

# Modeling & Manufacturing Process Plan for Solenoid Plunger

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## ABSTRACT

In manufacturing, the goal is to produce components that meet the design specifications. The design specification ensures the functionality aspect. Next step to follow is to assemble these components into final product. Process planning acts as a bridge between design and manufacturing by translating design specification into manufacturing process detail. A Linear Solenoid is an electromagnetic device that converts electrical energy into a mechanical energy pushing or pulling force or motion. When electrical current applied to a conductor in generates magnetic field. Here the problem find out that plunger releases huge amount of heat while it is in motion condition. So need to improve proper optimized design of solenoid plunger.

The main aim of this project is to develop the accurate design of solenoid plunger which forms less heat effects while be in motion conditions and developing proper manufacturing program for solenoid plunger. Design of solenoid plunger is done using NX-CAD, thermal coupled field analysis done through Ansys software and NC program generating using NX-CAM software.

Keywords: Heat, Magnetic, device, Solenoid, plunger, CAD,

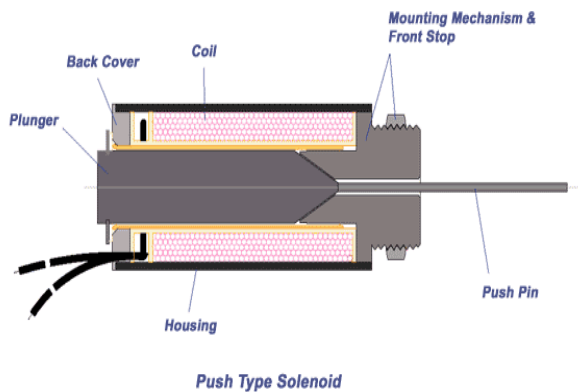
## INTRODUCTION

### 1.1 SOLENOID PLUNGER:

A solenoid valve is an electromechanical device used for regulating liquid or gas flow. When a coil in the solenoid valve is energized by electrical current, a magnetic field is created, causing movement of a plunger inside the coil and regulating the media stream.

Actuation for machine and process automation must range from the most basic on-off function to extremely complex sequencing. When the process involves linear or rotary motion, solenoids are among the best actuation devices in terms of size, cost, simplified installation and ease-of-use. On the following pages, we've shown several application examples that demonstrate the wide range of markets and applications to which our solenoid products are applied. In keeping with recent industry trends, we have developed many solenoid designs to be especially advantageous for specific application demands including:

- Saving Energy with magnetic latching solenoids for power off engagement
- Quiet operation
- Miniature size for space-restricted applications
- Long-life designs for extremely consistent and dependable operation
- High speed designs for maximum throughput and productivity



## PROCESS PLANNING

Process planning refers to the product design and decides how to manufacture it within the resource constraints. Process planning can be seen as an activity which integrates knowledge about products and resources. Manufacturing process planning is the process of selecting and sequencing manufacturing processes such that they achieve one or more goals and satisfy a set of domain constraints.

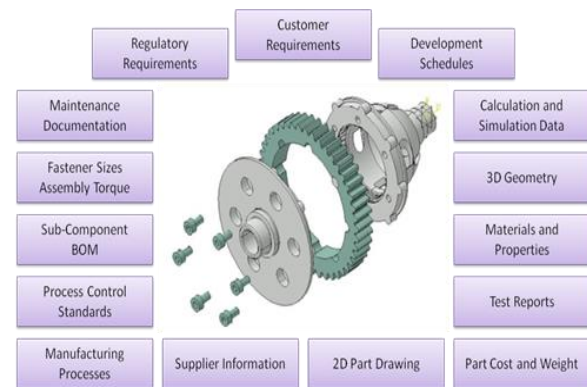
Process planning is a production organization activity that transforms a product design into a set of instruction (sequence, machine tool setup etc.) to manufacture machined part economically and competitively. The information provided in design includes dimensional specification (geometric shape and its feature) and technical specification (tolerance, surface finish etc.)

My project deals with the manufacturing of “support” component using CAM software (‘UGNX-7.5’ which is a CAD/CAM software used to generate part program by designing and feeding the geometry of the component) and defining the proper tool path and thus transferring the generated part program to the required CNC machine with the help of DNC lines. Then the program is executed with suitable requirements.

A board, usually of stainless steel, fitted under part of the wire in a Fourdrinier machine for supporting the pulp stack before it is sufficiently formed to support itself on the wire.

The component can be either designed in UG or can be retrieved from any other CAD software. Then sequence of programs such as modeling the component, selection of tools according to the sequence of operations and sizes, generating the tool path, at last the generated NC part program is verified and sent to the required CNC machine to manufacture the particular component. Finally the required surface finish has been obtained by machining the component at optimum speeds and feeds and the cost of machining is also optimized by choosing optimal machining process and machine tools.

Product Development in a Manufacturing Industry:



## PROBLEM DEFINITION AND METHODOLOGY

A Linear Solenoid is an electromagnetic device that converts electrical energy into a mechanical energy pushing or pulling force or motion. When electrical current applied to a conductor in generates magnetic field. Here the problem find out that plunger releases huge amount of heat while it is in motion condition. So need to improve proper optimized design of solenoid plunger.

