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Research Paper

REDUCTION OF REWORKS AND REJECTIONS IN MANUFACTURING OF A THIN WALLED AEROSPACE COMPONENT

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Nowadays rejection is a serious problem arising in every manufacturing industry. Due to this reason the manufacturing industry is advancing into losses. There are many factors responsible for rejection and reworks, such as human errors, machine errors, process planning. Machining of thin-walled components has increasingly become a difficulty for manufacturers. Advanced digital analyses have been developed by many researchers to model, predict and reduce errors induced by machining processes. Moreover, today's machining shop floors, characterized by a large variety of products in small batch sizes, require flexible simulation tools that can be quickly reconfigured. CAD/CAM systems play a vital role in design optimization and process optimization of any component and helpful in reducing the rejections and reworks. Keeping in view the above important aspect this project has been taken up for reducing the rejections to a minimum. The aim of the project is to reduce rejection rate rework rate. The thin wall component taken for this project is a missile shield. The missile shield protects the missile by covering the entire body. The missile shield design and process planning are studied in detail. This project also deals with development of manufacturing process plan of missile component (missile shield) 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. In this project efforts are made to produce different process plans in CAM software by changing the work holding systems, tool paths, cutting tools etc. Finally, recommending an optimum process plan for manufacturing of the component..

Keywords: NX-CAD, NX-CAM, Mandrel design, Manufacturing process plan, WHY-WHY analysis, MORI SEIKI 4-axis turning machine

INTRODUCTION

In the context of modern and fast emerging industrial world, technology and automation is considered to be a big boon for the fast

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and rapid industrial development. The main objective of today's industries is to maximize the production within the stipulated time using an optimum amount of man power and resources. The trends which accounts for today's technological development includes CNC machining, DNC, FMS, CAD/CAM etc. The development in these factors affects the production very much by increasing the quantity as well as the quality. These developments have been highly utilized in enhancing our defense warheads which includes several missiles AGNI, THRISHUL, PRUTHVI, AKASH, NAG etc.

A missile is a self-propelled guided weapon system. Missiles have four system components: targeting and/or guidance, flight system, engine, and warhead. Missiles come in types adapted for different purposes: surface-to-surface and air-to-surface (ballistic, cruise, anti-ship, anti-tank), surface-to-air (anti-aircraft and anti-ballistic), air-to-air, and anti-satellite missiles. The missile shield protects the missile by covering the entire body. The missile shield design and process planning are studied in detail.

This project also deals with development of manufacturing process plan of missile component (missile shield) 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.

The latest CAM software introduced includes the new NX 7.5 software, which has important features like 2D, 3D and surface modeling. The component and fixture can be either designed on this software or can be retrieved from any other CAD software. Then sequence of program such as modeling the component, generating the tool path, selection of tools according to the sequence of operations and sizes, at last the generated NC part program is verified and sent to the required CNC machine to manufacture the particular missile component. Optimizing feed and speed to get high surface finish can also be done.

COMPUTER AIDED DESIGN

Figure 1: 2D Input of Missile Shield Final 3D Model of Missile Shield Using Unigraphics NX-7.5

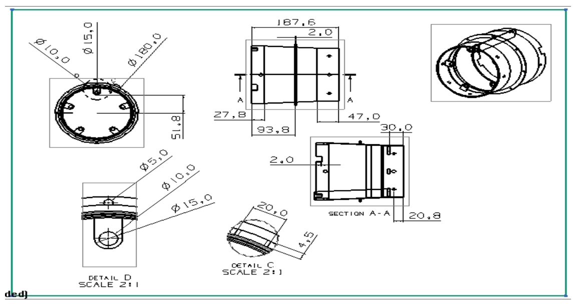
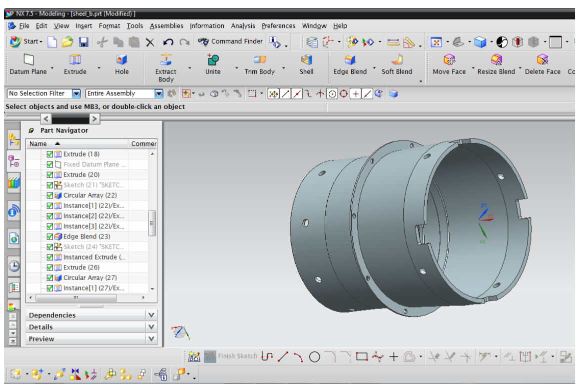


