DESIGN AND MANUFACTURING OF CUTTING TOOL FOR MACHINING PROFILE ON INCONEL SHELL

Done By

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About CMTI

Central Manufacturing Technology Institute (CMTI) has developed expertise over the last two decades in offering customized solutions in the areas of cutting tools, moulds & dies, jigs and fixtures, machine elements like ball screws etc. Typically, a customized solution involves study of the customer problem, evolving alternate design / methods to solve the problem, interaction with customer, preparation of detailed designs, manufacture, try-out and testing. CMTI offers total solutions in the following areas

- Cutting tools and tool holders of special requirements moulds and dies
- Machine tool accessories and attachments
- Machine elements like ball screws, linear guide ways, worm & worm wheel, duplexworms and drives
- Jigs and fixtures including modular and unitized fixtures for CNC machines
- Automation devices for job loading, inspection etc.

and so on

About CMF

CMF is the manufacturing hub of CMTI. CMF houses world class manufacturing facility for metal cutting operations. Department activities include, process planning, scheduling, raw material planning, fixture planning, tool planning, manual programming, CAD/CAM, Machining(conventional and non-conventional) & inspection.

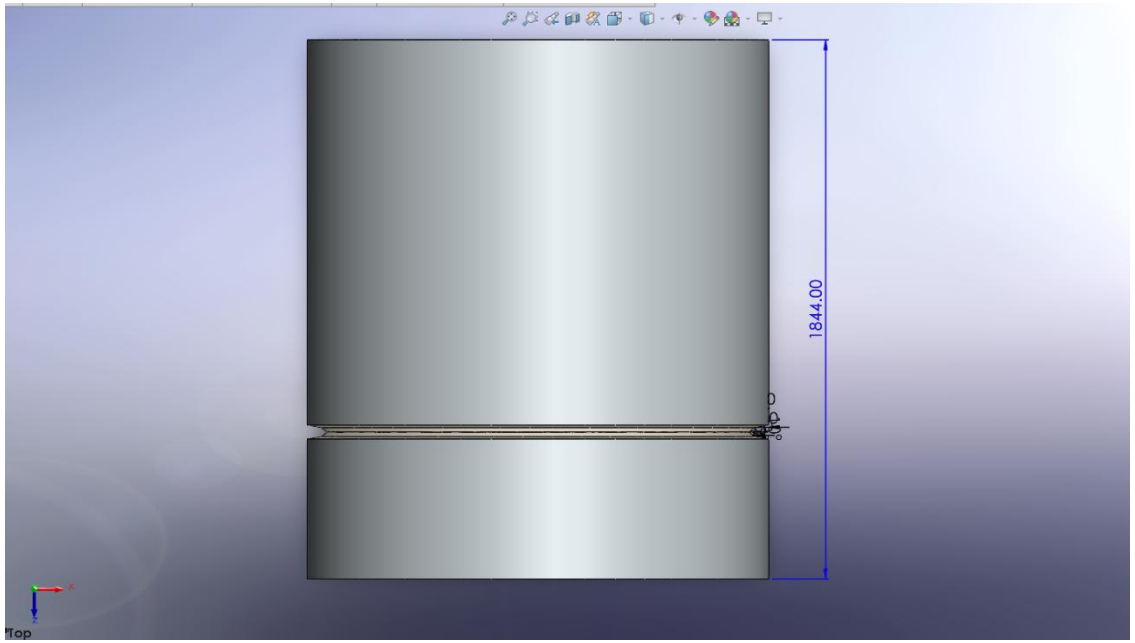
facility description

S.No	Type of Machine	Name of the Machine
1	5 Axis CNC machines	PKM XT 700S
		Xceeder 1200
		Bostomatic
2	4 Axis CNC Machines	Mikron WF 5C
		DMC 125 U duo block
		DMU60/DMC80H
3	3 Axis CNC machines	BMV 50
		MLV 5C Mitsubishi
4	Horizontal Boring machine	Varnsdorf TOS WH 10 CNC
5	JIG boring machine	Herbert Devlieg

Learning at CMF

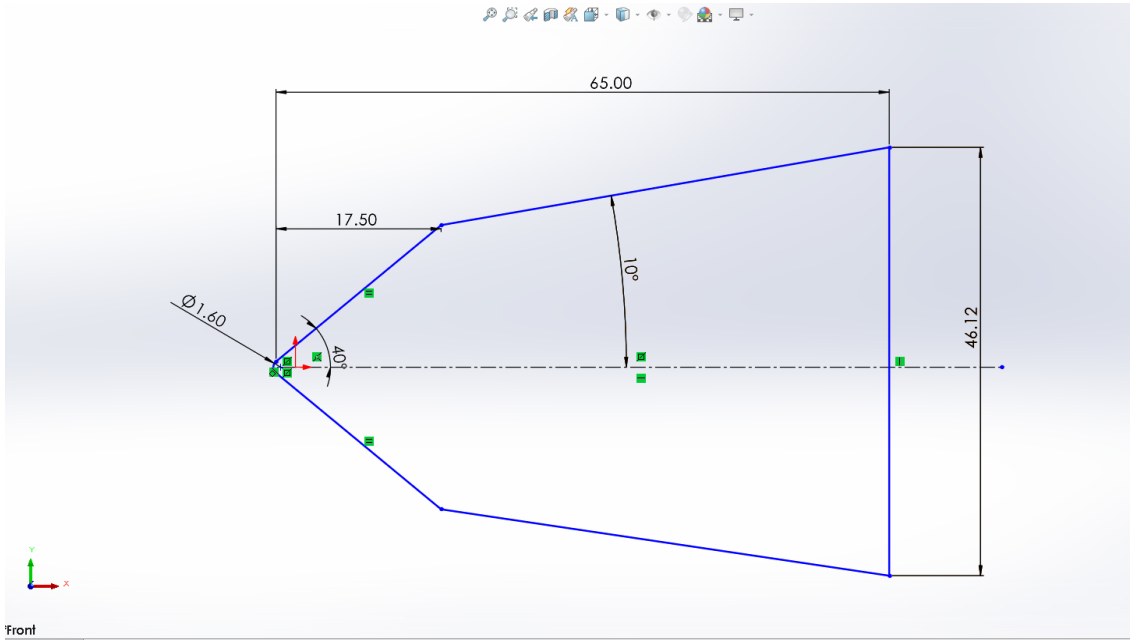
- Introduction to facilities in the Manufacturing Shop Floor
- Introduction to
  - Manual Programming concepts
  - Process Planning
  - SOLIDWORKS CAD software
    - CAD Modeling
    - Drafting
- Learned about inspections
- Learned about cutting tools