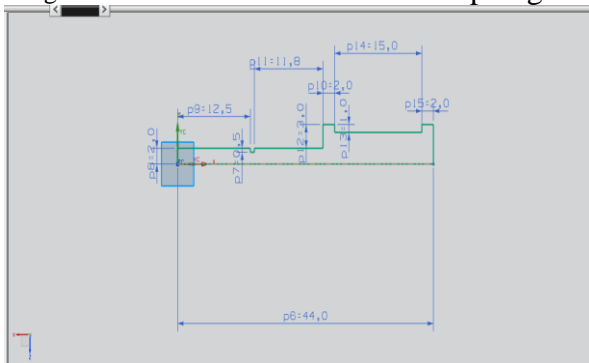
## 1. METHODOLOGY

- Design of solenoid plunger using NX-CAD
- Thermal coupled field analysis of solenoid plunger done for finding thermal stress values.
- Thermal coupled field analysis done using Ansys software.
- Manufacturing process of solenoid plunger done using NX-CAM.
- NC program is generated for solenoid plunger.

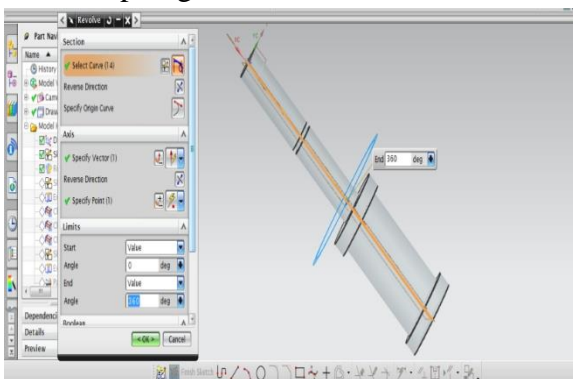
## 2. DESIGNING OF SOLENOID PLUNGER

### Sketching

Below is the sketch required to obtain the 3D model of the solenoid plunger from the above 2D drawing. Below image shows the SKETCH of the solenoid plunger.



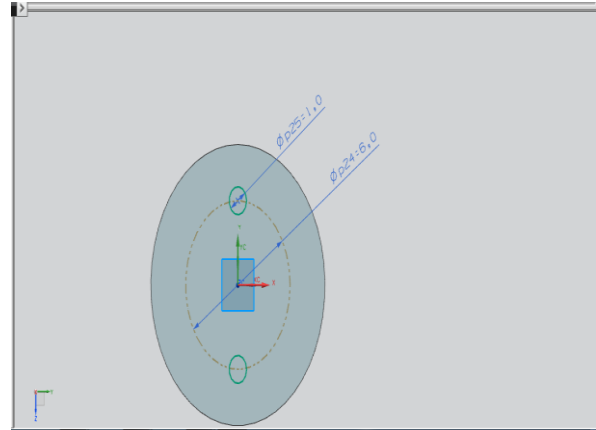
Below image shows the REVOLVE of the solenoid plunger.



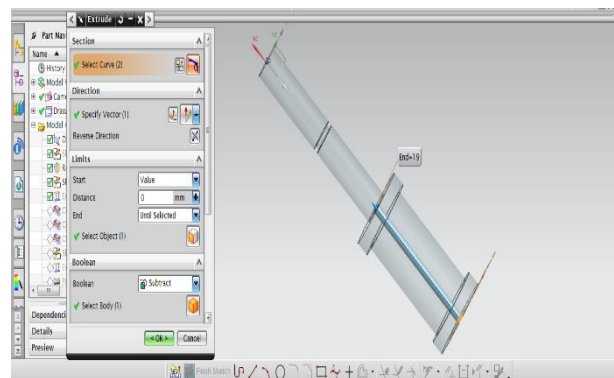
### REVOLVE

By using revolve command we convert sketch from 2D to 3D only for axis symmetry bodies.

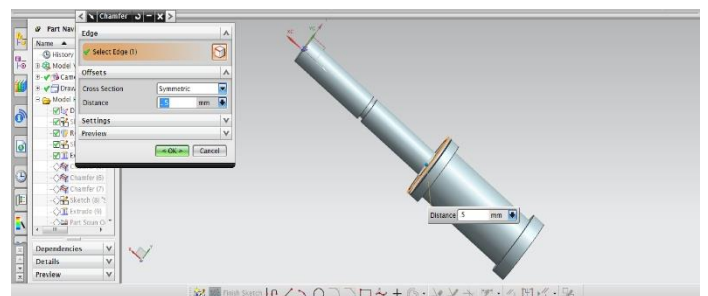
Below image shows the SKETCH on the right side view of the solenoid plunger.

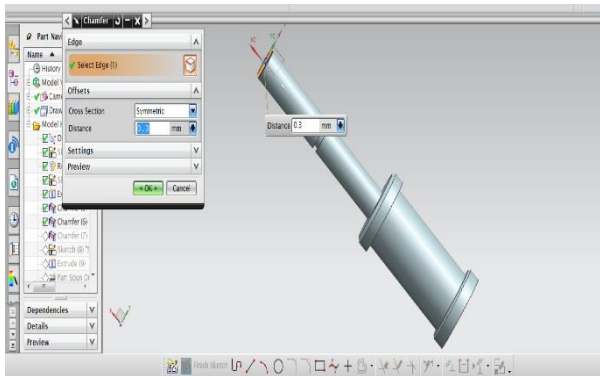


Below image shows the EXTRUDE option for the above sketch.



Below image shows the CHAMFER option





Below image shows the 3D component of the solenoid plunger.

