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Development Of Manufacturing Process Plan For Booster Rocket

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ABSTRACT:

Boosters are generally necessary to launch spacecraft into Earth orbit or beyond. The booster is dropped to fall back to Earth once its fuel is expended, a point known as **booster engine cut-off** (BECO). The rest of the launch vehicle continues flight with its core or upper-stage engines. The booster may be recovered and reused, as in the case of the Space Shuttle.

Missile parts should be manufactured with high accurate dimensions. Due to its complicated structure, it requires fixture to stop vibrations while machining and to reduce number of setups as well as the production rate also increases by reducing machining time. Because of its complexity in manufacturing, there is a demand to design fixture which reduces the machine time and setups.

This project deals with the 3d modeling and fixture design for Booster rocket using NX-CAD software. This project also deals with development of manufacturing process plan of missile component (Booster Rocket used in missile) using CAM software (NX 7.5) which is exclusively CAM software used to generate part program by 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. The operator thus executes the program with suitable requirements.

Keywords :- CAD/CAM/CAE Software, Booster Engine Cut-Off, Unigraphics, Booster

INTRODUCTION

1.1 ABOUT THE COMPONENT:

Boosters are generally necessary to launch spacecraft into Earth orbit or beyond. The booster is dropped to fall back to Earth once its fuel is expended, a point known as booster engine cut-off (BECO). The rest of the launch vehicle continues flight with its core or upper-stage engines. The booster may be recovered and reused, as in the case of the Space Shuttle.

Solid rocket engines are used on air-to-air and air-to-ground missiles, on model rockets, and as boosters for satellite launchers. In a solid rocket, the fuel and oxidizer are mixed together into a solid propellant which is packed into a solid cylinder. A hole through the cylinder serves as a combustion chamber. When the mixture is ignited, combustion takes place on the surface of the propellant. A flame front is generated which burns into the mixture. The combustion produces great amounts of exhaust gas at high temperature and pressure. The amount of exhaust gas that is produced depends on the area of the flame front and engine designers use a variety of hole shapes to control the change in thrust for a particular engine. The hot exhaust gas is passed through a nozzle which accelerates the flow. Thrust is then produced according to Newton's third law of motion.

The amount of thrust produced by the rocket depends on the design of the nozzle. The smallest cross-sectional area of the nozzle is called the throat of the nozzle. The hot exhaust flow is choked at the throat, which means that the Mach number is equal to 1.0 in the throat and the mass flow rate m dot is determined by the throat area. The area ratio from the throat to the exit Ae sets the exit velocity Ve and the exit pressure pe. You can explore the design and operation of a rocket nozzle with our interactive nozzle simulator program which runs on your browser.

The exit pressure is only equal to free stream pressure at some design condition. We must, therefore, use the longer version of the generalized thrust equation to describe the thrust of the system.

Notice that there is no free stream mass times free stream velocity term in the thrust equation because no external air is brought on board. Since the oxidizer is mixed into the propellant, solid rockets can generate thrust in a vacuum where there is no other source of oxygen. That's why a rocket will work in space, where there is no surrounding air, and a gas turbine or propeller will not work. Turbine engines and propellers rely on the atmosphere to provide the oxygen for combustion and as the working fluid in the generation of thrust.

The thrust equation given above works for both liquid and solid rocket engines. There is also an efficiency parameter called the specific impulse which works for both types of rockets and greatly simplifies the performance analysis for rocket engines.

1.2 UNIGRAPHICS INTRODUCTION:

NX, formerly known as NX Unigraphics or usually just U-G, is an advanced high-end CAD/CAM/CAE software package originally developed Unigraphics, but since 2007 by Siemens PLM Software. NX is one of the world's most advanced and tightly integrated CAD/CAM/CAE product development solutions. Spanning the entire range of product development, NX delivers immense value to enterprises of all sizes. It simplifies complex product designs, thus speeding up the process of introducing products to the market.

It is used, among other tasks, for:

- Design (parametric and direct solid/surface modeling)
- Engineering analysis (static, dynamic, electro-magnetic, thermal, using the Finite Element Method, and fluid using the finite volume method).
- Manufacturing finished design by using included machining modules.

The NX software integrates knowledge-based principles, industrial design, geometric modeling, advanced analysis, graphic simulation, and concurrent engineering. The software has powerful hybrid modeling capabilities by integrating constraint-based feature modeling and explicit geometric modeling. In addition to modeling standard geometry parts, it allows the user to design complex free-form shapes such as airfoils and manifolds. It also merges solid and surface modeling techniques into one powerful tool set.

DESIGNING FIXTURE FOR BOOSTER ROCKET

Fixtures accurately locate and secure a part during machining operations such that the part can be manufactured to design specifications. To reduce the design costs associated with fixturing, various computer-aided fixture design methods have been developed through the years to assist the fixture designer.

Fixture layout design is a major concern in the development of automated fixture design systems. The task of fixture layout design is to layout a set of locating & clamping points on work piece surfaces such that the work piece is accurately located & completely restrained during manufacturing operations. Fixtures accurately locate and secure a part during machining operations such that the part can be manufactured to design specifications. To reduce the design costs associated with fixturing, various computer-aided fixture design (CAFD) methods have been developed through the years to assist the fixture designer.

Fixture Design Concepts: (Managing degree of freedom)

3:2:1 →(3 At least 3-Point to define a plane) (2 At least 2-Points to define location) (1 At least 1-point for clamping)

Fixture layout design has received considerable attention in the recent years. However, little attention has been focused on the optimization of manufacturing fixture layout under dynamic conditions of the work piece.

LITERATURE SURVEY

HAMEED FARHAN, 2013: Productivity is one of the most important factors in manufacturing processes because of the high level of market competition. In this regard, modular fixtures (MFs) play an important role in practically improving productivity in flexible manufacturing systems (FMSs) due to this technology using highly productive computer numerical control (CNC) machines. MFs consist of devices called jigs and fixtures for accurately holding the workpiece during different machining operations. The design process is complex, and traditional methods of MF design were not sufficiently productive.

Burley and Corbett, 1998: A *Jig* is defined as a manufacturing aid that either holds a part or is itself located on the part and is fitted with devices to guide a cutting tool ensuring the correct location of the machining path relative to the part

• A *Fixture* is defined as a manufacturing aid for holding and locating parts during machining or assembly operations, which do not provide definite guidance for the cutting tools

• *Tooling* is used as the generic name for jigs and fixtures and also the tools set from the master gauges for calibrating jigs and fixtures

• Hence, *Jigless Assembly* is assembly without the use of jigs; it requires that parts are manufactured to sufficient accuracy to ensure correct assembly; it is not necessarily fixtureless [or toolless] assembly.

Iain Boyle: Various approaches have been adopted to develop tools that assist the designer, regardless of the actual artefact being designed. This chapter presents a review and critique of various tools and methodologies that have been used to aid design. Initially, various types of CAFD systems and techniques are reviewed, followed by a discussion of more general design theories. Specifically, case-based reasoning, axiomatic design, and decision-based design using utility analysis techniques are described and critiqued.

Shrikant V.Peshatwar : The fixture is a special tool for holding a work piece in proper position during machining operation. It is provided with device for supporting and clamping the work piece. Fixture eliminates frequent checking, positioning, individual marking, vacillate uniform quality in manufacture. This increase productivity and reduce operation time. Fixture is widely used in the industry practical production because of feature and advantages.

Pollack, 1976 :-

A *Fixture* is a workpiece locating and holding device used with machine tools, inspection, welding and assembly; it does not control the position of the tool or instrument which is being used

• Elements of the Jig or Fixture must also be present which *Support* the work and elements, called locators, which *Position* the work

• Once located and positioned, the work is *Clamped* so that it will not move off the supports or locators.

J. C. Trappey and C. R. Liu:-

Fixture design can be classified as a part of process planning. The taskwise description of process planning specifically states that "'fixture design for each workpiece set-up" is an integral planning task. However, the automation of fixture design has been overlooked in most research into automated process planning.

1. Fixture configuration - determining the types of fixture elements required, and selecting locating points on the selected elements according to the specified process information.
2. Fixture assembly - constructing and assembling modular fixture components. The orientation of each component on the baseplate is determined according to the workpiece set-up. Consequently, the assembly sequence of the fixture components is planned for automatic assembly by robot hand.
3. Fixture verification - proving the validity of the fixture configuration with consideration of some operating factors, such as the cutting directions, the acting forces and the machining sequence.

N. P. Maniar, D. P. Vakharia :-

Fixturing contributes significantly to overall manufacturing cost, it is sometimes neglected for the reason of cost reduction. The design and manufacture of fixtures can be time consuming, and it increases the manufacturing cycle time of any product that needs machining and/or assembly. The main reason is that fixtures are designed to tight tolerances, typically 30-50% of the overallworkpiece tolerance.

MANUFACTURING OF BOOSTER ROCKET

4.1 COMPUTER AIDED MANUFACTURING

Computer-aided manufacturing (CAM) is the use of computer software to control machine tools and related machinery in the manufacturing of work pieces. This is not the only definition for CAM, but it is the most common; CAM may also refer to the use of a computer to assist in all operations of a manufacturing plant, including planning, management, transportation and storage. Its primary purpose is to create a faster production process and components and tooling with more precise dimensions and material consistency, which in some cases, uses only the required amount of raw material (thus minimizing waste), while simultaneously reducing energy consumption.

CAM is a subsequent computer-aided process after computer-aided design (CAD) and sometimes computer-aided engineering (CAE), as the model generated in CAD and verified in CAE can be input into CAM software, which then controls the machine tool.

Historically, CAM software was seen to have several shortcomings that necessitated an overly high level of involvement by skilled CNC machinists.. CAM software would output code for the least capable machine, as each machine tool control added on to the standard G-code set for increased flexibility. In some cases, such as improperly set up CAM software or specific tools, the CNC machine required manual editing before the program will run properly. None of these issues were so insurmountable that a thoughtful engineer or skilled machine operator could not overcome for prototyping or small production runs; G-Code is a simple language. In high production or high precision shops, a different set of problems were encountered where an experienced CNC machinist must both hand-code programs and run CAM software.