Project Details



CUTTING PROFILE IN INCONEL SHELL DESIGN

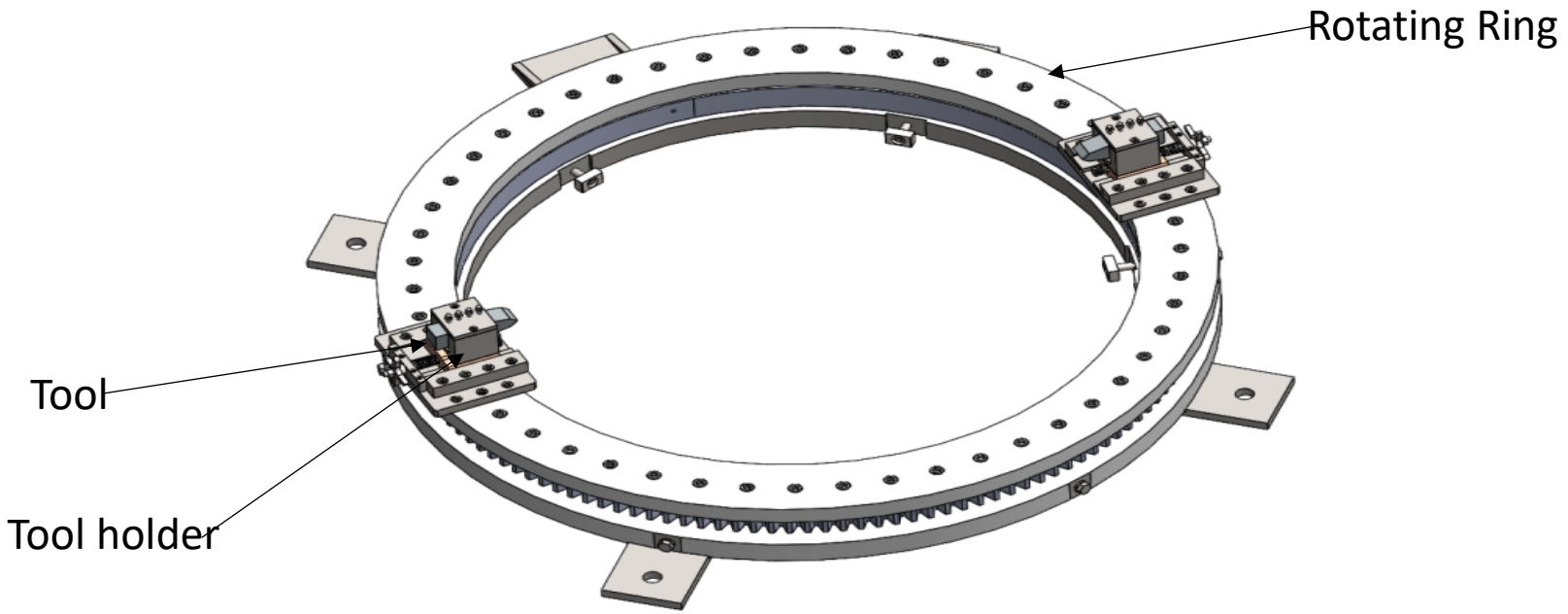
BARC Project



CUTTING PROFILE

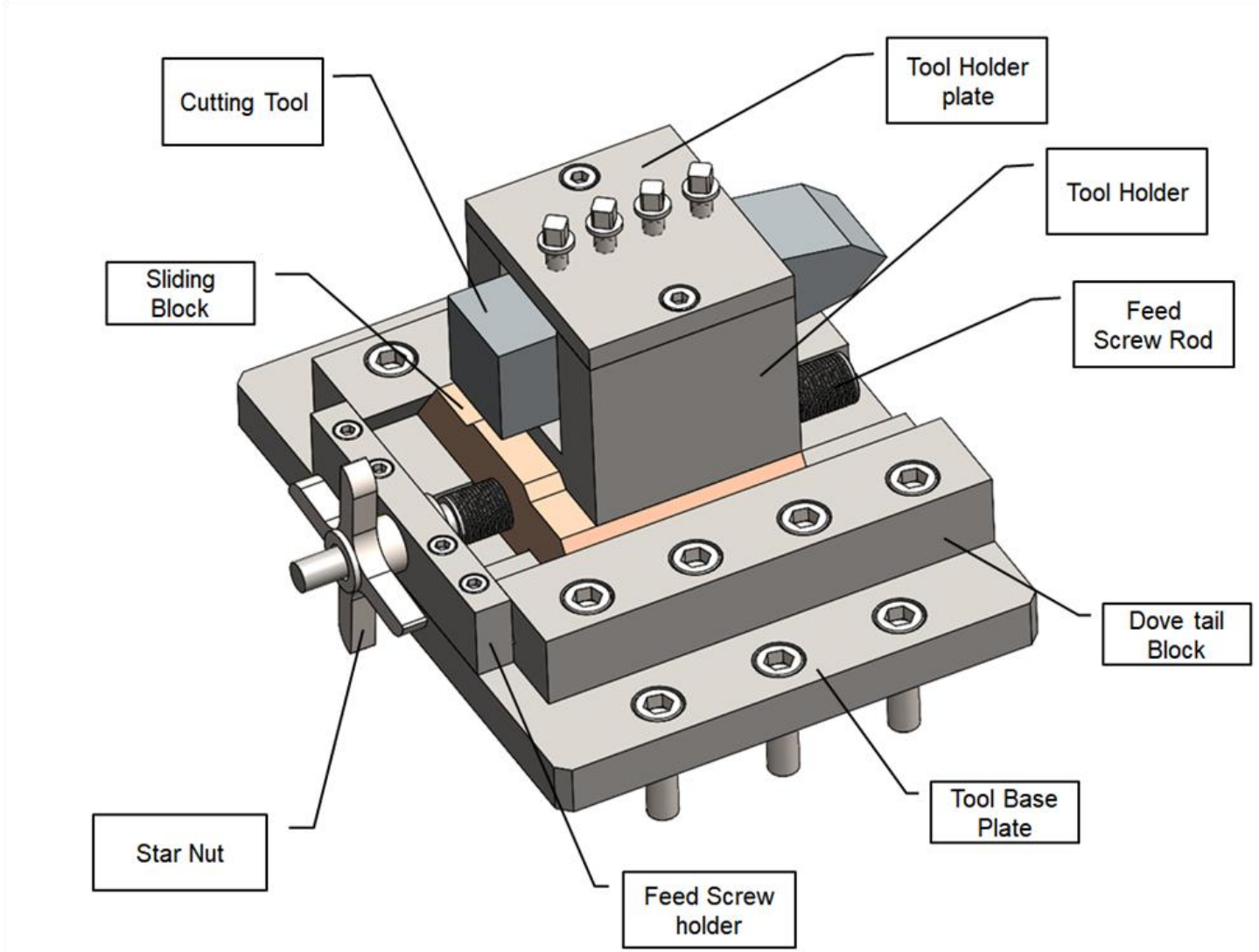
Machine Details

IN-SITU WELDING AND CUTTING EDGE PREPARATION(IWCEP)



IWCEP

- This IWCEP machine was made up only for machining special cutting profiles
- This machine is designed and developed by CMTI