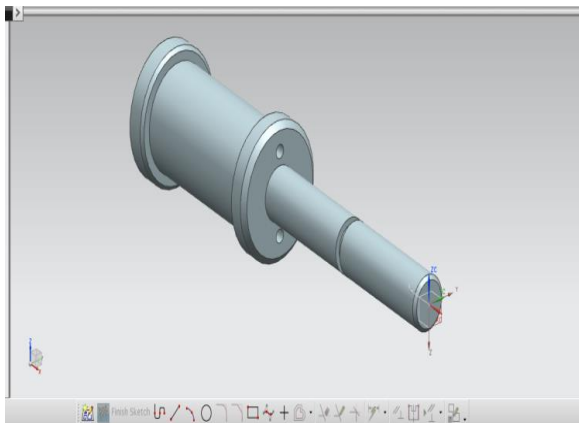


Fig. Final 3D modeling of solenoid plunger

## COUPLED FIELD ANALYSIS OF SOLENOID PLUNGER

### 5.1 INTRODUCTION TO FEM THEORY

Finite Element Modeling (FEM) also, Finite Element Analysis (FEA) are two most prominent mechanical building applications offered by existing CAE frameworks. This is ascribed to the way that the FEM is maybe the most famous numerical strategy for tackling building issues. The strategy is sufficiently general to deal with any unpredictable state of geometry (issue space), any material properties, any limit conditions and any stacking conditions. The all inclusive statement of the FEM fits the investigation necessities of the present complex building frameworks and plans where shut shape

arrangements are administering harmony conditions are not accessible. Furthermore it is a productive outline instrument by which creators can perform parametric plan examining different cases (distinctive shapes, material burdens and so forth.) investigating them and picking the ideal outline.

#### 5.1.1 FINITE ELEMENT METHOD

The FEM is numerical examination system for getting inexact answers for wide assortment of designing issues. The strategy began in the avionic business as a device to examine worries in confused airframe structures. It became out of what was known as the grid examination technique utilized as a part of air ship plan. The technique has picked up fame among the two analysts and professionals and after such a significant number of advancements codes are created for wide assortment of issues.

#### 5.1.2 APPLICATION OF FEM

For the most part, FEM is the technique for decision in a wide range of investigation in basic mechanics (i.e. illuminating for disfigurement and worries in strong bodies or progression of structures) while computational liquid flow (CFD) tends to utilize FDM or different strategies (e.g., limited volume strategy). CFD issues ordinarily require discretization of the issue into countless/network focuses (millions and that's just the beginning), hence cost of the arrangement favors more straightforward, bring down request estimate inside every phone. This is particularly valid for 'outer stream' issues, similar to wind stream around the auto or plane, or climate reenactment in an expansive zone.

#### 5.1.3 FEM TERMINOLOGY

Established expository mechanics is that concocted by Euler and Lagrange and created by Hamilton and Jacobi as a precise detailing of Newtonian mechanics. Its



objects of consideration are models of mechanical frameworks extending from particles made out of adequately vast of atoms, through planes, to the Solar System. The spatial setup of any such framework is depicted by its degrees of opportunity. These are additionally called summed up arranges. The terms state factors and essential factors are additionally utilized, especially in scientifically situated medications. In the event that the quantity of degrees of flexibility of the model is limited, the model is called discrete and persistent something else.

Since FEM is a Descritization strategy, the quantity of degrees of opportunity of a FEM demonstrate is essentially limited. The opportunities are gathered in a section vector called  $u$ . This vector is for the most part called the DOF vector or state vector. The term nodal relocation vector for  $u$  is held to mechanical applications. In expository mechanics, every level of opportunity has a comparing "conjugate" or "double" term, which speaks to a summed up compel. In non-mechanical applications, there is a comparative arrangement of conjugate amounts, which for need of a superior term are likewise called powers or driving terms. These powers are gathered in a segment vector called  $f$ . The internal item  $f^T u$  has the importance of outer vitality or work. Similarly as in the bracket issue, the connection amongst  $u$  and  $f$  is thought to be of straight and homogeneous. The last supposition implies that if  $u$  vanishes so does  $f$ . The connection is then communicated by the ace solidness conditions:

$$K u = f$$

$K$  is universally called the stiffness matrix even in non-structural applications because no consensus has emerged on different names.

#### 5.1.4 GENERAL PROCEDURE OF THE FINITE ELEMENT METHOD

The arrangement of a continuum issue by the limited component strategy ordinarily takes after an organized well ordered process. The accompanying advances appear by and large how the limited component technique functions. These means will turn out to be more justifiable when the FEA is shrouded in more detail later.

➤ Discretize the given continuum. The pith of the limited component strategy is to separate a continuum, that is, issue area, into semi disjoint non-covering components. This is accomplished by supplanting the continuum by an arrangement of key focuses, called hubs, which when associated appropriately create the components. The accumulation of hubs and components frames the limited component work. An assortment of component shapes and sorts are accessible. The expert or planner can blend component composes to take care of one issue. The quantity of hubs and components that can be utilized as a part of an issue involves designing judgment. When in doubt, the bigger the quantity of hubs and components, the more exact the limited component arrangement, yet in addition the more costly the arrangement is; more memory space is expected to store the limited component model, and more PC time is expected to acquire the arrangement. Figure 18-1 demonstrates a case of discretizing a cantilever pillar made of steel and supporting an amassed stack at its free end. Figure 18-1c indicates two writes (four-hub and six-hub) of a quadrilateral (component shape) component.

2. Select the arrangement estimate. The variety of the obscure (called field variable) in the issue is approximated inside every component by a polynomial. The field variable might be a scalar (e.g., temperature) or a vector (e.g., level and vertical removals). Polynomials are typically used to inexact the arrangement

over a component area since they are anything but difficult to coordinate and separate. The level of the polynomial relies upon the quantity of hubs per component, the quantity of questions (segments of field variable) at every hub, and certain progression necessities along component limits.