CAM ON BOOSTER CASING

Maintaining stable speed booster casing component is manufactured on CNC machine. The main objective of the project

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is to generate tool path for both geometry and fixture.

Methodology used in manufacturing of booster casing is as mentioned below:

- Identifying suitable machine.
- Selecting suitable tools for manufacturing thin walled component.
- Designing fixture/mandrel to booster casing component for external operations.
- Listing down the Sequence of operations performed on booster casing component.
- Generating tool path at specified cutting speed.
- Generating NC program using NX-CAM software.

4.2 IDENTIFY SUITABLE MACHINE:

TYPE OF CNC MACHINE USED IN THIS PROJECT:

For this Project both 5 Axis Milling & 4 Axis Turning Machine are used for generating Booster Casing.

DMG 5-axis milling machine is used for manufacturing rock drill component. In DMG 5-axis milling machine X, Y, Z, B, C are 5 vectors, X & Y are tool movement and Z is for table upwards movement, B for spindle movement, C for table rotation.

High rigidity with Integrated Spindle up to 12000rpm, Spindle is directly coupled with motor. Vertical Operations, Integrated rotary table of 1200mm X 700mm with rotary dia 700mm. Horizontal Operations, With head tilting at 90deg.Angular and 5-axes simultaneous machining, Capable of machining from +30 deg to -120deg head tilting. Machine accuracies, Positional Accuracy +/- 0.005mm, Repeatability +/- 0.003mm

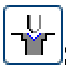
Fig. DMG 5-axis machine

- MORI SEIKI 4-AXIS CNC turning machine is used for machining missile shield. DMG 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.

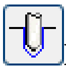
Fig: 4.2.1 4-axis CNC MORI SIEKI turning machine

4.3 SELECTING SUITABLE TOOLS FOR MANUFACTURING BOOSTER CASING COMPONENT:

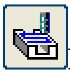
Selection of tools plays an important role in manufacturing any component. Proper tools must be selected otherwise in manufacturing process improper tools results in damage of work piece or damage to the tools, tool holders. Suitable tools for manufacturing rock drill are listed below

**SPOT_DRILLING**

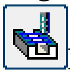
This operation subtype allows the tool to pause at the tool tip or shoulder depth of the tool by a specified number of seconds or revolutions.

**DRILLING**

This operation subtype allows you to do basic point-to-point drilling

**FACE_MILLING**

FACE_MILLING is the main Face Milling operation subtype. A milling cutter that cuts metal with its face. Face milling creates large flat surfaces.

**FACE_MILLING_AREA**

Face Milling Area is a Face Milling operation subtype that is customized to recognize a cut area and wall selection.

END MILL

A milling cutter that performs a mix of peripheral and face milling. End milling engages the bottom and edges of the milling cutter. An end mill is a type of milling cutter, a cutting tool used in industrial milling applications. It is distinguished from the drill bit in its application, geometry, and manufacture. While a drill bit can only cut in the axial direction, a milling bit can generally cut in all directions, though some cannot cut axially

ROUGHING END MILL

Roughing end mills quickly remove large amounts of material. This kind of end mill utilizes a wavy tooth form cut on the periphery. These wavy teeth form many successive cutting edges producing many small chips, resulting in a relatively rough surface finish. During cutting, multiple teeth are in contact with the work piece reducing chatter and vibration.

DRILL BITS

Drill bits are cutting tools used to create cylindrical holes, almost always of circular cross-section. Bits are held in a tool called a drill, which rotates them and provides torque and axial force to create the hole. Specialized bits are also available for non-cylindrical-shaped holes.

4.4 Selection of tools for turning operation: 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. Suitable tools for manufacturing missile shield are listed below

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,

OD_80_L rough

This process, also called rough or cutoff, is used to create deep grooves which will

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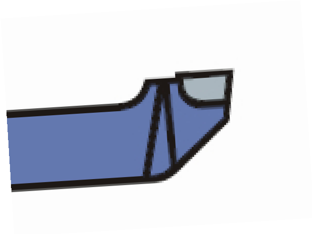
remove a completed or part-complete component from its parent stock.

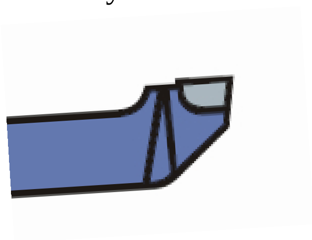
OD_55_L finish

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.

4.6 SEQUENCE OF OPERATIONS PERFORMED ON BOOSTER CASING COMPONENT

Sequence of operations performed on Booster Casing in NX-CAM software are listed below

In this operation both turning and milling operations will be done

Operations required for turning operation

- Facing operation
- Rough Turn OD operation
- Groove OD operation

Operations required for milling operation

- Face mill area operation
- Planar mill operation for step 1
- Planar mill operation for step 2
- Planar mill operation on top surface of casing.
- Variable Contour operation on top surface of casing.
- Z- Level Profile operation.
- Drilling operation for generating holes.
- Contour Area operation on top face of the casing.

4.7 CAM OPERATION IN NX-CAM

Basic cam setup

- In NX the NC machining environment is referred to as the setup.
- The set up for the machining jobs should be decided by looking at all the environmental information from four viewpoints: Program, Method, Geometry, and Tool.
- These four viewpoints were designed to mimic the thought process that can be used when planning the NC program.
- Each viewpoint organizes the information for the operation in a manner relevant to that particular viewpoint.
- For example there are some standard setups available in NX-CAM are given below
  - Below image shows operation navigator in CAM

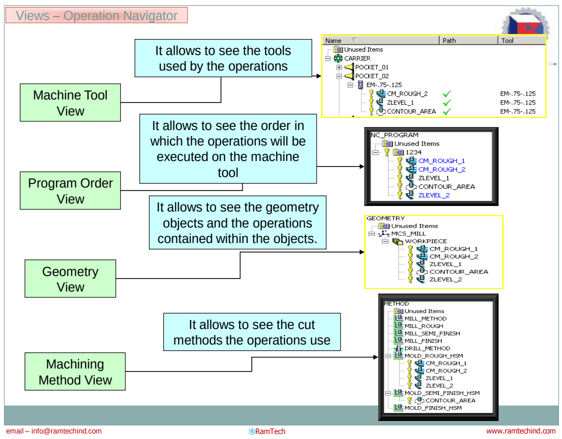


Fig. operation navigator

4.8 TOOL PATH GENERATION ON BOOSTER CASING

The series of movements made by the tip of a cutting tool. X and Z codes indicate a tool path within a part program. The path through space that the tip of a cutting tool follows on its way to producing the desired geometry of the work piece.

Booster casing material Aluminium alloys are alloys in which aluminum (Al) is the predominant metal. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

Alloys composed mostly of aluminum have been very important in aerospace manufacturing since the introduction of metal skinned aircraft. Aluminium-magnesium alloys are both lighter than other aluminium alloys and much less flammable than alloys that contain a very high percentage of magnesium.

Below image shows the Blank of Booster casing

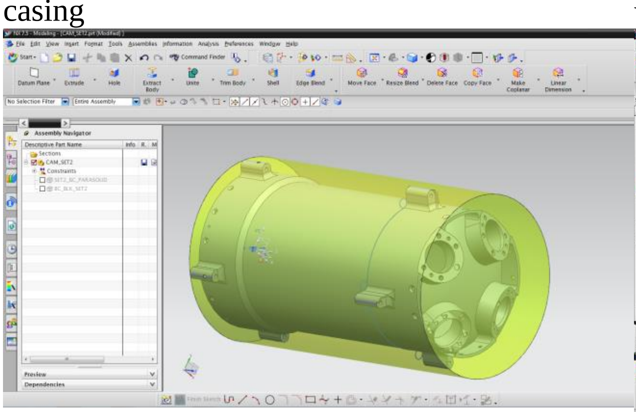


Fig.4.8.1. Blank of Booster Casing

Booster Casing raw material specifications are dia Ø189.9, length 318mm.

Create tools

Below image shows the selection of tools

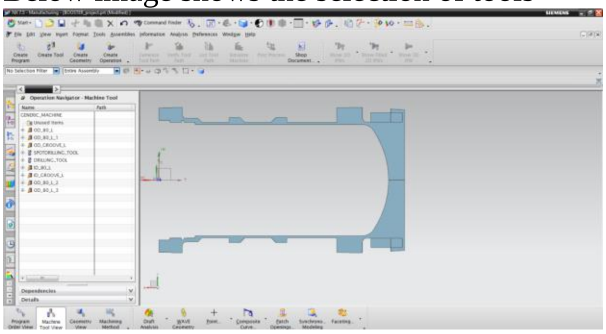


Fig.4.8.2. selection of tools

Create operations

Below image shows the creation of operations

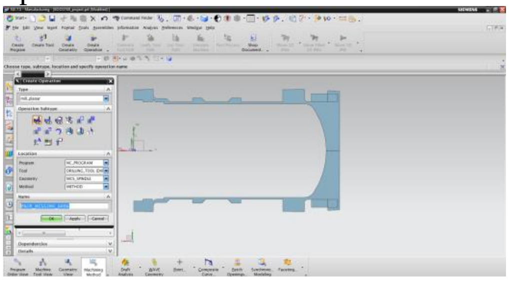


Fig.4.8.3. selection of operations

GENERATING TOOL PATH ON MISSILE SHIELD

The series of movements made by the tip of a cutting tool. X and Z codes indicate a tool path within a part program. The path through space that the tip of a cutting tool follows on its way to producing the desired geometry of the workpiece.

