heating the block to such a temperature, which is considerably higher than normal operating temperatures, destroys the resin impregnation, which results in a porous block which will not reliably hold oil and coolant. Reimpregnation of the aluminium block with the resin is not practical because any contaminant of oil, grease, dirt, label adhesives, or paint would cause local imperfections in the impregnation process, such that these areas would remain porous. It would be extremely laborious and, thus, very expensive to even attempt to adequately clean such contaminants from all surfaces and passages of the block and virtually impossible to accomplish. Thus, such a rebuilding process for aluminium block engines with interference fit iron cylinder liners could not be economically carried out or guaranteed. The restoration cylinders are formed of cast iron tubular stock having a wall thickness on the order of a tenth of an inch (100 mils) prior to prefinishing. The cylinders may be provided in a range of diameters, wall thicknesses, and lengths to accommodate the restoration of a wide variety of sizes of engine blocks. For a given engine block, the outer diameter of the sleeve is greater than the specified cylinder diameter of the engine block while the inner diameter is less than the specified cylinder diameter to allow for boring and honing of the inner surface of the sleeve to the required dimension and surface finish. As manufactured, the restoration sleeves may have the same inner diameter as originally specified for the new engine block, or original cylinder liners, and have a helical crosshatch surface pattern which facilitates the seating of piston rings within the restored cylinders. Such bored and honed sleeves are referred to herein as prefinished sleeves. Alternatively, the restoration sleeves may be provided in a bored, but not honed, condition to allow the engine rebuilder to hone the sleeve after installation in an engine block. Sleeves which are only bored are referred to herein as semi-finished sleeves. The restoration cylinders or sleeves are positioned in jigs or fixtures for boring and honing operations. A boring fixture for the sleeves is formed by base plate and a vertically spaced upper plate. The base and upper plates have aligned apertures with diameters slightly greater than the diameter to which the sleeves will be bored. Each of the base apertures in the base plate has an upper shoulder or edge groove which positively locates the lower ends of the sleeves with respect to the base apertures. Similarly, the upper apertures have lower shoulders or edge grooves to receive and positively locate the upper ends of the sleeves. The base and upper plates have a plurality of apertures so that a number of sleeves can be bored in a batch operation. A plurality of unfinished sleeves is positioned in alignment with the base apertures and supports the top plate which is positioned thereon. Regularly spaced over-centre clamps are engaged between the base plate and the upper plate to clamp and fix the positions of the sleeves within the boring fixture. The sleeves are bored by a rotary boring machine, either simultaneously or one at a time depending on the nature of the boring machine, to bring the inner diameter of the sleeves to within a selected tolerance of the desired diameter. A honing fixture, if used, is similar in some respects to the boring fixture and is formed by a base plate and an upper plate with aligned apertures. The apertures of the plates have facing edge grooves to positively position the sleeves in alignment with the apertures. The prebored sleeves are clamped between the base and upper plates by sets of circumferentially spaced bolts which are tightened to a torque which will adequately fix the positions of the sleeves but not so tight as to distort the shape of the sleeves. The inner surfaces of the sleeves may be honed by a rotary honing machine having a honing head formed by a plurality of honing sticks positioned as cylindrical elements of the honing head. Preferably, the honing machine is of the type wherein the centrifugal pressure of the honing sticks against the inner surface of the sleeves as well as the rotational speed and vertical dwell of the honing head can be precisely controlled by programming or by mechanical setup. Proper control of the centrifugal pressure of the honing sticks avoids radial distortion of the sleeve wall, resulting in precise inner sleeve diameter and radial uniformity. The vertical dwell of the honing head is controlled in such a manner as to apply a helical crosshatch surface finish to the inner surfaces of the sleeves which is needed to promote proper seating of piston rings during operational break-in of the remanufactured engine. In order to support the sleeve wall, particularly during honing, the sleeve supporting fixtures may be used in cooperation with a sleeve supporting bladder. The bladder is annular in shape with a central opening within which a sleeve is positioned during the machining operation. The bladder is inflated with a gas or liquid to engage an inner wall of the bladder with the outer surface of the sleeve wall to resist the radial pressure of the machining operation to thereby avoid radial distortion of the sleeve wall during machining. This enhances the precision of the honing operation and results in greater radial uniformity of the inner surface of the sleeve. Alternatively, the present invention contemplates other methods and apparatus or fixtures for supporting the restoration sleeves during machining operations. In a clam shell or separating block fixture, a support block is formed in halves which are slid ably supported on tracks or guides of a support plate for movement toward and away from one another by linear motors, such as hydraulic cylinders. A sleeve receiving cylinder recess, of a diameter to fit the sleeve stock to be machined, is bored in the support block halves, half the recess in each block half. A sleeve is positioned in the recess between the separated block halves, and the block halves are closed to snugly clamp the sleeve there between. The cylinder surface of the