Machine Tool Holder and Feeder

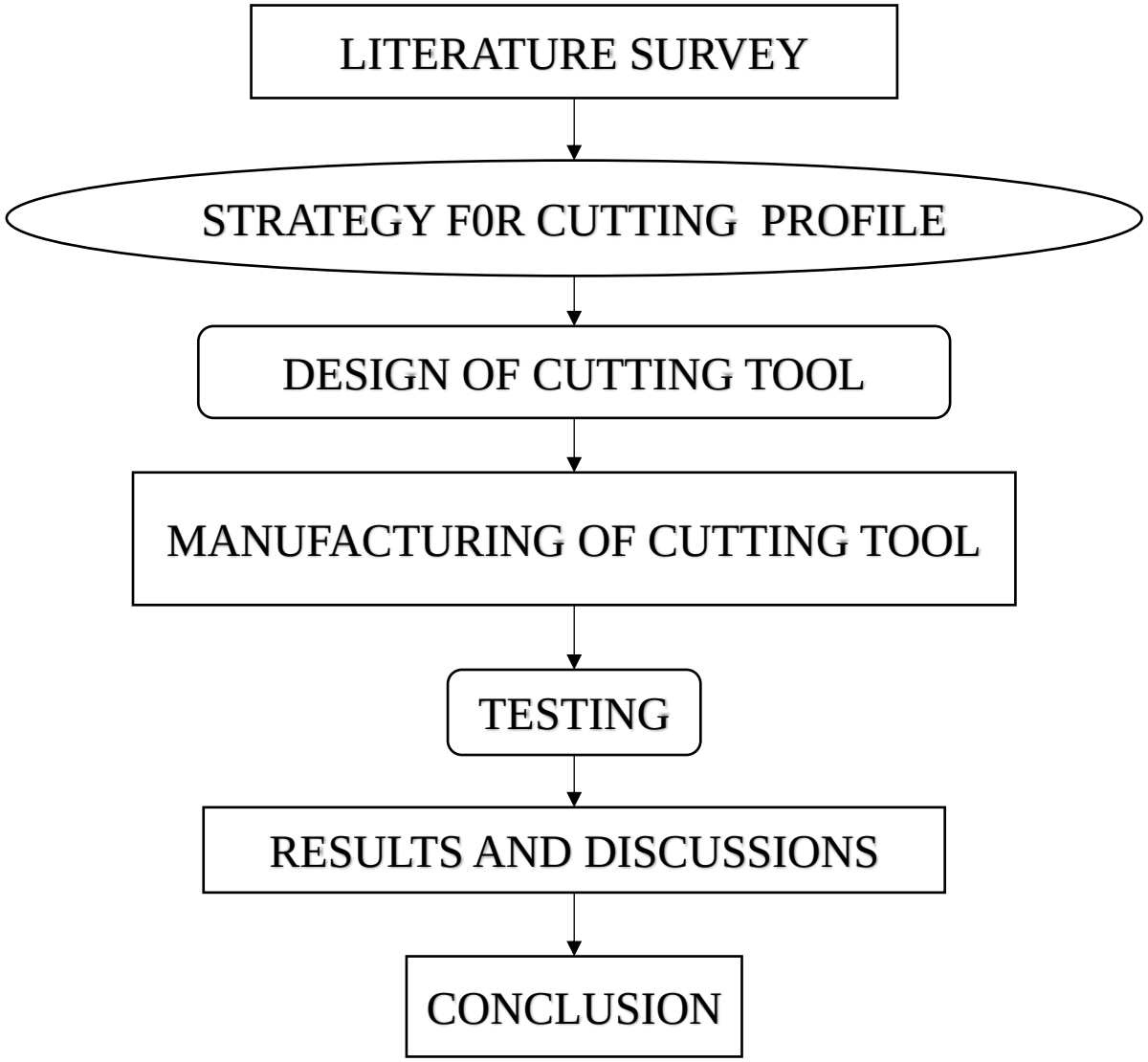
Motivation for the research

- Inconel(Nickle-Chromium-Iron) is a super alloy material and it is hard to cut.
- Develop new cutting tool.
  - Non-Regular conventional machining process
  - Special Cutting Profile required.

Explanation

Inconel (nickel-chromium-iron) is a superalloy material, and it is hard to cut. So CMTI developed a new machine. This machine is called IWCEP (In-Situ Welding and Cutting-Edge Preparation). This is a non-regular conventional machining process, and it is for machining a special cutting profile. Because of the special cutting profile, we need to design and manufacture the cutting tool and profile tool based on the cutting profile and machine tool holder.

Methodology



Literature Survey

S.NO	Author, Date of Publication	Title
1	Luqiang Tua , Shuai Tiana , Feng Xua, *, Xue Wanga , Chenhui Xua , Bin Heb,c, **, Dunwen Zuoa , Wenjun Zhangb, 29 April 2020	Cutting performance of cubic boron nitride-coated tools in dry turning of hardened ductile iron
2	M. Dhananchezian 16 January 2023	Surface roughness and insert wear in turning Ti-6Al-4 V and Inconel 600 alloys with tungsten carbide inserts under dry conditions
3	G. Veerappan a, D. Pritima a, N.R. Parthsarathy b, B. R amesh c, S. Jayasathyakawin d 19 May 2022	Experimental investigation on machining behavior in dry turning of nickel based super alloy-Inconel 600 and analysis of surface integrity and tool wear in dry machining
4.	M. Dhananchezian, 19 May 2022	Influence of variation in cutting velocity on temperature, surface finish, chip form and insert after dry turning Inconel 600 with TiAlN carbide insert
5	M. Sivaramakrishnaiaha *, P. Nanda Kumarb , G. Ranga Janardanac 2017	Online Monitoring of Metal cutting of Inconel 600 with Al2O3 coated carbide tools

Outcomes from the Literature survey

The effective cutting tool material for Inconel shell was selected from a literature survey.

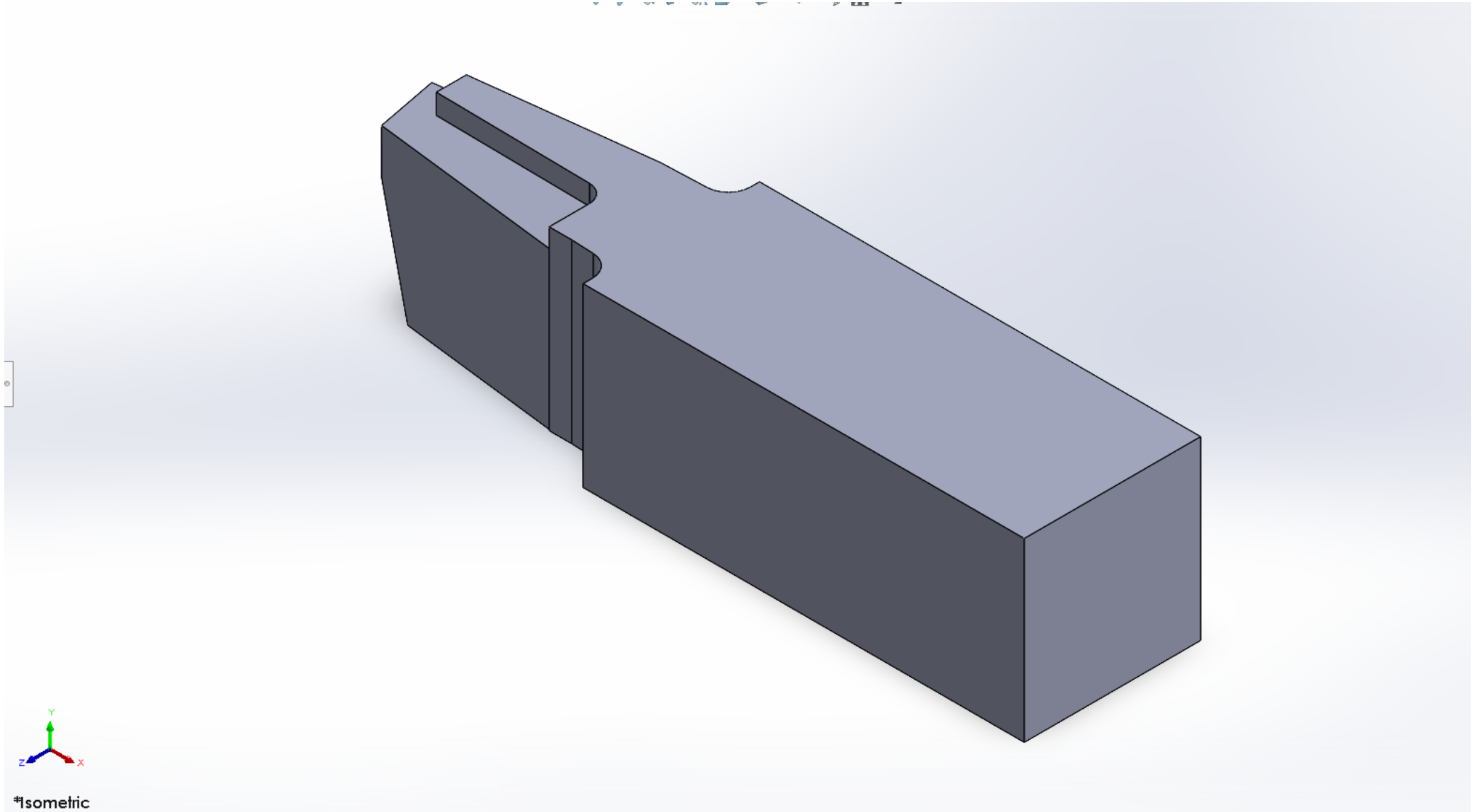
The materials are

1. Tungsten Carbide(WC)
2. HSS M48(High Speed Steel)
3. CBN(Cubic Boron Nitride)
4. Al2O3(Aluminium Oxide)
5. TiAlN(Titanium Aluminium Nitride)
6. AlCrN(Aluminium Chromium Nitride)
7. Ti-6Al-4V(Titanium Aluminium Vanadium)