Set_up_1 tool path generation in turning operation

Below image shows facing operation and verification

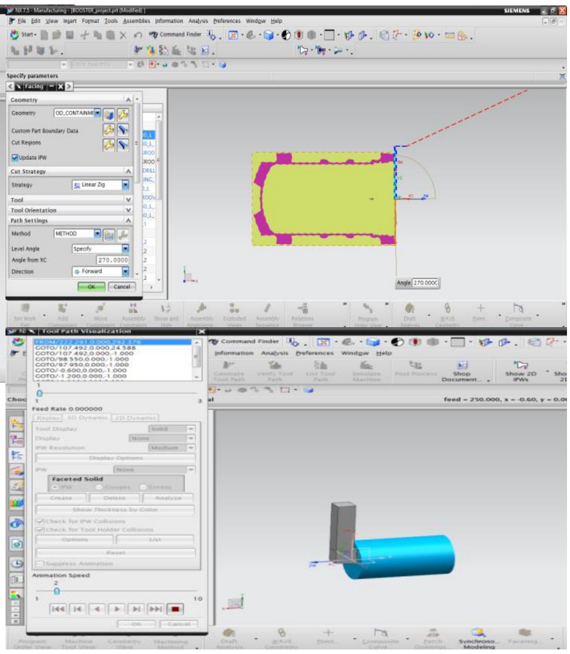


Fig. 4.8.4. facing operation and verification

Below image shows ROUGH_TURN_OD operation & verification

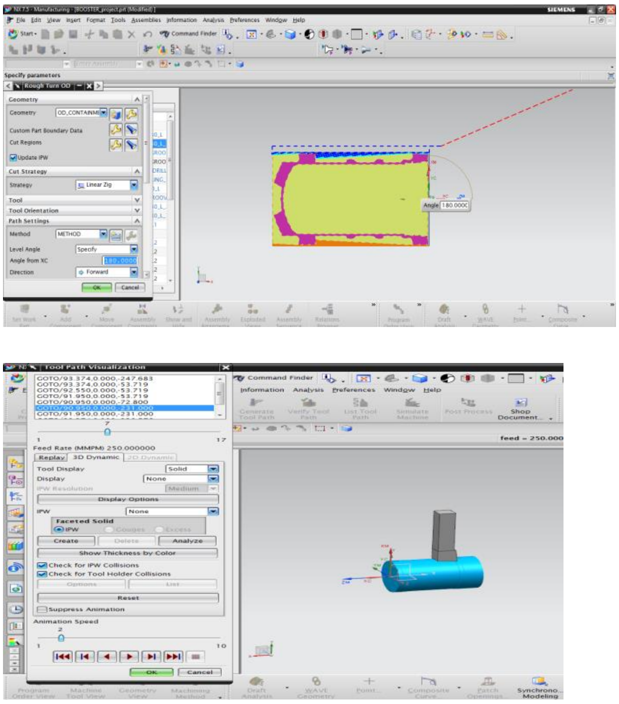


Fig. 4.8.5. ROUGH_TURN_OD operation & verification

Below image shows GROOVE_OD operation & verification

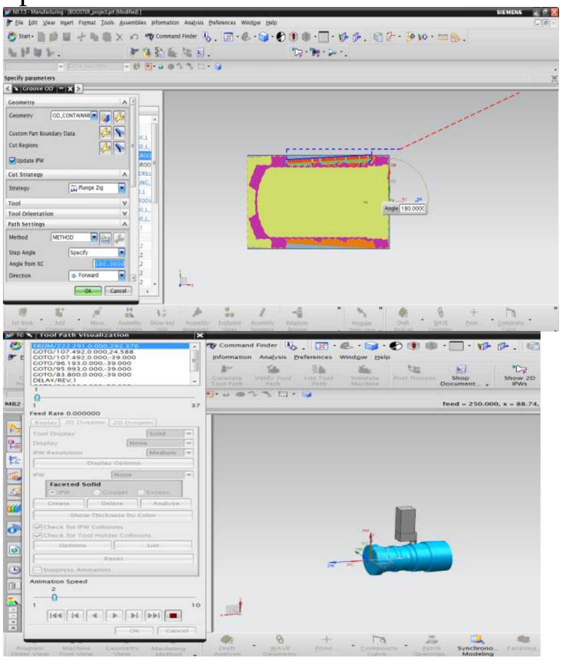


Fig. 4.8.6. GROOVE_OD operation & verification

Below image shows GROOVE_OD_1 operation & verification.

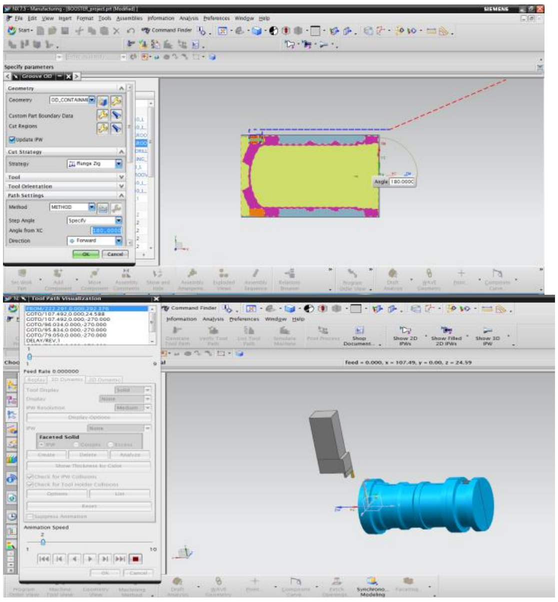


Fig. 4.8.7. GROOVE_OD_1 operation & verification

Below image shows CENTERLINE_SPOTDRILL operation & verification

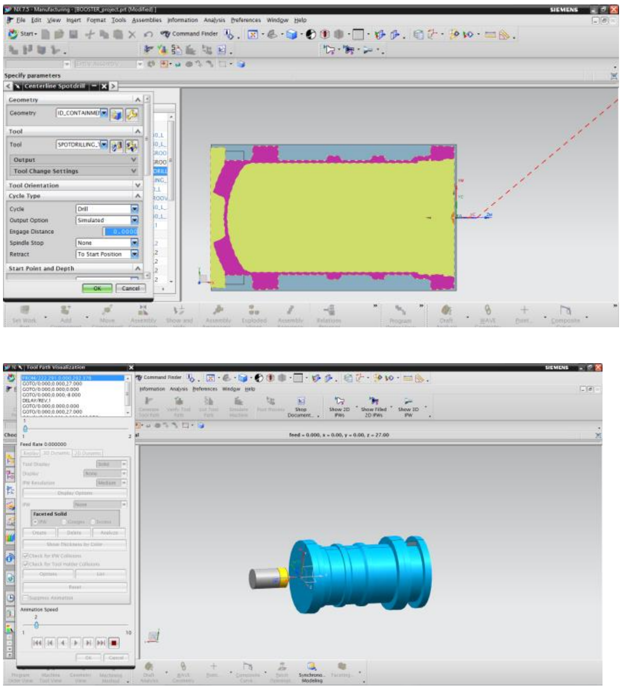


Fig. 4.8.8. CENTERLINE_SPOTDRILL operation & verification

Below image shows CENTERLINE_DRILLING operation

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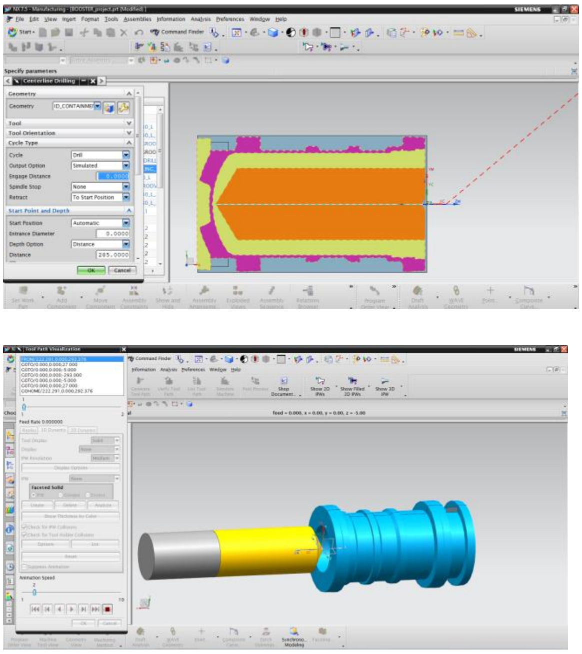