recess of the block prevents the pressure of the boring tool or the honing head from distorting the wall of the sleeve during machining operations. The clam shell type of fixture is best suited to high volume manufacturing operations where the cost of providing a set of block halves for each size of sleeve to be manufactured can be more readily justified. The support block may be sized and bored to simultaneously support a plurality of sleeves. The outer cylindrical surfaces of the sleeves are machined to bring their radial uniformity to a selected tolerance using a centreless grinding process. Engine block restoration sleeves manufactured and prefinished or semi-finished in a variety of sizes by the above described processes are stockpiled for later installation in engine block cylinders. When an engine block is to be remanufactured, the cylinders of a cast iron block engine, or the existing cast iron cylinder liners of an aluminium block engine, are overbored to a diameter which will achieve a selected degree of clearance or tightness with the installed cylinder sleeves. Sleeves of the proper size to restore the cylinder block to its original cylinder specifications are then inserted into the overbored cylinders. A preferred sleeve insertion process in the present invention is to overbore the original cylinders to a diameter just slightly greater than the outer diameter of the restoration sleeves to achieve a non-interference fit of the sleeves within the rebored cylinders structures and to adhesively retain the sleeves within the overbored cylinder structures. The original cylinders are overbored to a clearance of about two to four thousandths of an inch (0.025 to 0.05 millimetres) relative to the outer diameter of the replacement cylinders. An adhesive is then applied to the overbored cylinder surfaces and the outer surfaces of the restoration sleeves, and the sleeves are inserted into the overbored cylinders where the adhesive is allowed to cure. The adhesive used is preferably an an aerobically curing adhesive which is tolerant of the operating temperatures of the engine and which does not interfere with the transfer of heat from the sleeves through the original cylinders. Certain kinds of acrylic adhesives of this type are known and used in various applications in the automotive industry, such as adhesives of the type known as methyl acid/methyl acrylic ester adhesives. Curing of such adhesives is caused by a combination of pressure and a lack of oxygen. A even, continuous layer of adhesive without gaps is required to provide even transfer of heat from within the cylinders through the restoration sleeves to the engine block and thereby avoid localized overheating of the sleeves. In order to insure that a continuous layer of adhesive has been applied to the sleeve and the cylinder, the present invention provides the adhesive with a dye which is fluorescent in the presence of ultraviolet light. The dye is an ultraviolet light sensitive organic fluorescent dye. After the adhesive is applied to the machined cylinder surface or the sleeve outer surface, either or both may be inspected using ultraviolet light for gaps in the adhesive coverage. Any such gaps can be touched up prior to insertion of the sleeve into the cylinder. The present invention provides processes for economically remanufacturing aluminium engine blocks with interference fit cast iron cylinder liners, as well as cast iron blocks used in common automobiles. The most critical aspect of manufacturing the restoration sleeves, which is the honing and surface finishing process, may be carried out on a large scale which is a more efficient use of the expensive honing machinery and specialized machinist skills. The restoration sleeve insertion process does not require that the sleeve be forced into the block cylinder, which avoids the potential for distortion of the sleeve wall and other components within the engine block by such forced insertion. Thus, the efforts of an engine rebuilding shop in remanufacturing an engine block are substantially reduced by using the prefinished cylinders and method of adhesive installation of the present invention, without compromising the quality of the end product. Alternatively, the restoration sleeves may be provided as semi-finished. The semi-finished sleeves are installed in the same manner as the prefinished sleeves, but the engine rebuilder must then hone the inner surface of the sleeve to the final inner diameter and surface finish. Some rebuilders prefer to do the final honing in their own shops. Although adhesive retention of the restoration cylinders in a non-interference fit relationship within the rebored cylinders is preferred, the present invention provides an alternative method of installing the restoration cylinders in an engine block. The block cylinders are overbored for an interference fit of the replacement cylinders therein, and the replacement cylinders are cold shrunk prior to insertion. The over boring process must be accomplished with a high degree of precision and regularity, as compared to the boring process used in conventional cylinder repair processes, since any irregularity of the cylinders will be transferred to the cylinder sleeve which is installed and since no further machining of the installed sleeve will occur. Cold shrinking contracts the sleeves which can be inserted into with little or no resistance. As the temperature of the sleeves rises to equilibrium with the block, the sleeves expand to frictionally engage the overbored cylinders. It should be noted that the cold shrunk sleeves must be handled using refrigerated tools to avoid localized warming of portions of the sleeves which can cause distortions and possible stresses and consequent failure of the sleeves during operation of the engine. Although the engine block overboring process requires a fair degree of precision and the cold shrinking of the sleeves prior to insertion in the engine blocks requires the provision of specialized refrigeration equipment, the overall process of remanufacturing an engine block at an engine rebuilder's facility is simplified and, thereby, economized.