Objectives

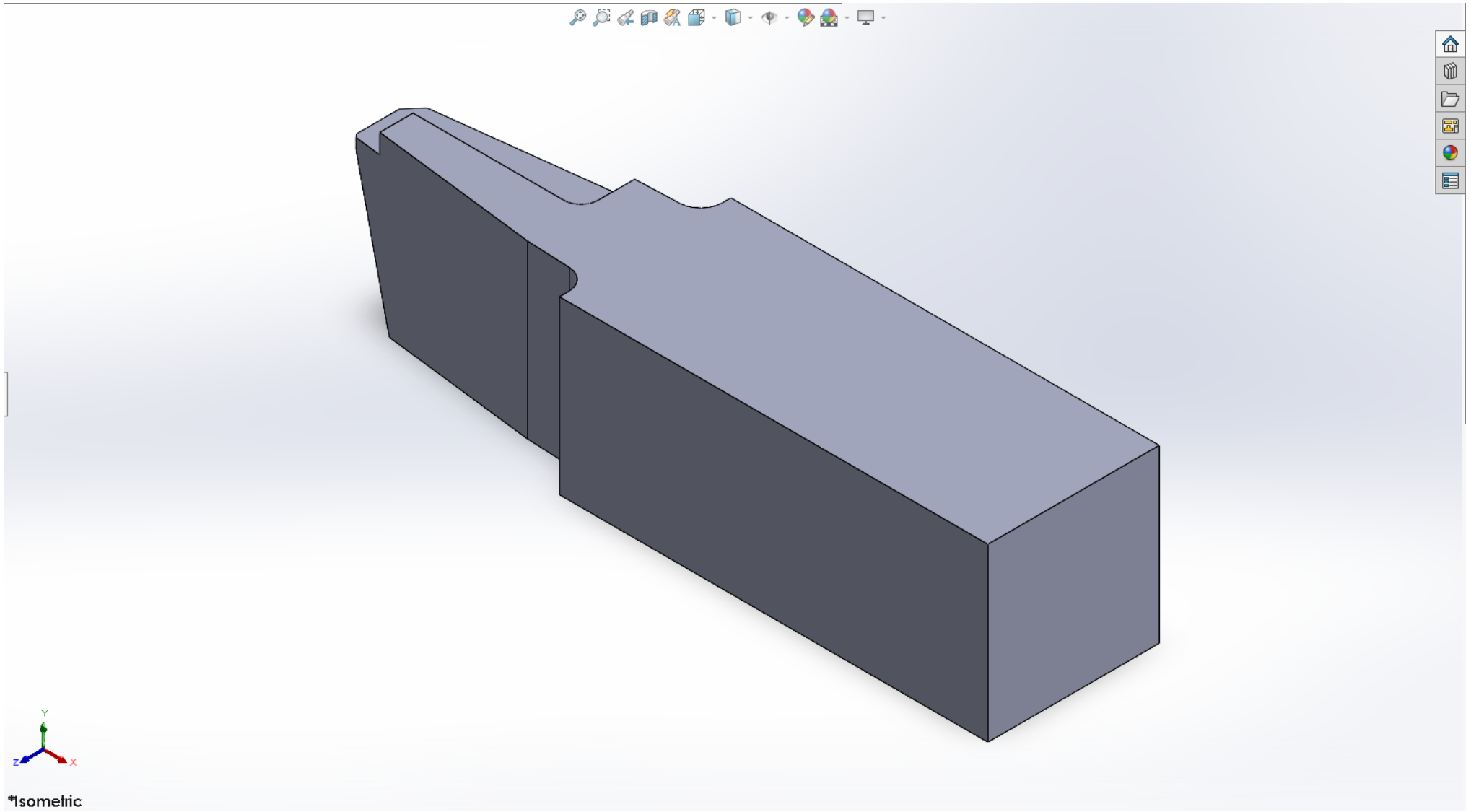
- ❑ Designed the cutting tool for Inconel shell
- ❑ Process planned for manufacturing a cutting tool
- ❑ Manufactured the cutting tool for the Inconel shell

DESIGN OF PROFILE TOOL HOLDER(LS)



DESIGN OF PROFILE TOOL HOLDER(EN24)

DESIGN OF PROFILE TOOL HOLDER(RS)

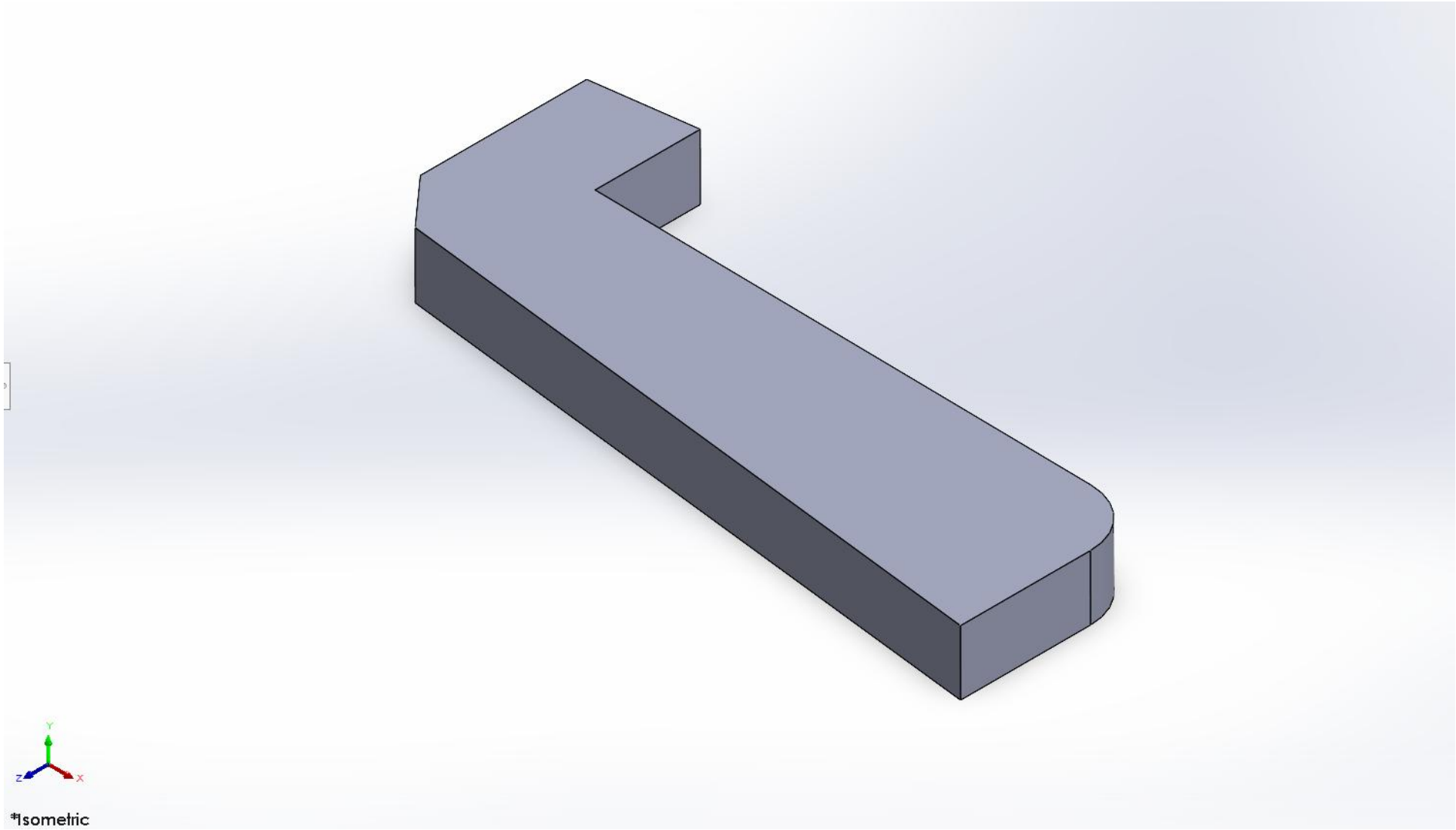


DESIGN OF PROFILE TOOL HOLDER(EN24)