Fig. 4.8.9. CENTERLINE_DRILLING operation

Below image shows ROUGH_BORE_ID operation

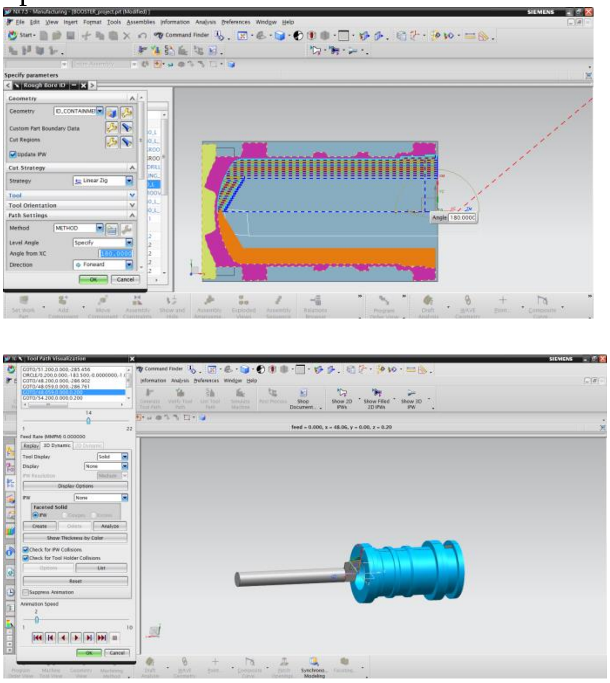

Fig. 4.8.10. ROUGH_BORE_ID operation

Below image shows GROOVE_ID operation

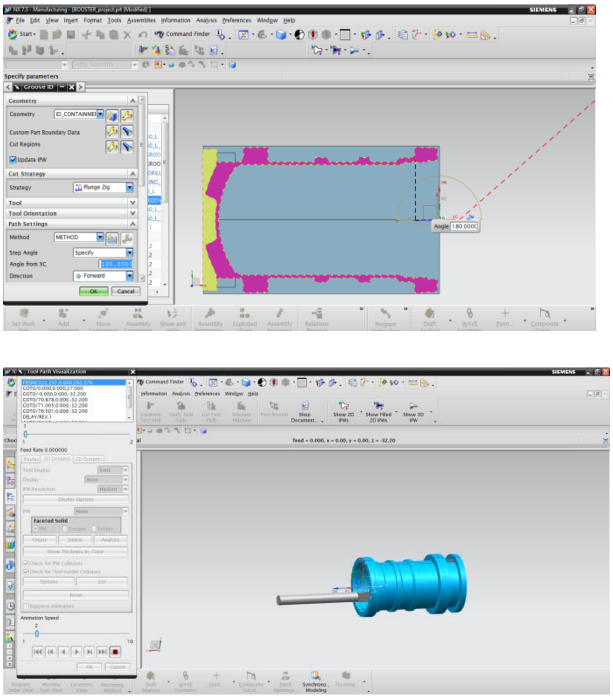

Fig. 4.8.11. GROOVE_ID operation

Setup_2 operations

Below image shows FACING_1operation

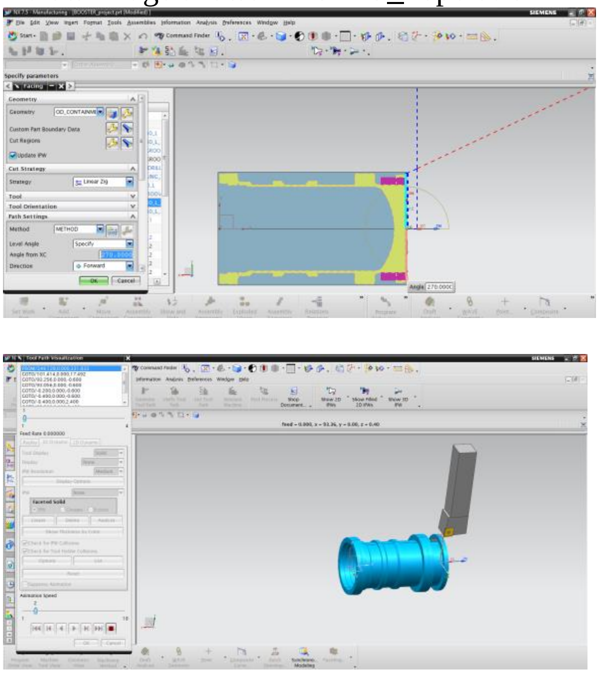

Fig. 4.8.12. FACING_1 operation

Below image shows ROUGH_TURN_OD_1 operation

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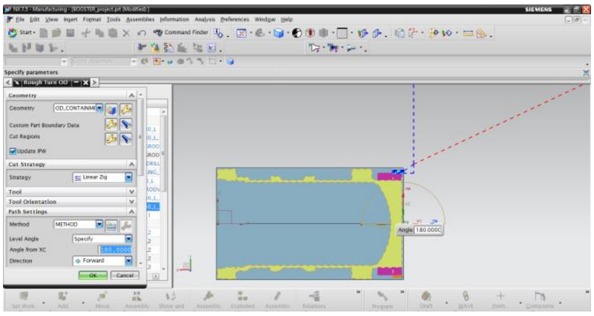


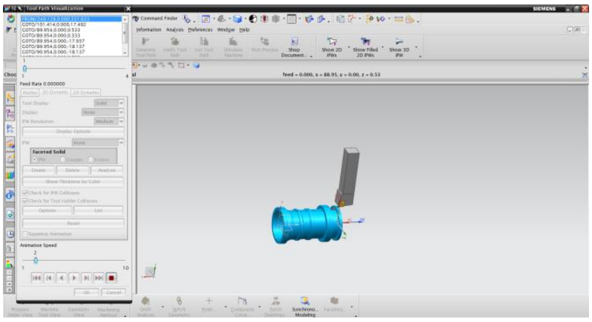


Fig. 4.8.13. ROUGH_TURN_OD_1 operation

Milling operations on semi finished booster rocket

Raw material for milling operations

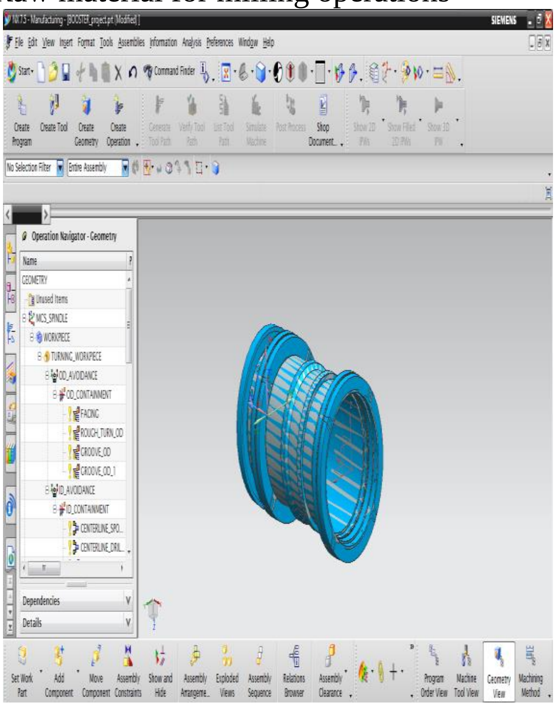
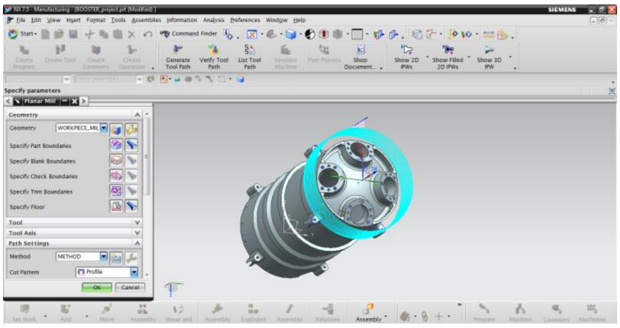


Fig: semi finished part Below image shows planar mill operation and verification



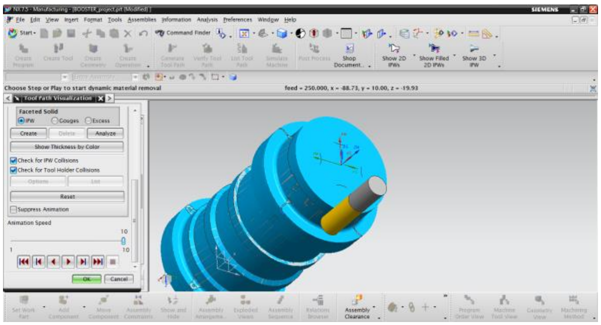
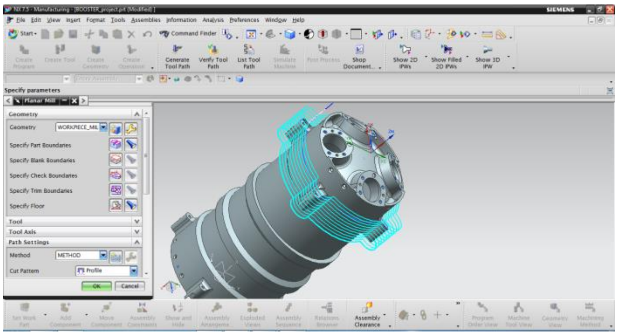


Fig.planar mill operation and verification

Below image shows planar mill at fins operation and verification



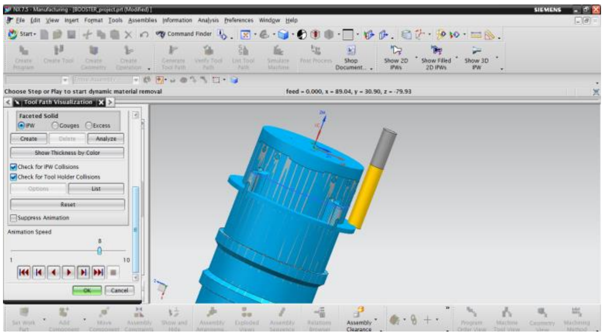


Fig.planar mill operation at fins and verification

Below image shows planar mill at fins operation and verification

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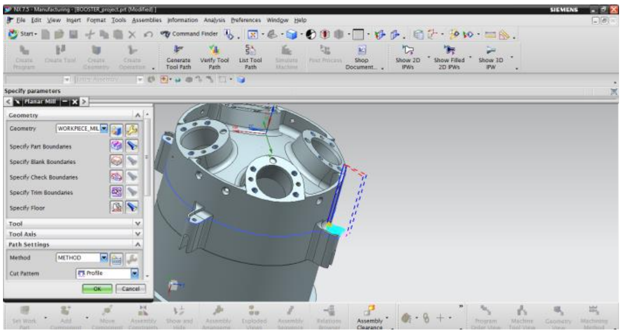


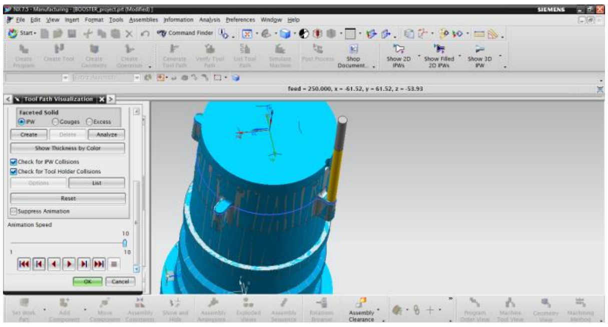
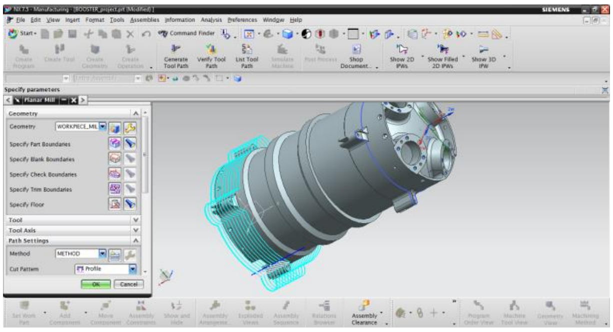