Modern precision manufacturing demands extreme dimensional accuracy and surface finish. Such performance is very difficult to achieve manually, if not impossible, even with expert operators. In cases where it is possible, it takes much higher time due to the need for frequent dimensional measurement to prevent overcutting. It is thus obvious that automated motion control would replace manual “hand wheel” control in modern manufacturing. Development of computer numerically controlled (CNC) machines has also made possible the automation of the machining processes with flexibility to handle production of small to medium batch of parts. In the 1940s when the U.S. Air Force perceived the need to manufacture complex parts for high-speed aircraft. This led to the

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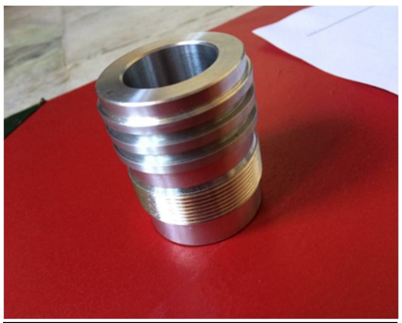
development of computer-based automatic machine tool controls also known as the Numerical Control (NC) systems. Commercial production of NC machine tools started around the fifties and sixties around the world. CNC machines offer the following advantages in manufacturing. • Higher flexibility: This is essentially because of programmability, programmed control and facilities for multiple operations in one machining centre, • Increased productivity: Due to low cycle time achieved through higher material removal rates and low set up times achieved by faster tool positioning, changing, automated material handling etc. • Improved quality: Due to accurate part dimensions and excellent surface finish that can be achieved due to precision motion control and improved thermal control by automatic control of coolant flow. • Reduced scrap rate: Use of Part programs that are developed using optimization procedures • Reliable and Safe operation: Advanced engineering practices for design and manufacturing, automated monitoring, improved maintenance and low human interaction • Smaller footprint: Due to the fact that several machines are fused into one. On the other hand, the main disadvantages of NC systems are • relatively higher cost compared to manual versions • More complicated maintenance due to the complex nature of the technologies • Need for skilled part programmers. The above disadvantages indicate that CNC machines can be gainfully deployed only when the required product quality and average volume of production demand it.

VI. RESULTS AND DISCUSSION

By implementing the generated coding in CNC machine, the work piece is machined as per the design specifications:



Length	-	60mm
Outer Diameter	-	50mm
Inner Diameter	-	40mm
Wall thickness	-	5mm
Pitch	-	1.5mm

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VII. CONCLUSION

Computer Numerical Control is automation of machine tools that are operated by precisely programmed commands encoded on storage medium in which computers plays an integral part of the control. In this project the effective uses of CNC machine is utilized. CNC machines offer the following advantages in manufacturing like higher flexibility, increased productivity, Improved quality, Reduced scrap rate, Reliable and Safe operation. Incorporating the capabilities of CNC machining the complex components are manufactured. Most of the components used in an aircraft are complex in nature and should have material and compound quality to sustain loads so, in this project by implementing the capabilities of CNC techniques we designed and manufacture an open sleeve which is used in aircrafts ignition system and oil filtration system.

VIII. ACKNOWLEDGEMENT

We are very much thankful to Mathukumalli Sowmya Former Mlrit Aeronautical Student and Present Associate Analyst at Camp systems, Hyderabad

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