PROPERTIES OF EN24

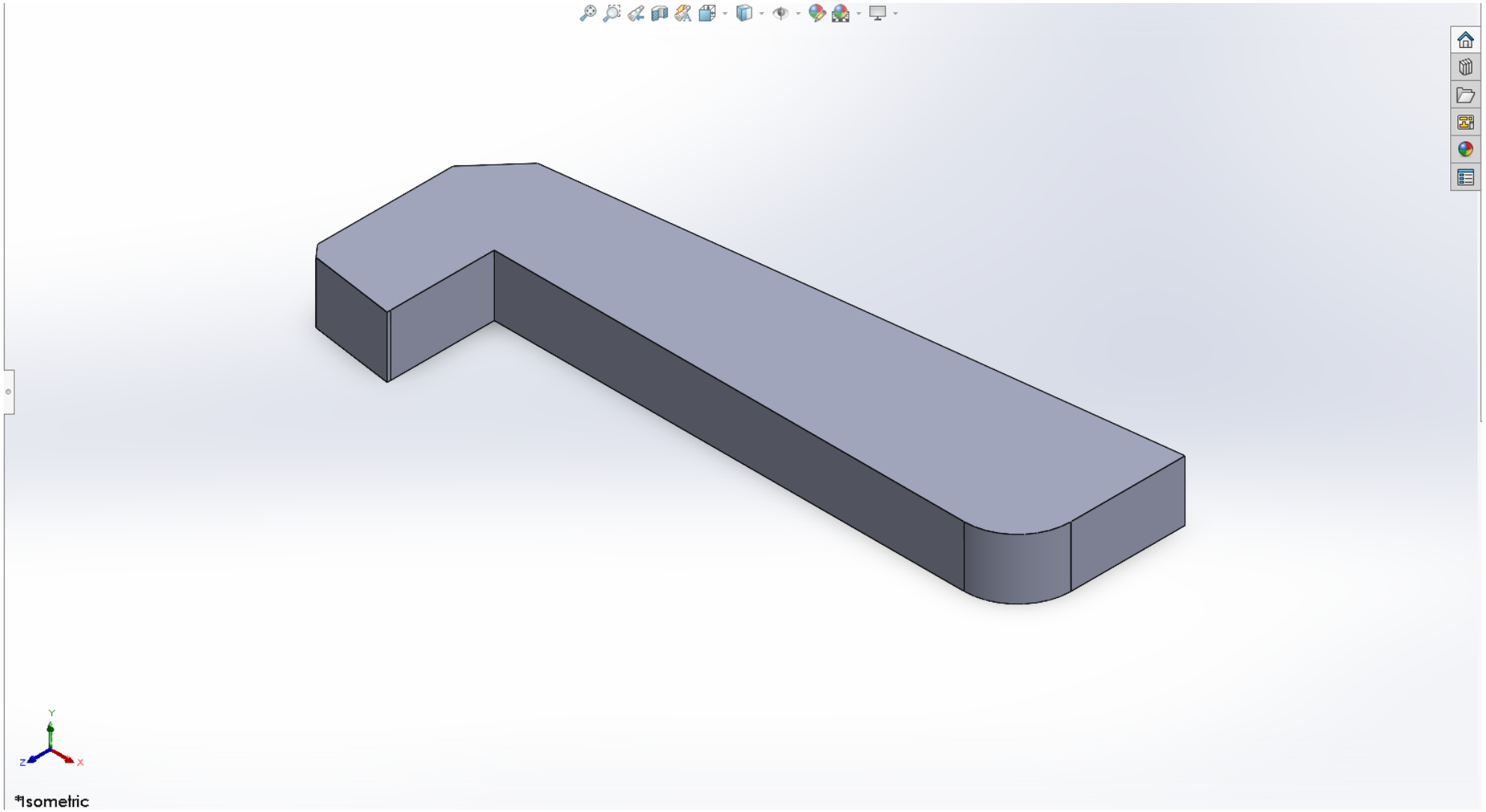
En24 steel is a heat-treatable, high-strength, and high-toughness alloy steel. It is usually supplied in a hardened and tempered condition. And EN24 has a melting temperature of 817°C (1,501°F).

DESIGN OF TOOL INSERT(LS)



DESIGN OF CUTTING TOOL INSERT (TUNGSTEN CARBIDE(WC))

DESIGN OF TOOL INSERT

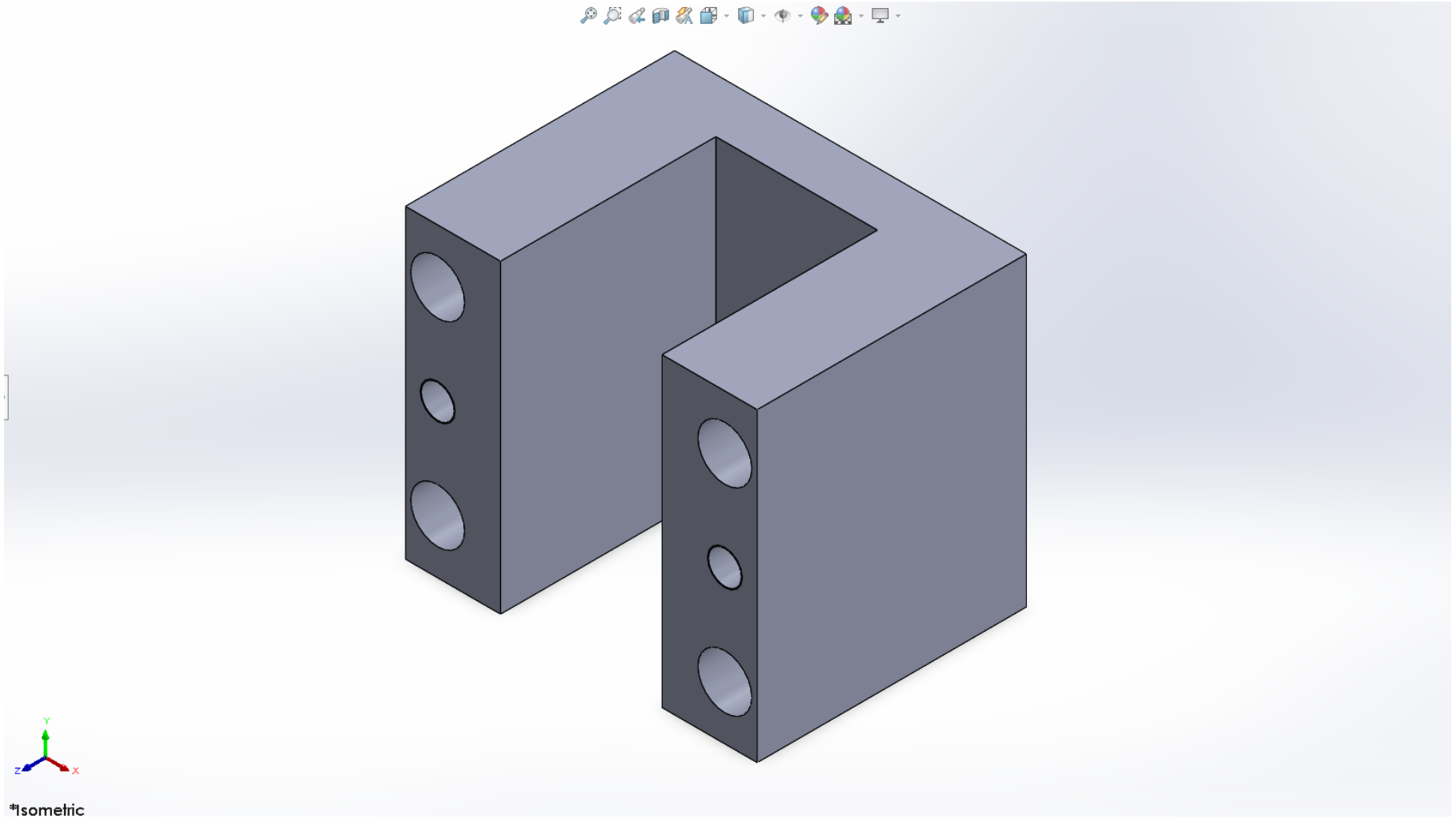


DESIGN OF CUTTING TOOL INSERT (TUNGSTEN CARBIDE(WC))