Fig.planar mill operation at fins and verification

Below image shows planar mill operation at fins and verification



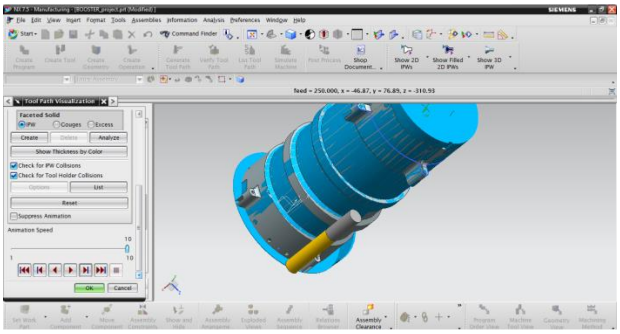
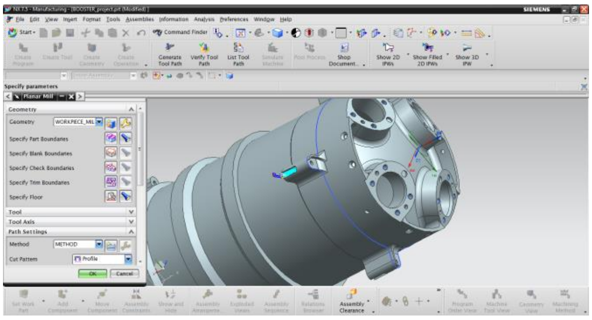


Fig.planar mill operation at fins and verification

Below image shows planar mill operation at fins and verification



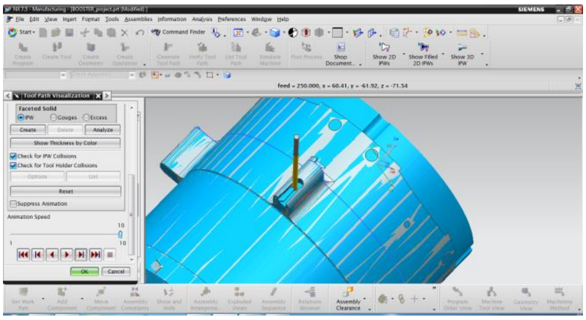
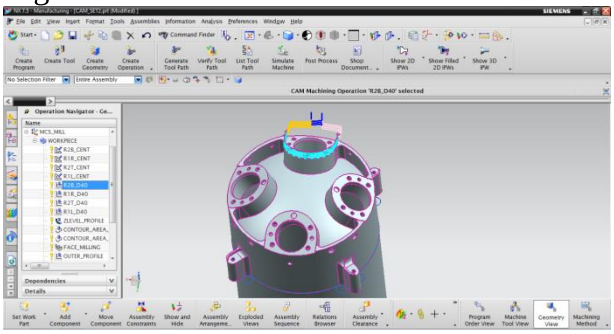


Fig.planar mill operation at fins and verification

Below image shows planar mill operation at angled holes and verification



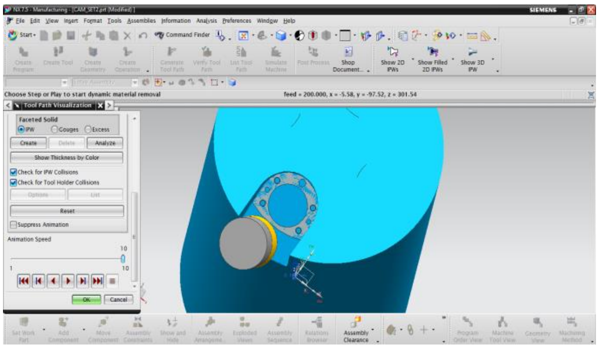
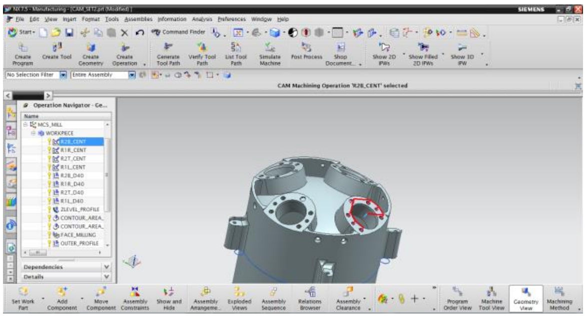


Fig.planar mill operation at angled holes and verification

Below image shows spot drilling operation at angled holes and verification



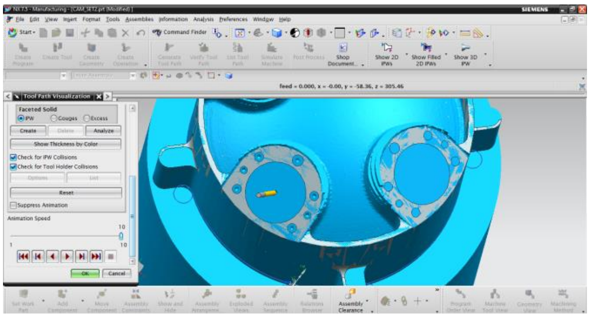
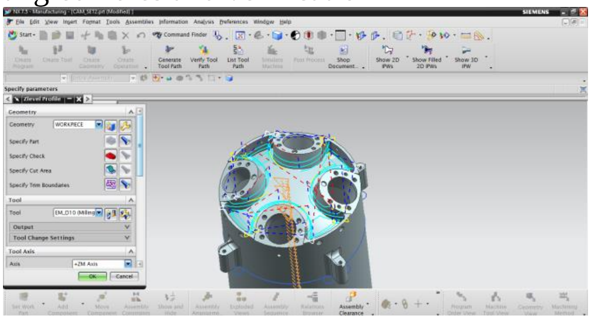


Fig. spot drilling operation at angled holes and verification

Below image shows milling operation at angled holes and verification



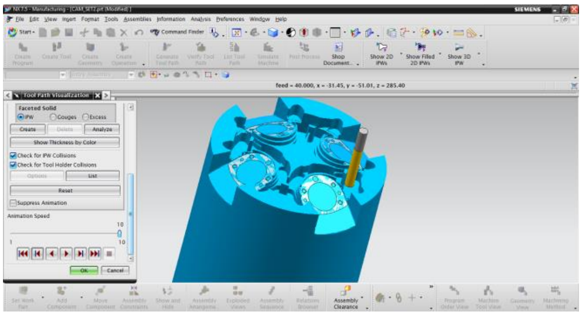
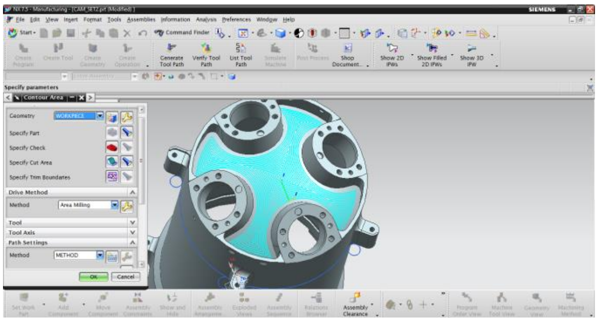


Fig. milling operation at angled holes and verification

Below image shows milling operation at angled holes and verification



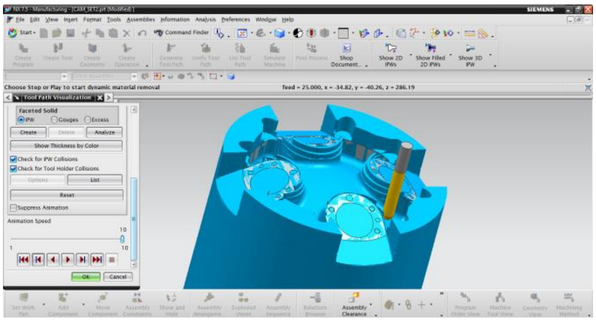
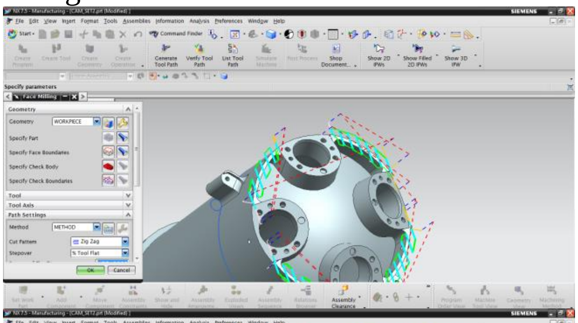


Fig. milling operation at angled holes and verification

Below image shows face milling operation at angled holes and verification



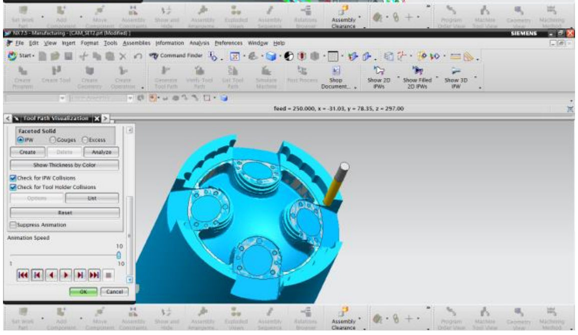


Fig. face milling operation at angled holes and verification

Below image shows planar milling operation and verification

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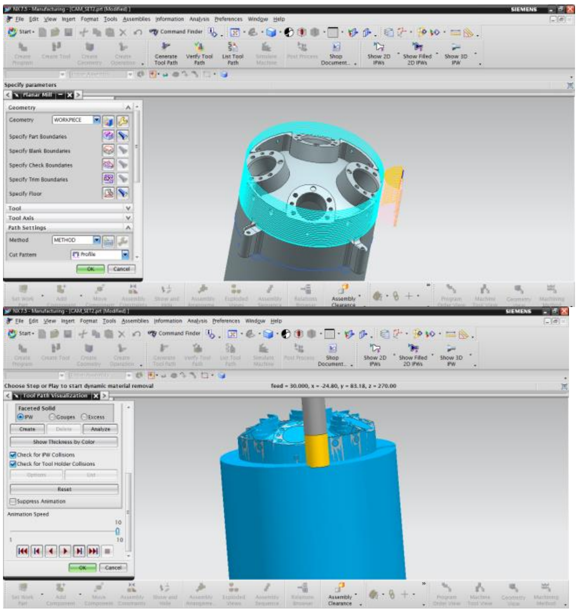