3. Create component grids and conditions. The limited component plan exhibited in the following segment includes change of the representing conditions from the continuum area. Once the hubs and material properties of a given component are characterized, its relating grids (solidness lattice, mass network, and so on.) and conditions can be determined. Four techniques are accessible to determine component networks and conditions: the immediate strategy, the variation strategy, the weighted lingering technique, and the vitality strategy. In this part, we cover the second (appropriate for strong mechanics issues) and the third (reasonable for warm liquids issues) strategies.

4. Amass the component conditions. The individual component grids are included by summing the balance conditions of the components to acquire the worldwide lattices and arrangement of arithmetical conditions. Before illuminating this framework, it must be altered by applying the limit conditions. On the off chance that limit conditions are not connected, wrong outcomes are acquired, or a particular arrangement of conditions may come about.

5. Understand for the questions at the hubs. The worldwide of logarithmic conditions is unraveled by means of Gauss end techniques to give the estimations of the field factors at the hubs of the limited component work. Estimations of field factors and their subordinates at the hubs frame the entire limited component arrangement of the first continuum issue before Descritization. Qualities at different focuses inside the continuum other than the

hubs are conceivable to acquire, in spite of the fact that it isn't usually done.

6. Translate the outcomes. The last advance is to examine the arrangement and results got from the past advance to settle on plan choices. The right understanding of these outcomes requires a sound foundation in both designing and FEA. This is the reason regarding FEA and FEM codes as a black box is generally not prescribed and, truth be told, is viewed as perilous.

With regards to the above well ordered system, unmistakably there are different basic choices that experts of the limited component investigation need to make, e.g., the sort of examination, the quantity of hubs, the degrees of opportunity (parts of the field variable) at every hub, the component shape and sort, the material kind, lastly the translation of the outcomes. Settling on these choices turns out to be more clear after we talk about the above strides in more detail while covering FEA.

## **5.2 INTRODUCTION TO ANSYS**

The ANSYS program is independent broadly useful limited component program created and kept up by Swason Analysis Systems Inc. The program contain numerous schedules, all bury related, and just for fundamental motivation behind accomplishing an answer for an a building issue by limited component technique.

ANSYS finite element analysis software enables engineers to perform the following tasks:

- Build computer models or transfer CAD models of structures, products, components, or systems.
- Apply operating loads or other design performance conditions
- Study physical responses ,such as stress levels, temperature distributions, or electromagnetic fields
- Optimize a design early in the development process to reduce production costs.

- Do prototype testing in environments where it otherwise would be undesirable or impossible

The ANSYS program has a compressive graphical UI (GUI) that gives clients simple, intelligent access to program capacities, charges, documentation, and reference material. An instinctive menu framework enables clients to explore through the ANSYS Program. Clients can enter information utilizing a mouse, a console, or a mix of both. A graphical UI is accessible all through the program, to manage new clients through the learning procedure and give more experienced clients numerous windows, pull-down menus, discourse boxes, apparatus bar and online documentation.

### 5.2.1 ORGANIZATION OF THE ANSYS PROGRAM

The ANSYS program is organized into two basic levels:

- Begin level
- Processor (or Routine) level

The start level goes about as a portal in to and out of the ANSYS program. It is additionally utilized for certain worldwide program controls, for example, changing the activity name, clearing (focusing out) the database, and duplicating parallel records. When we initially enter the program, we are at the start level.

At the processor level, a few processors are accessible; every processor is an arrangement of capacities that play out a particular investigation errand. For instance, the general preprocessor (PREP7) is the place we manufacture the model, the arrangement processor (SOLUTION) is where we apply stacks and acquire the arrangement, and the general postprocessor (POST1) is the place we assess the outcomes and get the arrangement. An extra postprocessor (POST26), empowers we to assess

arrangement comes about at particular focuses in the model as an element of time.

### 5.2.2 PERFORMING A TYPICAL ANSYS ANALYSIS

The ANSYS program has many finite element analysis capabilities, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis. The analysis guide manuals in the ANSYS documentation set describe specific procedures for performing analysis for different engineering disciplines.

A typical ANSYS analysis has three distinct steps:

- Build the model
- Apply loads and obtain the solution
- Review the results

The following table shows the brief description of steps followed in each phase.

PRE-PROCESSOR	SOLUTION PROCESSOR	POST-PROCESSOR
Assigning element type	Analysis definition	Read results
Geometry definition	Constant definition	Plot results on graphs
Assigning real constants	Load definition	View animated results
Material definition	Solve	
Mesh generation		
Model display		

### PRE-PROCESSOR:

The info information for an ANSYS investigation are readied utilizing a preprocessor. The general preprocessor (PREP 7) contains ground-breaking strong displaying a work age abilities, and is likewise used to characterize all different investigation information with the advantage of date base definition and control of examination information. Parametric information, client records, macros and broad online documentation are likewise accessible, giving more instruments and adaptability

For the expert to characterize the issue. Broad designs ability is accessible all through the ANSYS program, including isometric, keen, area, edge, and concealed

line presentations of three-dimensional structures-y diagrams of info amounts and results, and form showcases of arrangement comes about.