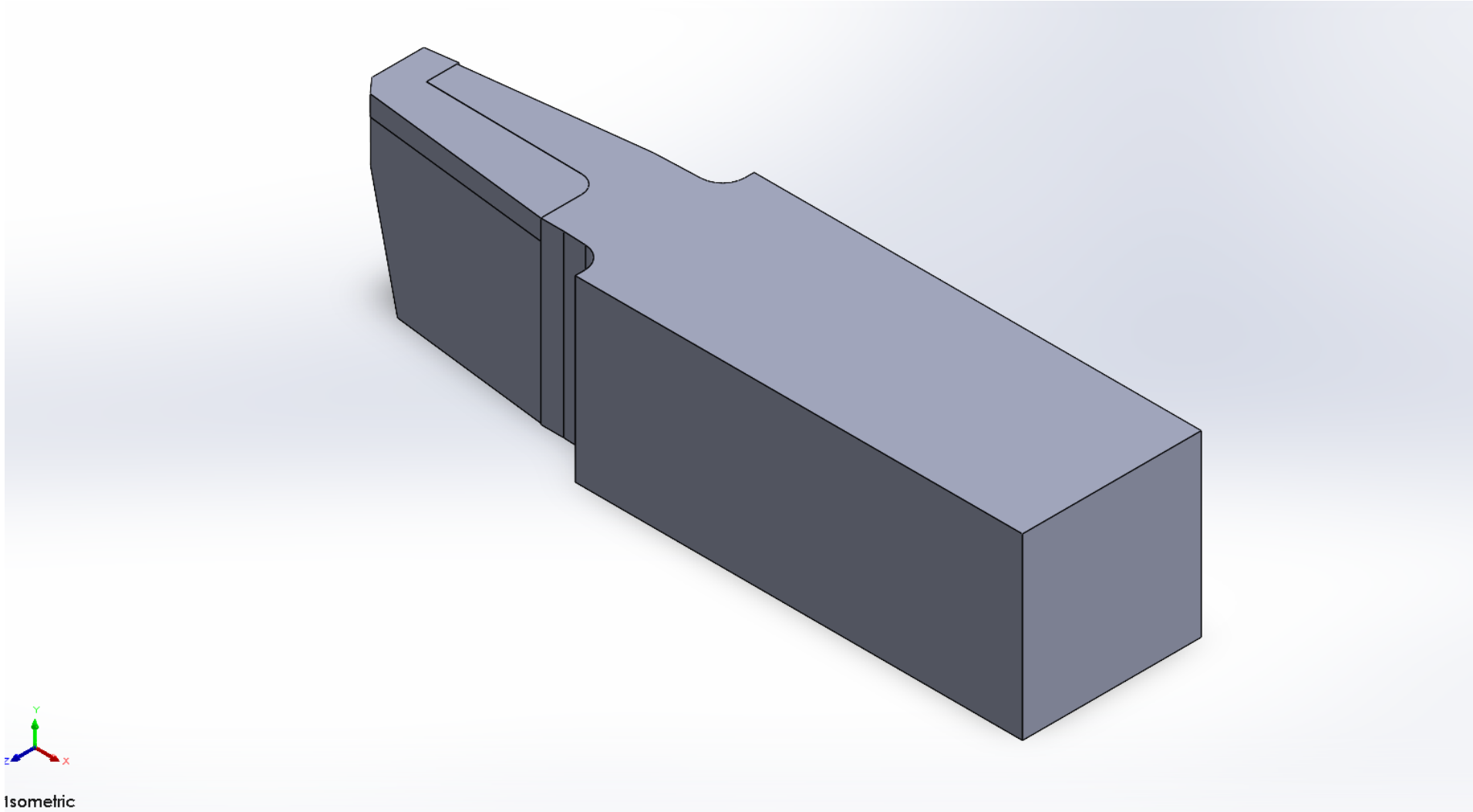
PROPERTIES OF TUNGSTEN CARBIDE

Tungsten carbide is a highly durable material, making it useful for a variety of applications. It is an extremely hard material, with a Vickers hardness of around 2400. It is also very resistant to wear and tear, as well as corrosion and oxidation. Additionally, it has a very high melting point of around 5,700°F (3,150°C). It is also highly heat and electrical conductive. Finally, tungsten carbide is non-magnetic and has a low coefficient of friction.