Fig. planar milling operation and verification

Below image shows drilling operation and verification

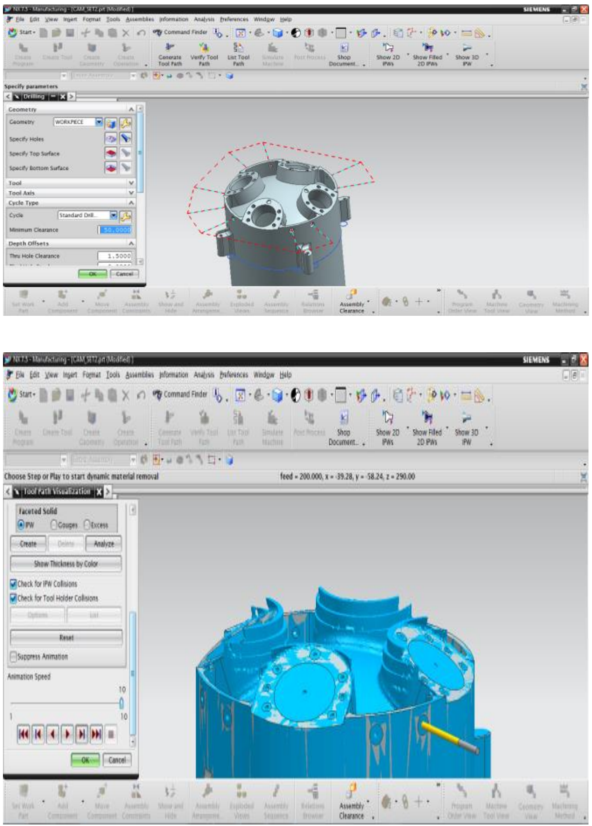
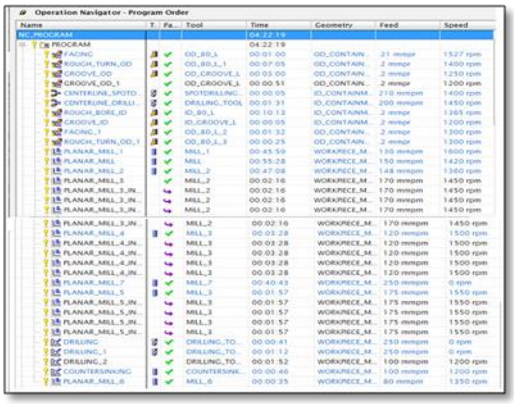


Fig. drilling operation and verification



Operation Navigator - Program Order

Name	T.	Fa...	Tool	Time	Geometry	Feed	Speed
NC_PROGRAM				04:22:19			
PROGRAM				04:22:19			
FACING			OD_80_L	00:01:00	OD_CONTAIN...	.21 mmpr	1527 rpm
ROUGH_TURN_OD			OD_80_L_1	00:07:05	OD_CONTAIN...	.2 mmpr	1400 rpm
GROOVE_OD			OD_GROOVE_L	00:03:00	OD_CONTAIN...	.2 mmpr	1250 rpm
GROOVE_OD_1			OD_GROOVE_L	00:00:51	OD_CONTAIN...	.2 mmpr	1200 rpm
CENTERLINE_SPOTD...			SPOTDRILLING...	00:00:05	ID_CONTAINM...	210 mmpm	1400 rpm
CENTERLINE_DRILLI...			DRILLING_TOOL	00:01:31	ID_CONTAINM...	200 mmpm	1450 rpm
ROUGH_BORE_ID			ID_80_L	00:10:13	ID_CONTAINM...	.2 mmpr	1365 rpm
GROOVE_ID			ID_GROOVE_L	00:00:05	ID_CONTAINM...	.2 mmpr	1200 rpm
FACING_1			OD_80_L_2	00:01:32	OD_CONTAIN...	.2 mmpr	1300 rpm
ROUGH_TURN_OD_1			OD_80_L_3	00:00:25	OD_CONTAIN...	.2 mmpr	1300 rpm
PLANAR_MILL_1			MILL_1	00:45:59	WORKPIECE_M...	130 mmpm	1600 rpm
PLANAR_MILL			MILL	00:55:28	WORKPIECE_M...	150 mmpm	1420 rpm
PLANAR_MILL_2			MILL_2	00:47:08	WORKPIECE_M...	148 mmpm	1360 rpm
PLANAR_MILL_3			MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_3_IN...			MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_3_IN...			MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_3_IN...			MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_3_IN...			MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_4			MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_4_IN...			MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_4_IN...			MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_4_IN...			MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_4_IN...			MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_7			MILL_7	00:40:43	WORKPIECE_M...	250 mmpm	0 rpm
PLANAR_MILL_5			MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
PLANAR_MILL_5_IN...			MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
PLANAR_MILL_5_IN...			MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
PLANAR_MILL_5_IN...			MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
PLANAR_MILL_5_IN...			MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
DRILLING			DRILLING_TO...	00:00:41	WORKPIECE_M...	250 mmpm	0 rpm
DRILLING_1			DRILLING_TO...	00:01:12	WORKPIECE_M...	250 mmpm	0 rpm
DRILLING_2			DRILLING_TO...	00:01:52	WORKPIECE_M...	100 mmpm	1200 rpm
COUNTERSINKING			COUNTERSINK...	00:00:46	WORKPIECE_M...	100 mmpm	1200 rpm
PLANAR_MILL_6			MILL_6	00:00:35	WORKPIECE_M...	80 mmpm	1350 rpm

Booster rocket component is rejected due to improper holding of component at high cutting speeds and error in dimensional accuracy. Most of the inspected Components are rejected at angled holes. For drilling angle holes the component must be fixed rigidly and to get high surface finish high cutting speeds are recommended. To allow high cutting speeds component should be fixed rigidly with internal support. To overcome rejection rate due to dimensional error at angular holes fixture should be designed according to the component required.

4.5 Fixture used for manufacturing Booster Casing

3D model is designed by using NX cad software.

Sketching:

Below is the sketch required to obtain the 3D model of the Fixture from the above 2D drawing.

Below image shows the **SKETCH** of the Fixture.

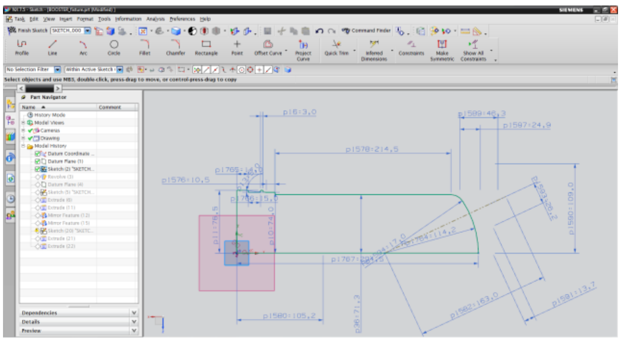


Fig.4.5.1. sketch option

Below image shows the **revolve** of the Fixture.

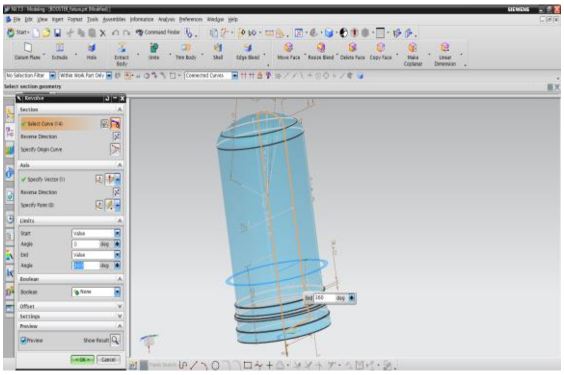


Fig. 4.5.2. Revolve option

Below image shows the **SKETCH** of the Fixture.

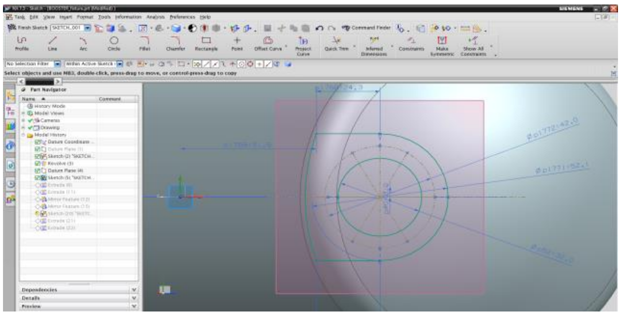


Fig.4.5.3. sketch option for generating holes

Below image shows **extrude** of the hole.

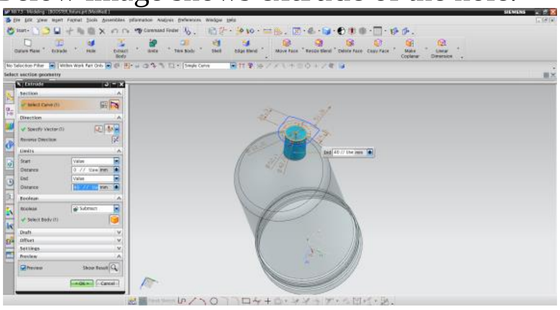


Fig.4.5.4.Extrude option for generating holes

Below image shows Instant Feature of the holes.

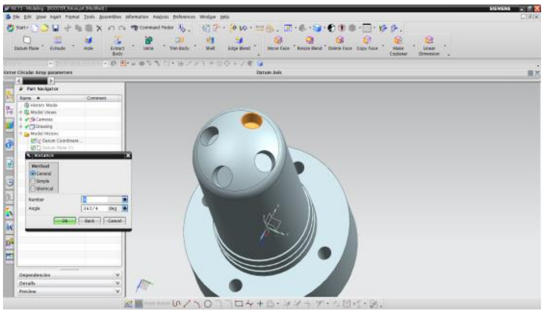


Fig.4.5.5.Instant Feature option for patterning holes

Below image shows the **SKETCH** of the Fixture base.

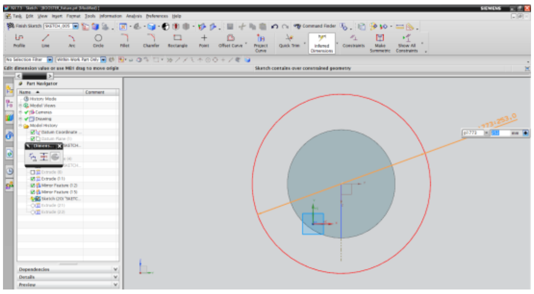


Fig.4.5.6.Sketch option for Fixture base

Below image shows **extrude** of the Fixture base.