Figure 2: Final 3D Model



Manufacturing process plan

- Identifying suitable machine.
- Selecting suitable tools for manufacturing thin walled component.
- Designing fixture/mandrel to missile shield component for external operations.
- Listing down the Sequence of operations performed on missile shield component.
- Generating tool path at specified cutting speed.

Identify Suitable 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.

Figure 3: MORI SEIKI 4-axis Machine

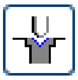
Selecting Suitable Tools

OD_80_L Facing, Roughing

Facing in the context of turning work involves moving the cutting tool at right angles to the axis of rotation of the rotating work piece.

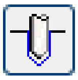
ID_80_L rough

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



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.



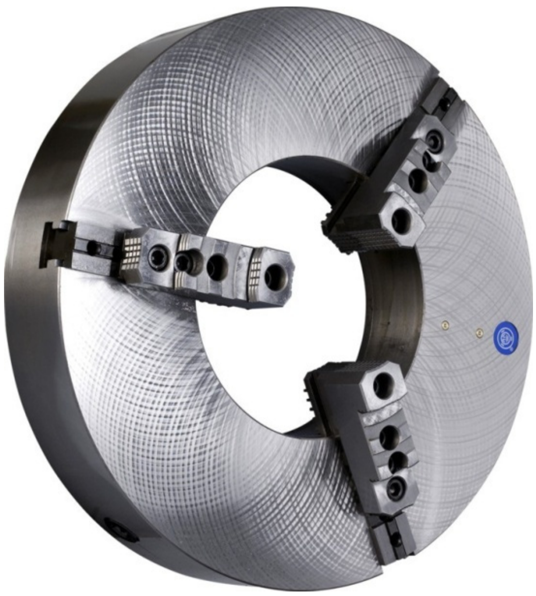
Spot Drilling

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.

Selection of Fixture

3-jaw chucks provide the quickest and easiest way of holding work in the milling and lathe machines.

Figure 4: 3-Jaw Chuck



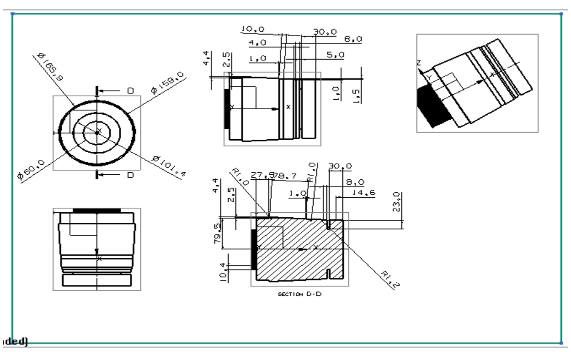
DESIGN OF MANDREL

Mandrel is used to support missile shield component internally to allow high cutting speed. When external operations done on the thin walled component without any support from inside it may damage or scratches may form due to its thin wall. To overcome this, mandrel is designed to reduce rejection rate and to increase production rate.

Mandrel is modeled by considering inner dimensions of missile shield. Inner dimensions of missile shield will be outer dimensions of mandrel.

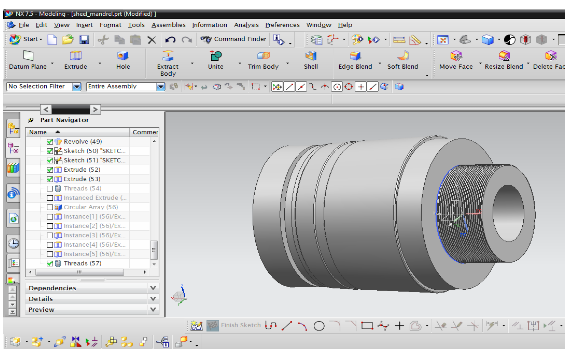
Input 2D Drawing for Mandrel.