**The pre-processor stage involves the following:**

- Specify the title, which is the name of the problem. This is optional but very useful, especially if a number of design iterations are to be completed on the same base mode.
- Setting the type of analysis to be used ,e.g., Structural, Thermal, Fluid, or electromagnetic, etc
- Creating the model. The model may be created in pre-processor, or it can be imported from another CAD drafting package via a neutral file format.
- Defining element type, these chosen from element library.
- Assigning real constants and material properties like young's modules, Poisson's ratio, density, thermal conductivity, damping effect, specific heat, etc
- Apply mesh. Mesh generation is the process of dividing the analysis continuum into number of discrete parts of finite elements.

**SOLUTION PROCESSOR**

Here we create the environment to the model, i.e, applying constraints &loads. This is the main phase of the analysis, where the problem can be solved by using different solution techniques. Her three major steps involved:

- Solution type required, i.e. static, modal, or transient etc., is selected
- Defining loads. The loads may be point loads, surface loads; thermal loads like temperature, or fluid pressure, velocity are applied.
- Solve FE solver can be logically divided in o three main steps, the pre-solver, the mathematical-engine and

post-solver. The pre-solver reads the model created by pre-processor and formulates the mathematical representation of the model and calls the mathematical-engine, which calculates the result. The result return to the solver and the post solver is used to calculate strains, stresses, etc., for each node within the component or continuum.

**POST –PROCESSOR:**

Post handling implies the consequences of an investigation. It is presumably the most essential advance in the investigation, since we are attempting to see how the connected burdens influences the outline, how nourishment your limited component work is, et cetera.

The investigation comes about are looked into utilizing postprocessors, which can show mutilated geometries, anxiety forms, stream fields, security factor forms, shapes of potential documented outcomes; vector field shows mode shapes and time history charts. The postprocessor can likewise be utilized for logarithmic tasks, database controllers, separation, and joining of figured outcomes. Reaction spectra might be produced from dynamic examination. Results from different stacking might be agreeably stacked hub metric structures.

**REVIEW THE RESULTS:**

Once the arrangement has been figured, we can utilize the ANSYS postprocessor to audit the outcomes. Two postprocessors are accessible: POST1 and POST 26. We utilize POST 1, the general postprocessor to survey the outcomes at one sub venture over the whole model or chose part of the model. We can get form shows, misshape shapes and unthinkable postings to audit and decipher the aftereffects of the examination. POST 1 offers numerous different abilities, including mistake



estimation, stack case blend, count among comes about information and way tasks.

We utilize POST 26, the time history post processor, to survey comes about at particular focuses in the model over unsurpassed advances. We can get diagram plots of results, information versus time and forbidden postings. Other POST 26 abilities incorporate number juggling figurings and complex variable based math.

In the arrangement of the investigation the PC assumes control and illuminates the synchronous arrangement of conditions that the limited component technique produces, the consequences of the arrangement are

- Nodal degree of freedom values, which form the primary solution
- Derived values which form the element solution

### 5.3 COUPLED FIELD ANALYSIS OF SOLENOIDAL PLUNGER

ZAMAK MATERIAL PROPERTIES:

**Density -6.60 g/cm<sup>3</sup>**

**Ultimate Tensile strength -240MPa**

**Modulus of elasticity -96 GPa**

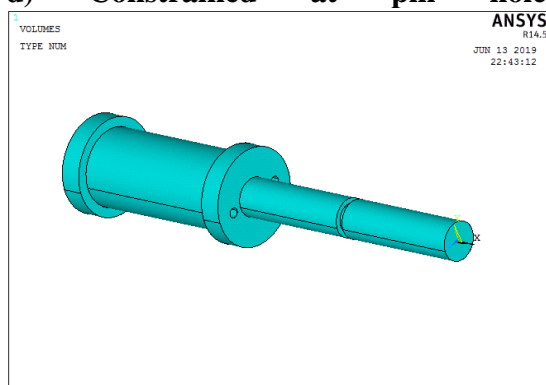
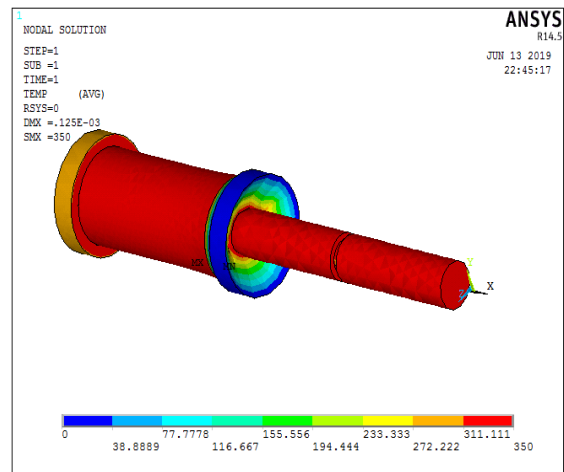
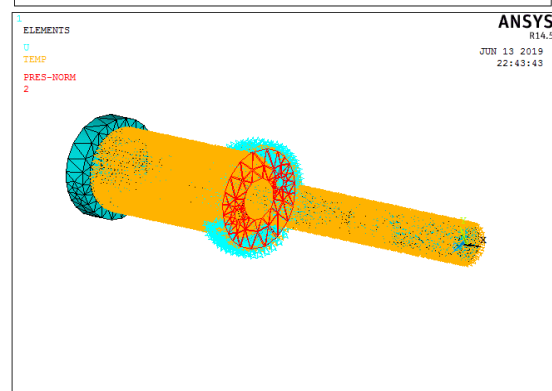
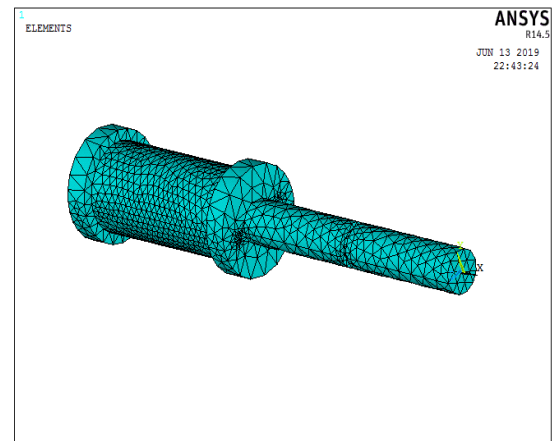
**Poisson ratio - 0.29**