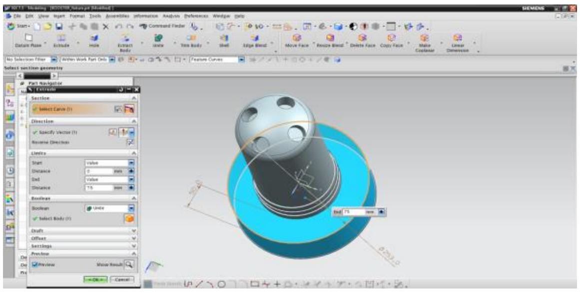


Fig.4.5.6.Extrude option for Fixture base

Below image shows Final 3d model of the Fixture used for Booster Casing.

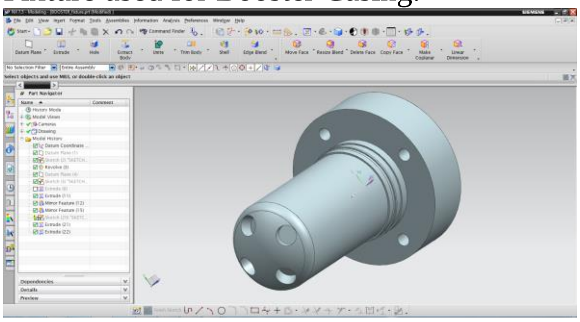
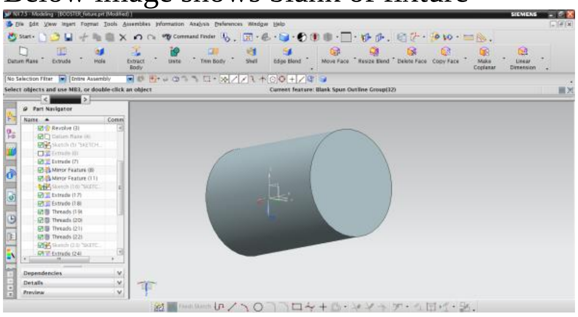


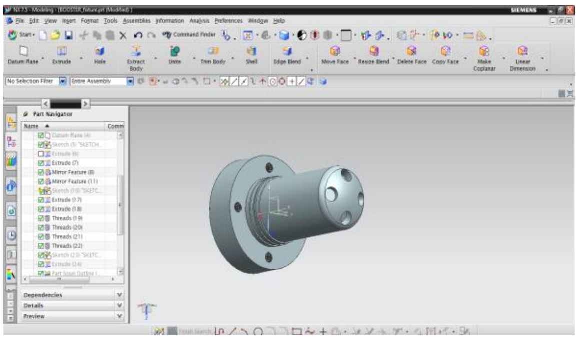
Fig.4.5.7.shows the final design for Fixture

TOOL PATH GENERATION OF FIXTURE

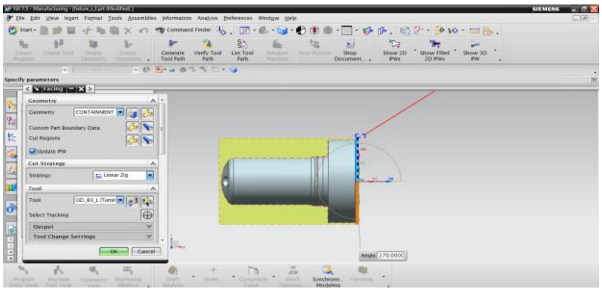
Below image shows blank of fixture



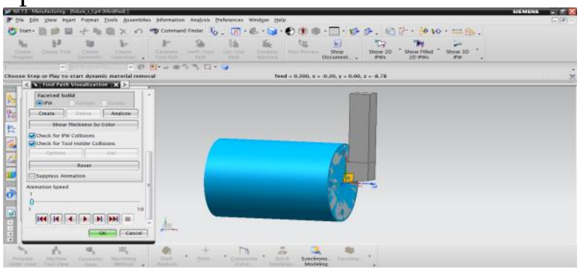
Below image shows part of fixture



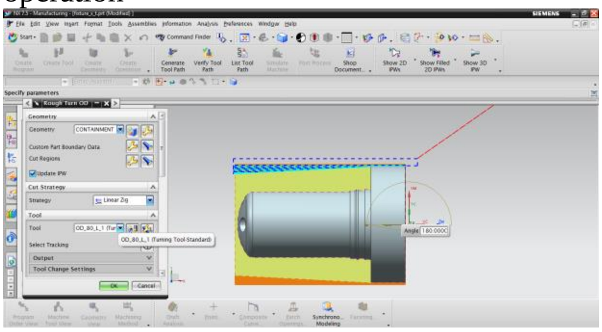
Below image shows facing operation



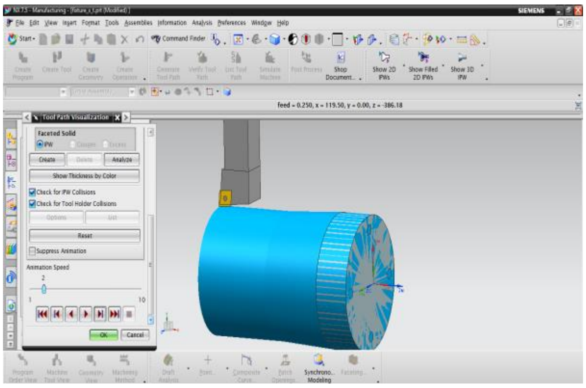
Below image shows verification of facing operation



Below image shows Rough turn OD operation

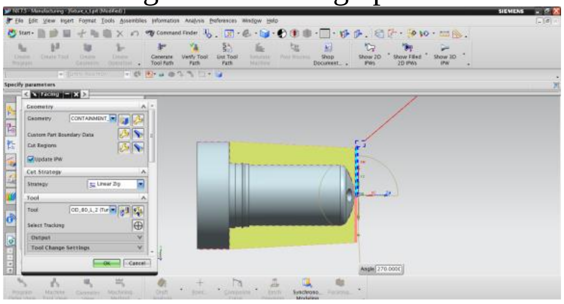


Below image shows verification of Rough turn OD operation

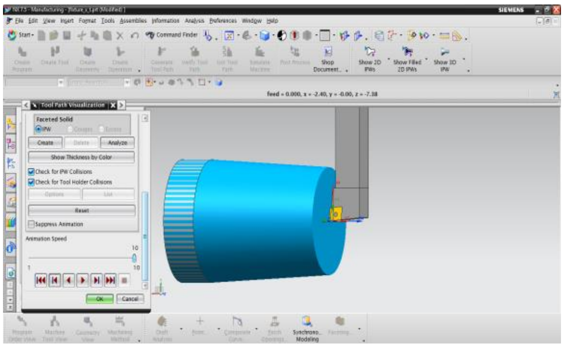


Setup2

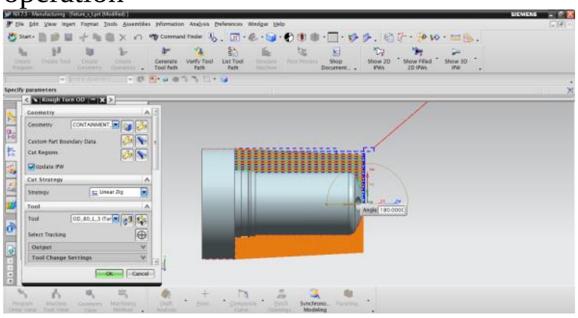
Below image shows facing operation



Below image shows verification of facing operation



Below image shows Rough turn OD operation



Below image shows verification of Rough turn OD operation

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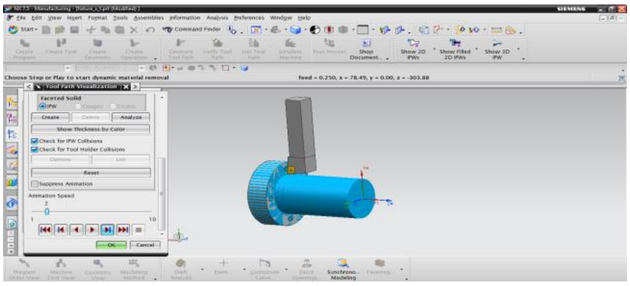
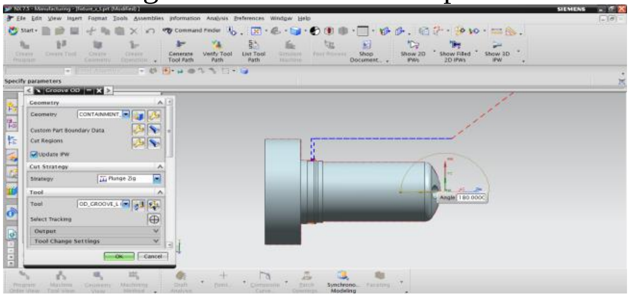
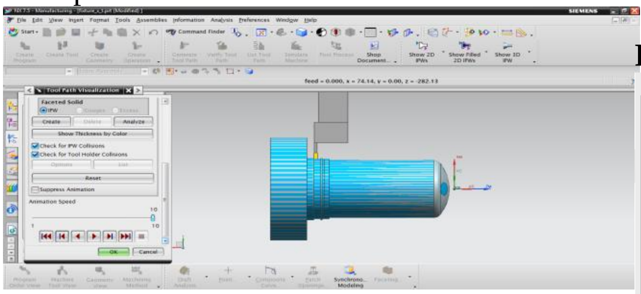