Figure 5: 2D Input of Mandrel



Below image shows the final part of the mandrel

Figure 6: Final Part of Mandrel



Sequence of operation

Set up-1

- Facing operation
- OD_Rough_Turn operation
- ID_Rough_Bore operation

Set up-2

- Facing operation
- OD_Rough_Turn operation
- Finally Drilling operation

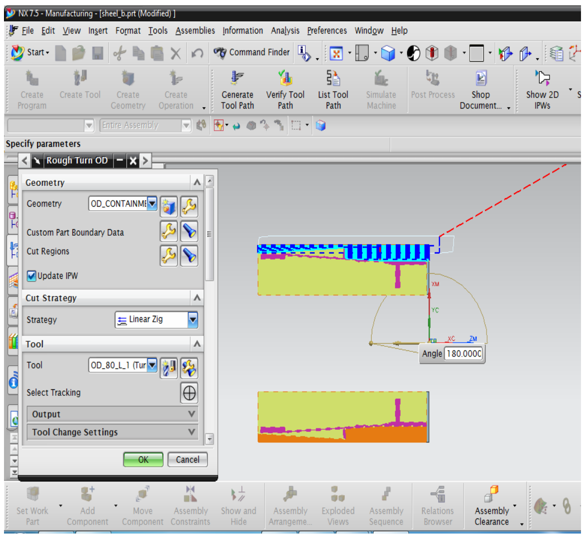
Generating tool path

Turning operations on missile shield

Material of missile shield is aluminum alloys. Aluminium alloys are light weight and high strength material.

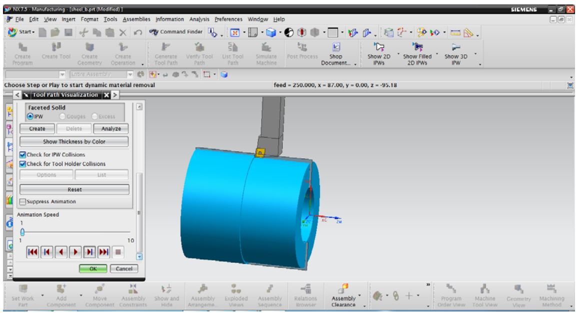
Below image shows ROUGH TURN_OD operation of missile shield with 1500rpm speed and 0.2mmpr feed.

Figure 7: ROUGH TURN_OD operation



Below image shows verification of ROUGH TURN_OD operation

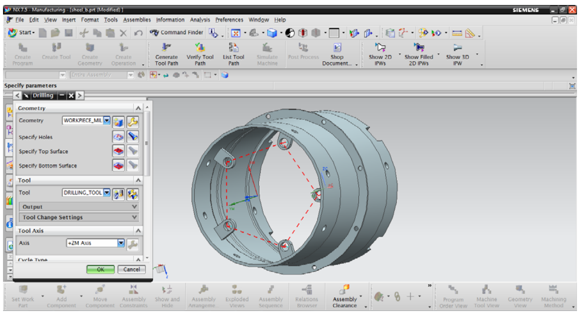
Figure 8: Verification of ROUGH TURN_OD Operation



Milling Operations on Missile Shield

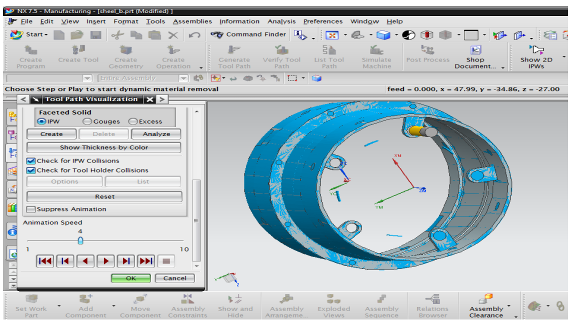
Below image shows drilling operation of missile shield with 1400rpm speed and 240mmpm feed.