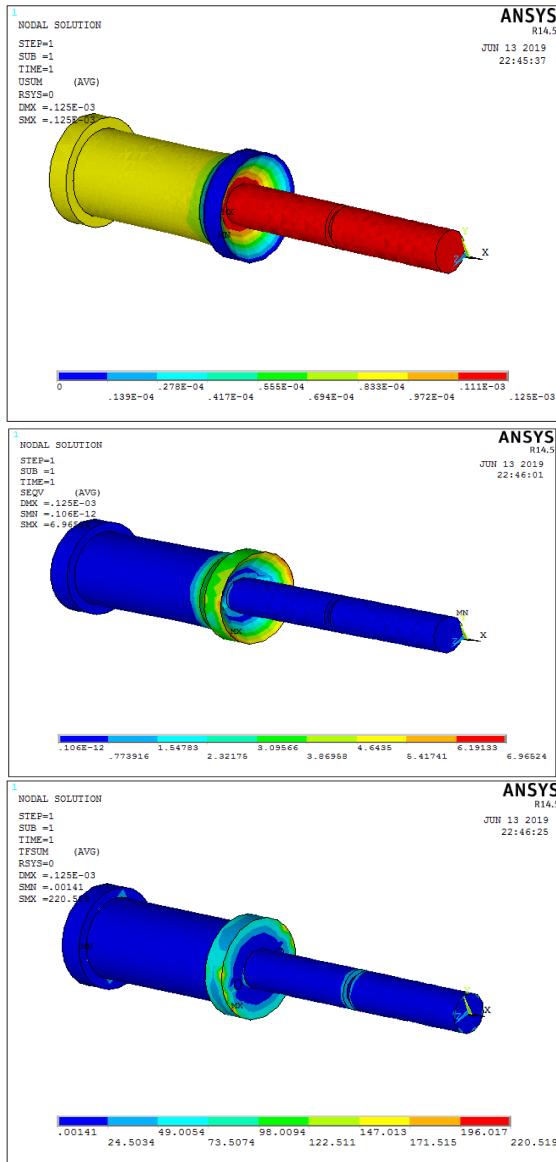
**Specific heat -420J/kg-K**

**Thermal conductivity -113W/m-K**

BOUNDARY CONDITIONS:

- Temperature 350K on Solenoid plunger
- Convection on total body (200W/m<sup>2</sup>K)
- Pressure 2MPa on push pin
- Constrained at pin holes**





## 6.2 IDENTIFY SUITABLE MACHINE.

TYPES OF CNC MACHINE USED IN THIS PROJECT:

MORI SEIKI 4-AXIS CNC turning machine is used for machining missile solenoid plunger. MORI SEIKI offers the industry's best lineup of high-performance lathes with better precision and rigidity, greater multi-axis compatibility and smaller footprints.

High rigidity with Integrated Turning Spindle. Spindle is directly coupled with motor. Rigid Turret with BIM (Built In Motor) Technology. Directly coupled Integrated driven tools. Is a patent technology. Y-axis machining, Up to

100mm (+/- 50). 4-axes simultaneous machining, C-axis with 360 deg and Y-axis, Machine accuracies, Positional Accuracy +/- 0.005mm, Repeatability +/- 0.003mm. In 4-axis turning machine, Axis represents as work piece rotation and spindle movement in x, y, z directions.



Fig: 4-axis CNC MORI SEIKI turning machine

## 6.3 SELECTION OF TOOLS

Selection of tools plays an important role in manufacturing any component. Proper tools must be selected otherwise in manufacturing process improper tools results in damage of work piece or damage to the tools, tool holders.



OD\_80\_L facing

Facing in the context of turning work involves moving the cutting tool at right angles to the axis of rotation of the rotating workpiece. This can be performed by the operation of the cross-slide, if one is fitted, as distinct from the longitudinal feed (turning). It is frequently the first operation performed in the production of the workpiece,



D\_800\_L rough

This process, also called **rough** or **cutoff**, is used to create deep grooves which will remove a completed or part-complete component from its parent stock.



OD\_55\_L finish

Finish tool remove the left over stock after roughing process. It is the last process which gives surface finish.



ID\_80\_L rough

Rough tool used to create deep grooves which will remove a completed or part-complete component from its parent stock internally.



ID\_55\_L finish

Finish tool remove internally the left over stock after roughing process. It is the last process which gives surface finish.

#### 6.4 SEQUENCE OF OPERATIONS PERFORMED ON MISSILE SOLENOID PIUNGER COMPONENT

Sequence of operations performed on missile solenoid piunger in NX-CAM software are listed below

##### TURNING OPERATIONS

Facing operation

Rough\_Turn\_OD

Groove\_OD

##### MILLING OPERATIONS

Drilling\_D1

Step by step procedure of NC part program is shown below in flow chat

#### MANUFACTURING OF SOLENOID PLUNGER

##### 6.1 SELECTION OF SUITABLE MATERIAL

###### TYPES OF MATERIALS

###### Zamak

Zamak used as raw material for solenoid piunger.