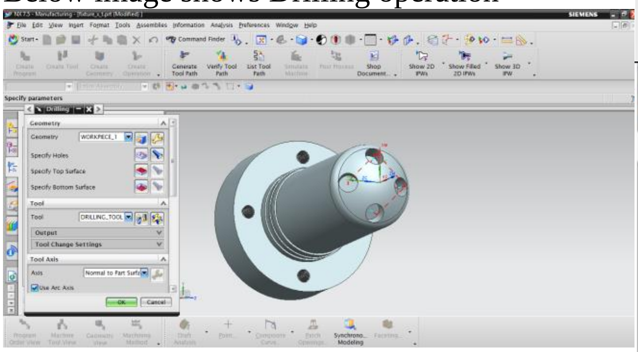
Below image shows Groove OD operation



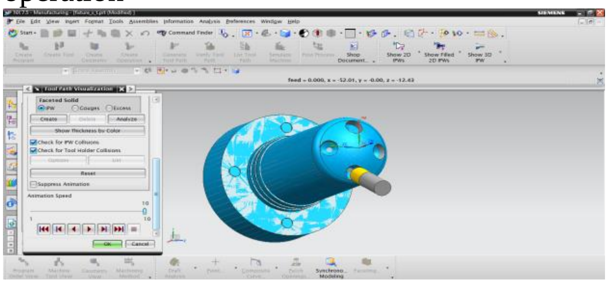
Below image shows verification of Groove OD operation



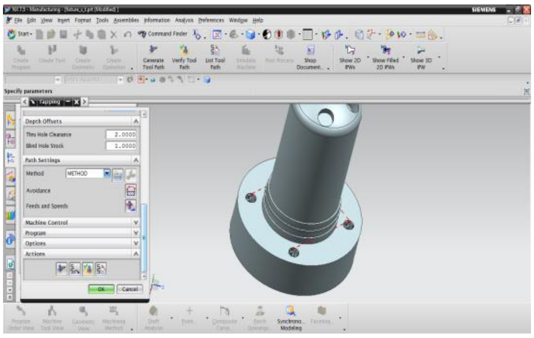
Below image shows Drilling operation



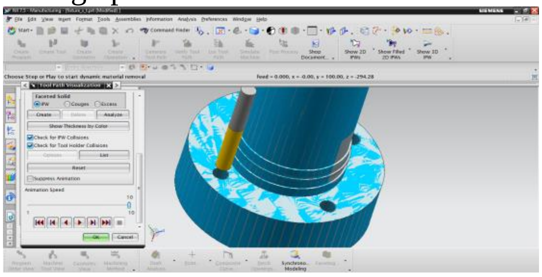
Below image shows verification of drilling operation



Below image shows Tap Drilling operation



Below image shows verification of Tap Drilling operation



Process plan of fixture

Operation Navigator - Program Order

Name	T...	P...	Tool	Tool Description	Time	Feed	Speed
NC_PROGRAM					00:16:49		
PROGRAM					00:05:36		
FACING		✓	OD_80_L	Turning Tool-Stand...	00:01:31	.2 mmpr	1900 rpm
ROUGH_TURN_OD		✓	OD_80_L_1	Turning Tool-Stand...	00:03:41	.25 mmpr	1850 rpm
Unused Items					00:00:00		
PROGRAM_SETUP2					00:11:13		
FACING_1		✓	OD_80_L_2	Turning Tool-Stand...	00:01:00	.2 mmpr	1900 rpm
ROUGH_TURN_OD_1		✓	OD_80_L_3	Turning Tool-Stand...	00:06:52	.25 mmpr	1800 rpm
GROOVE_OD		✓	OD_GROOVE_L	Grooving Tool-Sta...	00:00:16	.2 mmpr	1500 rpm
DRILLING		✓	DRILLING_TOOL	Drilling Tool	00:00:34	250 mmpm	1520 rpm
TAPPING		✓	TAP	Drilling Tool	00:01:31	250 mmpm	1520 rpm

Operation Navigator - Program Order

Name	T.	Pa...	Tool	Time	Geometry	Feed	Speed
NC_PROGRAM				02:56:02			
PROGRAM				02:56:02			
FACING		✓	OD_80_L	00:01:00	OD_CONTAIN...	.21 mmpr	1527 rpm
ROUGH_TURN_OD		✓	OD_80_L_1	00:07:05	OD_CONTAIN...	.2 mmpr	1400 rpm
GROOVE_OD		✓	OD_GROOVE_L	00:03:00	OD_CONTAIN...	.2 mmpr	1250 rpm
GROOVE_OD_1		✓	OD_GROOVE_L	00:00:51	OD_CONTAIN...	.2 mmpr	1200 rpm
CENTERLINE_SPOTD...		✓	SPOTDRILLING...	00:00:05	ID_CONTAINM...	210 mmpm	1400 rpm
CENTERLINE_DRILLI...		✓	DRILLING_TOOL	00:01:31	ID_CONTAINM...	200 mmpm	1450 rpm
ROUGH_BORE_ID		✓	ID_80_L	00:10:13	ID_CONTAINM...	.2 mmpr	1365 rpm
GROOVE_ID		✓	ID_GROOVE_L	00:00:05	ID_CONTAINM...	.2 mmpr	1200 rpm
FACING_1		✓	OD_80_L_2	00:01:32	OD_CONTAIN...	.2 mmpr	1300 rpm
ROUGH_TURN_OD_1		✓	OD_80_L_3	00:00:25	OD_CONTAIN...	.2 mmpr	1300 rpm
PLANAR_MILL_1		✓	MILL_1	00:22:20	WORKPIECE_M...	268 mmpm	1750 rpm
PLANAR_MILL		✓	MILL	00:25:17	WORKPIECE_M...	275 mmpm	1746 rpm
PLANAR_MILL_2		✓	MILL_2	00:23:21	WORKPIECE_M...	245 mmpm	1850 rpm
PLANAR_MILL_3		✓	MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_3_IN...			MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_3_IN...			MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_3_IN...			MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_3_IN...			MILL_2	00:02:16	WORKPIECE_M...	170 mmpm	1450 rpm
PLANAR_MILL_4		✓	MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_4_IN...			MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_4_IN...			MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_4_IN...			MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_4_IN...			MILL_3	00:03:28	WORKPIECE_M...	120 mmpm	1500 rpm
PLANAR_MILL_7		✓	MILL_7	00:32:03	WORKPIECE_M...	278 mmpm	1800 rpm
PLANAR_MILL_5		✓	MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
PLANAR_MILL_5_IN...			MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
PLANAR_MILL_5_IN...			MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
PLANAR_MILL_5_IN...			MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
PLANAR_MILL_5_IN...			MILL_3	00:01:57	WORKPIECE_M...	175 mmpm	1550 rpm
DRILLING		✓	DRILLING_TO...	00:00:41	WORKPIECE_M...	250 mmpm	0 rpm
DRILLING_1		✓	DRILLING_TO...	00:01:12	WORKPIECE_M...	250 mmpm	0 rpm
DRILLING_2		✓	DRILLING_TO...	00:01:52	WORKPIECE_M...	100 mmpm	1200 rpm
COUNTERSINKING		✓	COUNTERSINK...	00:00:46	WORKPIECE_M...	100 mmpm	1200 rpm
PLANAR_MILL_6		✓	MILL_6	00:00:35	WORKPIECE_M...	80 mmpm	1350 rpm

From the above tables it is concluded that there is reduction in time and reduction in rejection rate. Out of 746 parts 2 parts are rejected due to manufacturing defect. Using designed fixture we can go for high cutting speeds and feeds and we can also increase depth per cut this results in reduction of time. Manufacturing cost and labour cost are directly proportional to machining time. If manufacturing time is reduced cost of the component also reduces.

RESULTS AND CONCLUSION

RESULTS

Manufacturing of booster rocket without fixture

Time taken to manufacture a single component without fixture on CNC machine = 4hr 22min 19sec= 262min

If the time in seconds is above 30 then it is taken as 1min, if it is below 30 then it is exception

Manufacturing cost of CNC milling machine per hour = 1200rs/hr

Manufacturing cost of single booster rocket = (1200/60)*262= 5240rs

Direct Labour Cost = Tm * Man Hour Rate Rs.

Man Hour Rate = 500 Rs.

Tm =(262/60) hrs= 4.4hrs

Direct Labour Cost = 4.4*500= 2183 Rs.

Machining type	Time required to machining	Machine cost/hr	Raw material cost	Labour cost	Manufacturing Cost	Total cost of part
Milling machine	4hr 22in 19sec	1200	830	2183	5240	8253

Total cost of part =raw material cost + labour cost +manufacturing cost = 830+2183+5240= 8253

Manufacturing of booster rocket with fixture

Time taken to manufacture a single component with fixture on CNC machine = 2hr 56min 2sec=176min

If the time in seconds is above 30 then it is taken as 1min, if it is below 30 then it is exception

Manufacturing cost of CNC milling machine per hour = 1200rs

Machining cost per piece for milling operations (machining cost per min x machining time in min) = (1200/60)*176= 3520rs

Manufacturing cost of single booster rocket= 3520rs

Direct Labour Cost = Tm * Man Hour Rate Rs.

Man Hour Rate = 500 Rs.

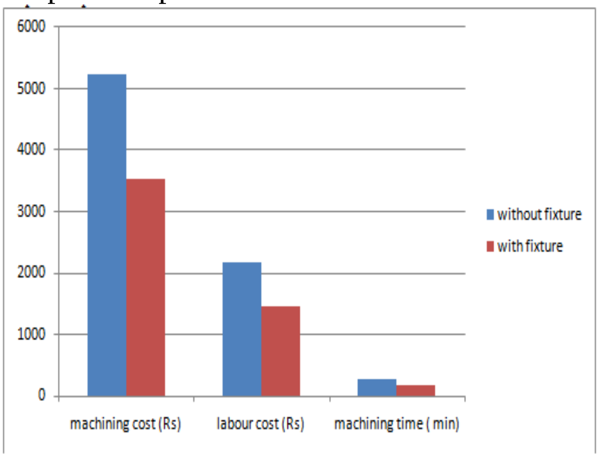
Tm =(176/60) hrs= 2.9hrs

Direct Labour Cost = 2.9*500= 1467 Rs.

Machining type	Time required to machining	Machine cost/hr	Raw material cost	Labour cost	Manufacturing Cost	Total cost of part
Milling machine	2hr 56min 2sec	1200	830	1467	3520	5817

Total cost of part =raw material cost + labour cost +manufacturing cost = 830+1467+3520= 5817

Graphical representation



CONCLUSION:

- Using designed fixture there is reduction of manufacturing time, labour cost, manufacturing cost.
- Reduction of time and cost are represented in graphical and shown in results.
- There is a drastic reduction of reworks and rejection rate using designed fixture.

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