Figure 9: Drilling Operation



Below image shows verification of drilling operation

Figure 10: Verification of Drilling Operation



The Manufacturing Process of Missile Shield on CNC Machine.

Raw material is placed on the machine, and degree of freedom is arrested using fixtures. Facing operation is general operation which will be done for any component, after facing internal operations are done on the missile shield.

First Step: facing operation is done on the raw material

Second Step: internal roughing operation done on the component

Third Step: the designed mandrel is fixed internally in the missile shield component and external roughing is done

Fourth Step: the component is fixed reversely in the fixture and setup_2 operations are done. Outer roughing operation is done.

Fifth Step: drilling operation is done on final turning component on milling machine.

Surface finish is not obtained by using non expandable designed mandrel, due to the gap between the mandrel and missile shield component. At high cutting speeds the load of the tool is directly applied on the missile shield component and scratches are formed due to the gap between the missile shield component and mandrel. Hence increase in rejection rate due to bad surface finish. In order to overcome from this rejection rate expandable mandrel is designed for missile shield.

DESIGN OF EXPANDABLE MANDREL

Below shows the 2D drawings of the expandable mandrel with all the required dimensions representations the suits the best for manufacturing the component without any errors.

Figure 11: 2D Input of Expandable Mandrel

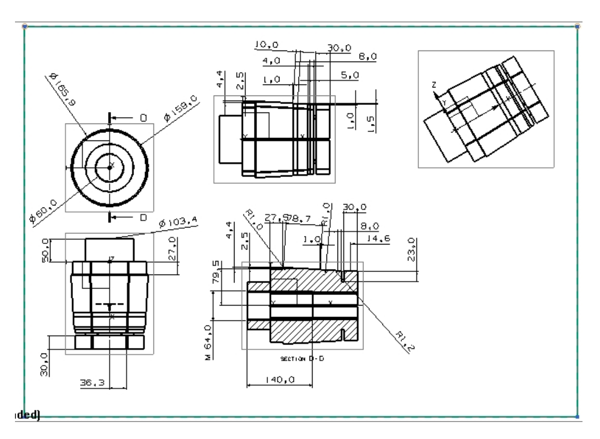
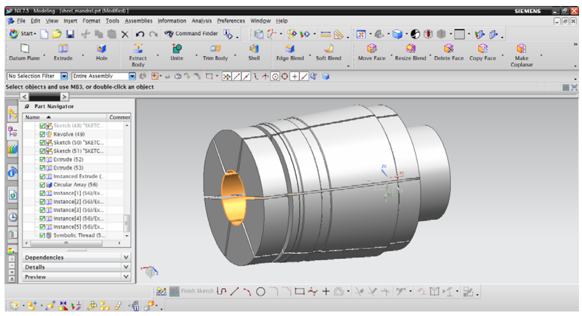


Figure 12: Final Part of Expandable Mandrel



Missile shield is again machined by using expandable mandrel. After completing internal operation expandable mandrel is used as jig. Expandable mandrel expands inside the Missile shield component and makes contact; this contact supports the component at high cutting speeds and gives high surface finish.

WHY-WHY Analysis

It is a method of questioning that leads to the identification of the root cause(s) of a problem. A why-why is conducted to identify solutions to a problem that address it's root cause(s). Rather than taking actions that are merely band-aids, a why-why helps to identify how to really prevent the issue from happening again. A why-why is most effective in a team setting or with more than one person involved. Involve the right people - it helps to have those that are familiar with the process and the problem in the room so they are able to answer why something happened. It is also helpful to have someone with a fresh eye participate - often they ask questions that help those involved in the problem extract the real reasons something happened.