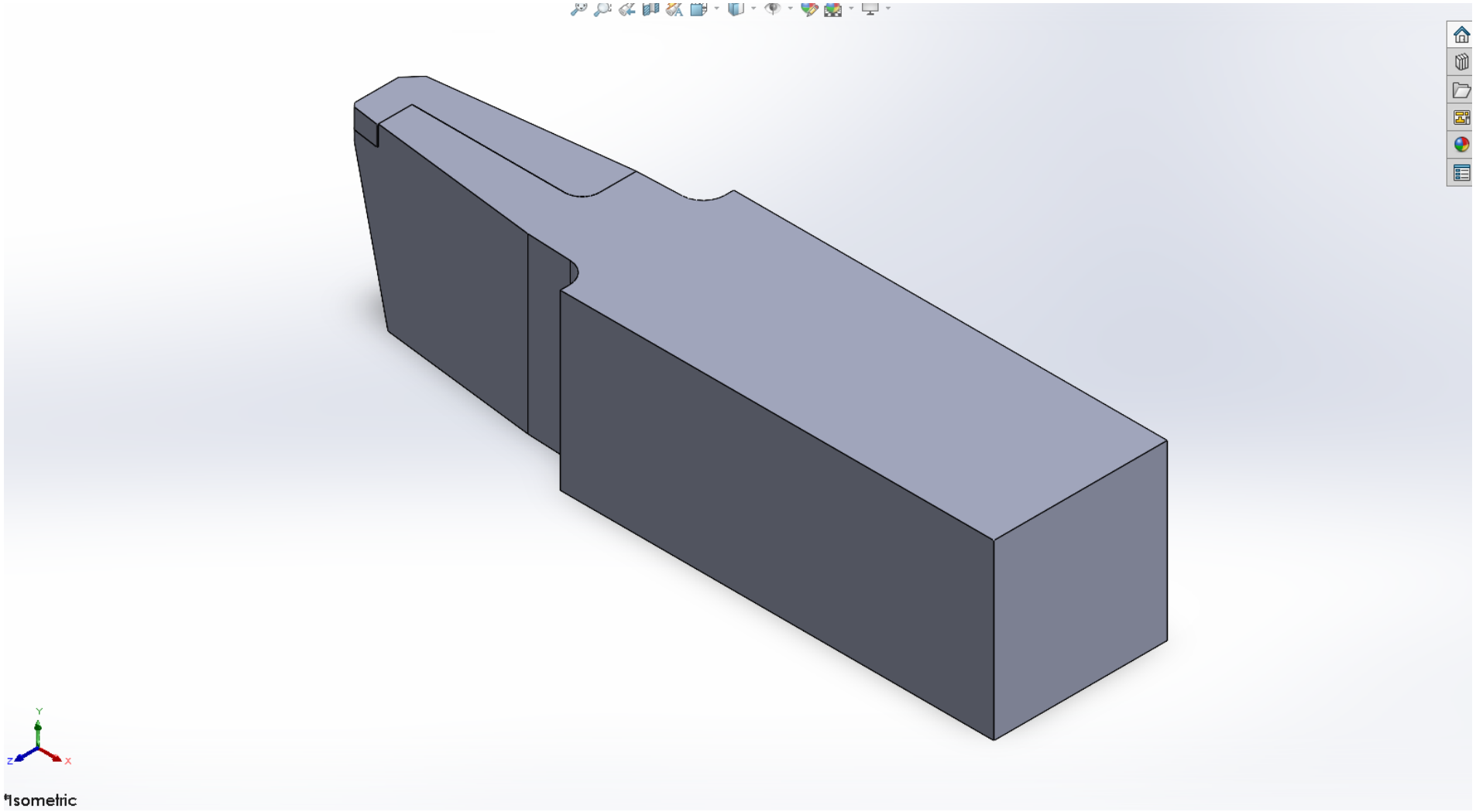
DESIGN OF MACHINE TOOL HOLDER



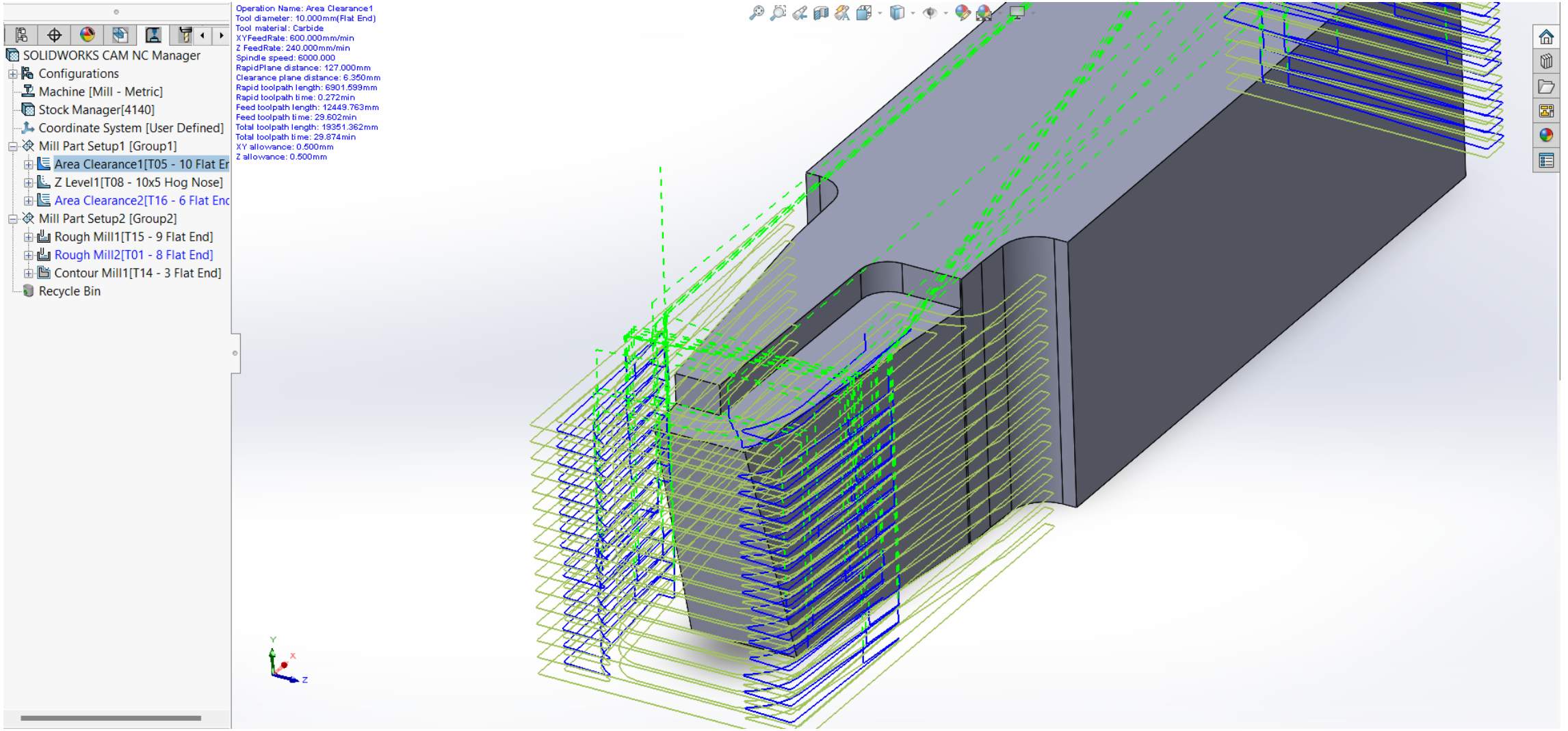
CAD ASSEMBLY OF PROFILE TOOL HOLDER AND TOOL INSERT (LS)



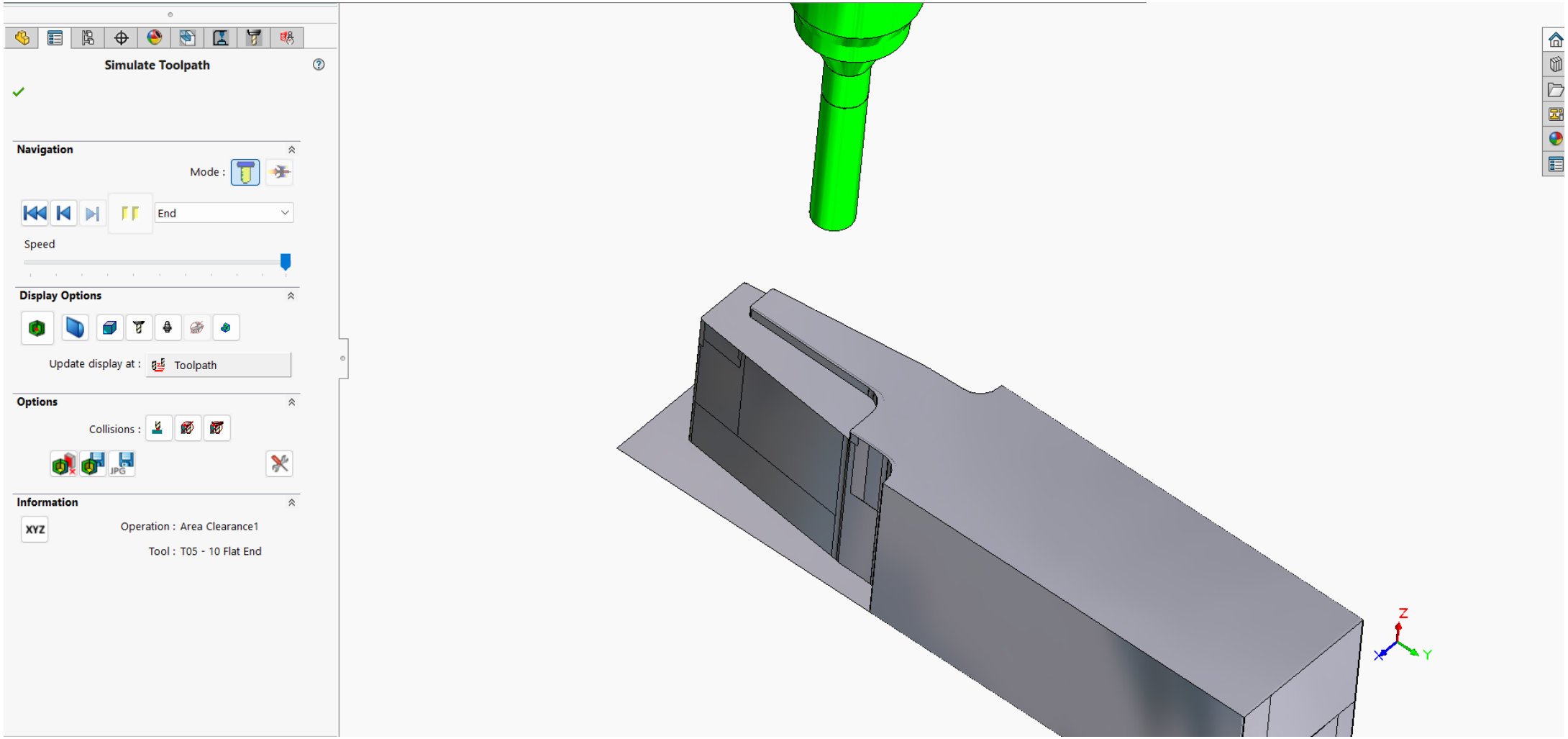
CAD ASSEMBLY OF PROFILE TOOL HOLDER AND TOOL INSERT (RS)