###### Zamak Specifications

Pure Zamak is alloyed with many other metals to produce a wide range of physical and mechanical properties. The alloying elements are used as the basis to classify Zamak alloys into two categories: non-heat-treatable and heat-treatable.

Most of Zamak specifications designate Zamak alloys in the following way:

- First digit – principal alloying constituent(s),
- Second digit – variations of initial alloy,
- Third and fourth digits – individual alloy variations (number has no significance but is unique).

Cast Zamak Specifications. The designation system and specifications for cast Zamak alloys are similar in some respects to that of wrought alloys. The cast alloy designation system also has four digits and the first digit specifies the major alloying constituent(s). However, a decimal point is used between the third and fourth digits to make clear that these are designations used to identify alloys in the form of castings (0) or foundry ingot (1,2).

##### 6.2 IDENTIFY SUITABLE MACHINE.

###### TYPES OF CNC MACHINE USED IN THIS PROJECT:

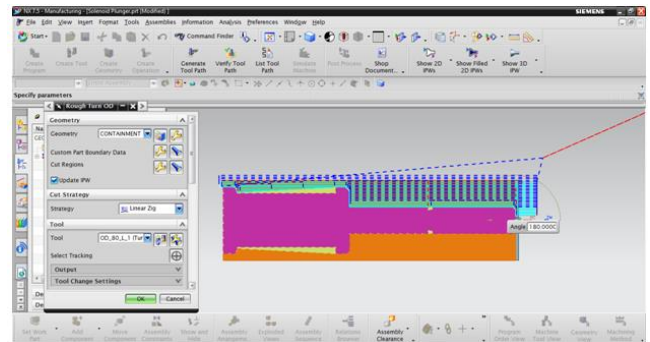
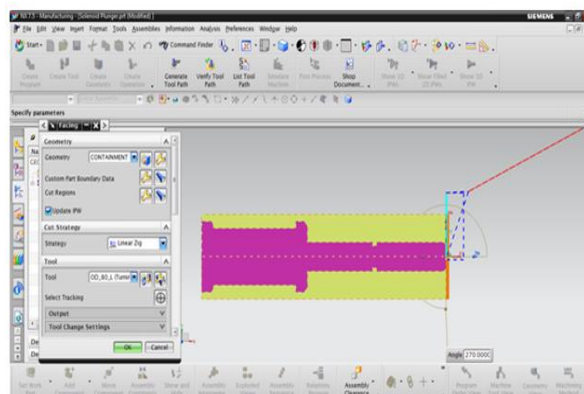
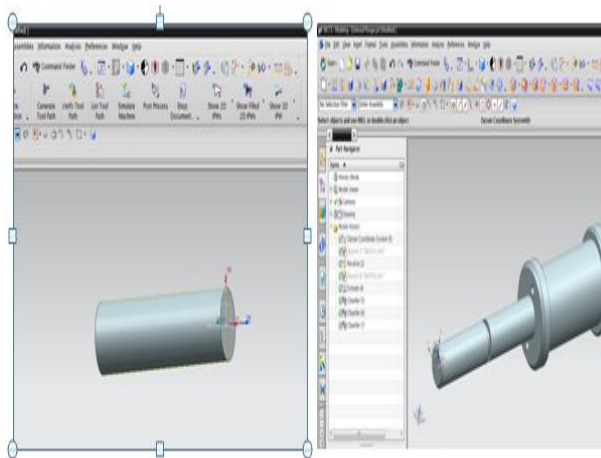
MORI SEIKI 4-AXIS CNC turning machine is used for machining missile solenoid piunger. MORI SEIKI offers the

industry's best lineup of high-performance lathes with better precision and rigidity, greater multi-axis compatibility and smaller footprints.

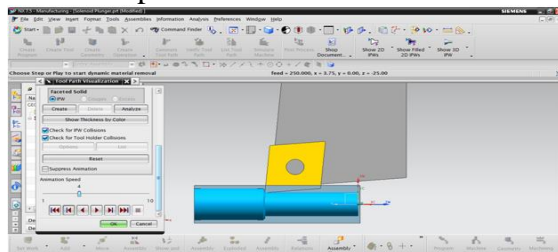
High rigidity with Integrated Turning Spindle. Spindle is directly coupled with motor. Rigid Turret with BIM (Built In Motor) Technology. Directly coupled Integrated driven tools. Is a patent technology. Y-axis machining, Up to 100mm (+/- 50). 4-axes simultaneous machining, C-axis with 360 deg and Y-axis, Machine accuracies, Positional Accuracy +/- 0.005mm, Repeatability +/- 0.003mm. In 4-axis turning machine, Axis represents as work piece rotation and spindle movement in x, y, z directions.