Main Causes of Rejection Rate in Industries

Operator’s negligence at work place and their poor knowledge in manufacturing. Rejection rate also increased due to equipment such as component setup, assigning improper tools, fixture design problems. Another cause of increase in rejection rate is due to procedure of machining like mistakes in sequence of operations (Turning, Milling and Drilling). Another cause is following the norms or rules of the company in impossible conditions of machining the component.

Root Causes of Rejection Rate in Manufacturing of Missile Shield

Missile shield is thin walled component it is difficult to manufacture. Rejection rate due to equipment such as component setup, assigning improper tools, fixture design problems. Another cause due to improper design of mandrel. Going for high cutting speed which is not preferred for machining Missile shield component in order to reduce machining time. Another cause of increase in rejection rate is due to procedure of machining like mistakes in sequence of operations (Turning, and Drilling).

Solution Obtained to Reduce Rejection and Reworks

To reduce rejection rate the thin walled component is manufactured in a sequence as first internal operations and next by using mandrel support external operations are done. Proper tools are specified which will support for machining thin walled component. Redesign of mandrel is done to reach high surface finish without fail.

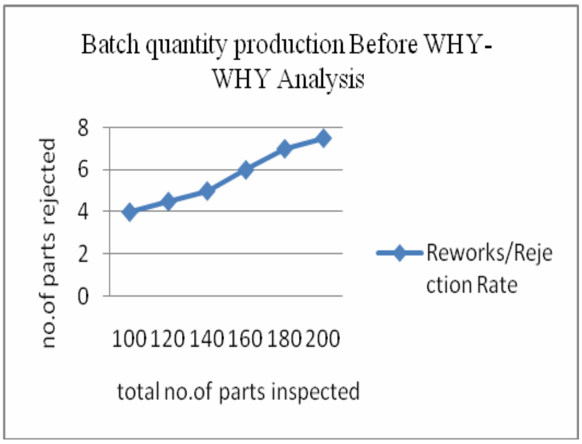
RESULTS

Results are represented graphically to specify the quality control of missile shield component.

Graphical Representation of Rejection and Reworks Rate

Below graphs shows the rejection and reworks rate before WHY-WHY analysis and after WHY-WHY analysis.

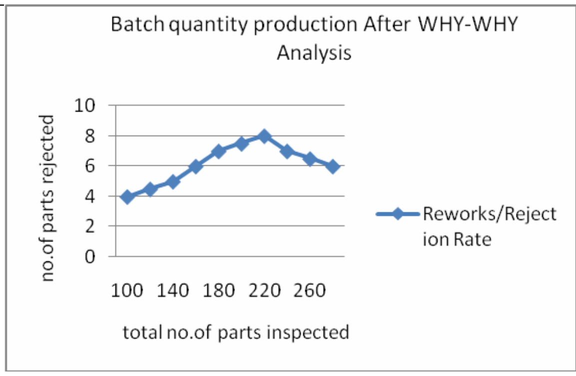
Figure 13: Rejection and Reworks Rate Before WHY-WHY Analysis



Results After WHY-WHY Analysis

These four causes for rejection which are mentioned above is rectified by using WHY-WHY Analysis. The following graph indicates rejection rate after WHY-WHY Analysis.

Figure 14: Rejection and Reworks Rate After WHY-WHY Analysis



CONCLUSION

By considering 2D inputs 3D model is generated using NX-CAD software. Tool path is generated on missile shield using NX_CAM software. The thin walled (missile shield) component is manufactured in a sequence as first internal operations and next by using mandrel support external operations are done to reduce rejection rate. Non-expandable Mandrel has been designed to support the component for external operations. By using Non-expandable Mandrel the rejection rate is more due to the gap between the mandrel and missile shield. Proper tools are specified which will support for machining thin walled component. Expandable mandrel is designed to overcome the rejection rate. Use of expandable mandrel results in less rejection compared to before mandrel. By WHY-WHY analysis is done to check rejection and rework rate is reduce or not. Graphical representation of rejection and reworks rate before and after WHY-WHY analysis is shown in results.

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