## 6.6 MANUFACTURING PROCESS PLANNING

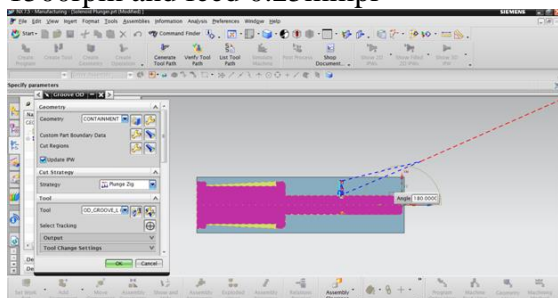
Below images shows raw material and blank



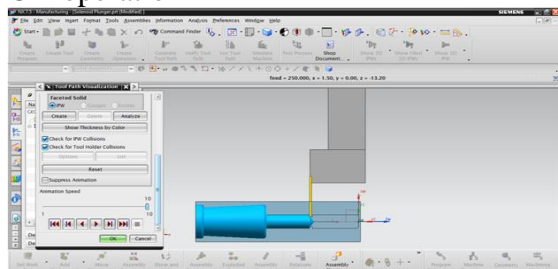
Below images shows verification of rough turn OD operation



Below images shows groove OD operation of solenoid plunger maintaining speed 1500rpm and feed 0.25mmpr

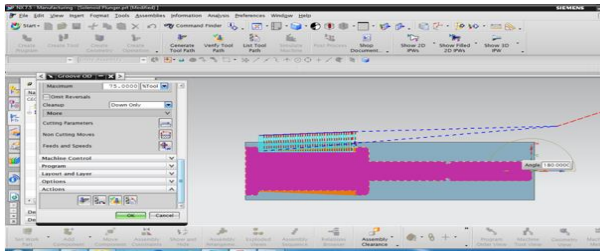


Below images shows verification of groove OD operation

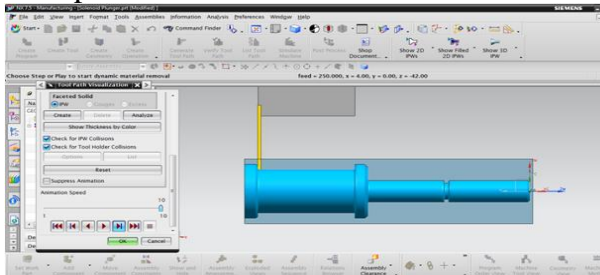


Below images shows groove OD operation of solenoid plunger maintaining speed 1500rpm and feed 0.25mmpr

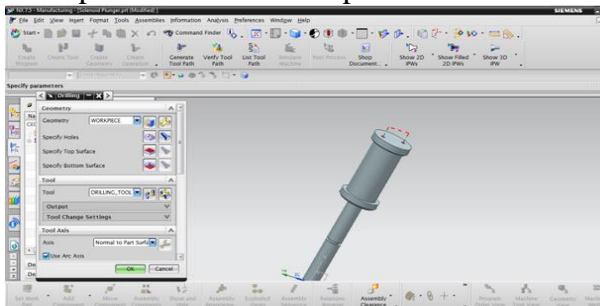




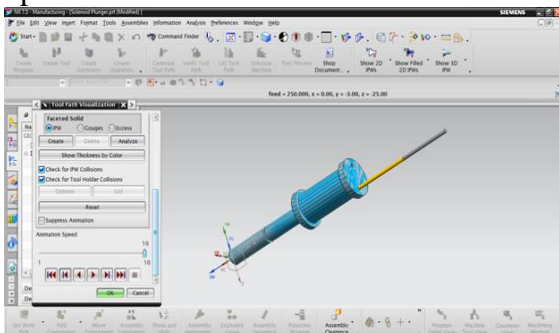
Below images shows verification of groove OD operation



Below images shows drilling operation of solenoid plunger maintaining speed 1500rpm and feed 250mmpm



Below images shows verification of drilling operation



Operation list by Program  
**PROGRAM NAME : PROGRAM**

OPERATION NAME	OPERATION DESCRIPTION	TOOL NAME
FACING	turning/FACING	OD_80_L
ROUGH_TURN_OD	turning/ROUGH_TURN_OD	OD_80_L_1
GROOVE_OD	turning/GROOVE_OD	OD_GROOVE_L
GROOVE_OD_1	turning/GROOVE_OD	OD_GROOVE_L
DRILLING	drill/DRILLING	DRILLING_TOOL

### Tooling Lists

TOOL NAME	DESCRIPTION	NOSE RAD	TOOL ORIENT	ADJ REG
OD_80_L	Turning Tool-Standard	0.2000	5.0025	0
OD_80_L_1	Turning Tool-Standard	0.2000	5.0025	0
OD_GROOVE_L	Grooving Tool-Standard	0.2000	90.0456	0

### DRILLING TOOLS

TOOL NAME	DESCRIPTION	DIAMETER	TIP ANG	FLUTE LEN	ADJ REG
DRILLING_TOOL	Drilling Tool	1.0000	118.0000	35.0000	0

### CONVERT TO NC CODE

Using the post processor we have to convert CL file data into machine specified NC part program

1. In the Project Manager, select the first operation on the Operations page, then hold down the Shift key and select the last operation. All the cutting operations are selected.
2. Press the right mouse button and select NC Code from the menu.
3. Select a Machine Format file from the pull down list (3-Axis/5-Axis).
4. Select Apply.

### RESULTS AND CONCLUSION

#### Results :

- In this project, solenoid plunger was analyzed and generated NC Program for manufacturing of solenoid plunger.

- 3D modeling of solenoid plunger is done by using unigraphics software
- Coupled field analysis of solenoid plunger done by ansys.

RESULTS	VALUE
Deformation (mm)	0.000125
Thermal stress (MPa)	6.96
Thermal flux (W/m <sup>2</sup> )	220.5

- NC program is generated using NX-CAM software.

Generated NC program is given to 4-axis moriseiki CNC machine and manufactured solenoid plunger.

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