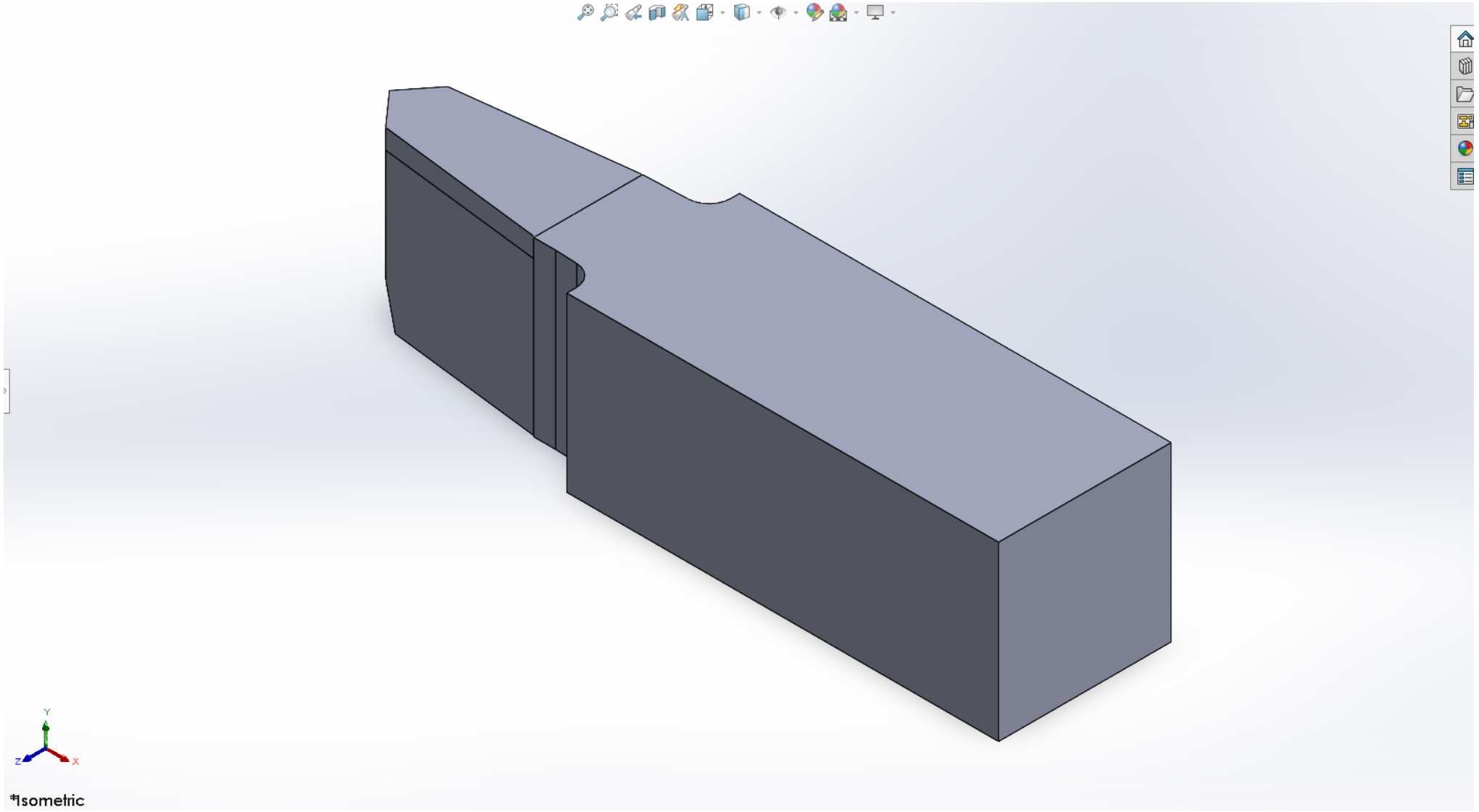
CAM Of Profile Tool Holder



CAM SIMULATION Of Profile Tool Holder



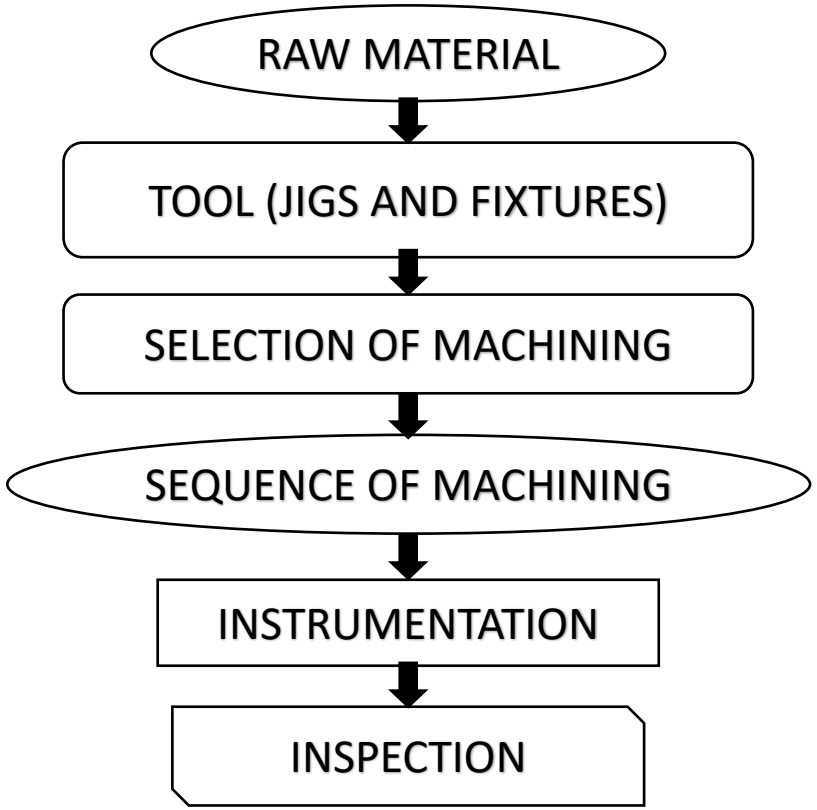
Full Cutting Profile Tool



Manufacturing of cutting tool

Based on our requirements, this below process planning is done

PROCESS PLANNING

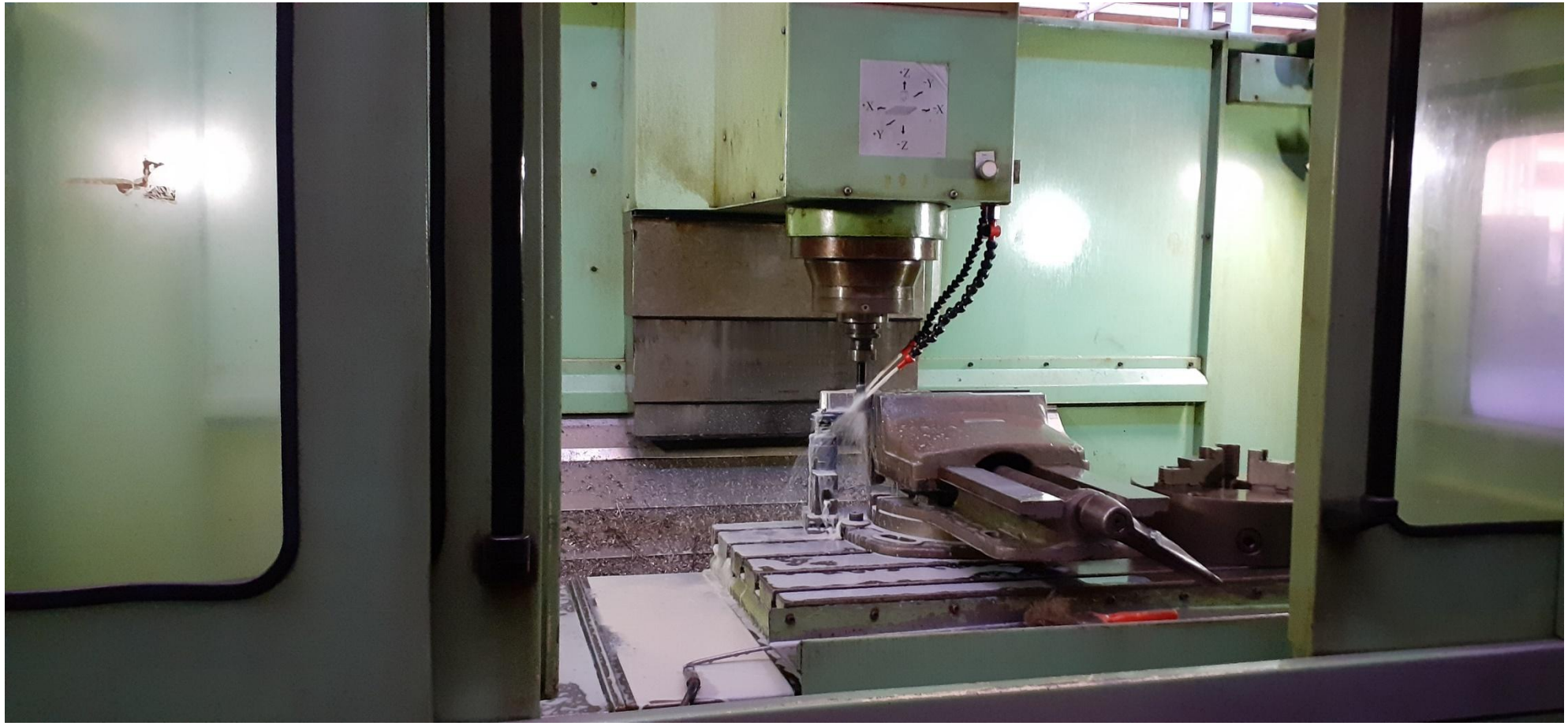


Raw Material

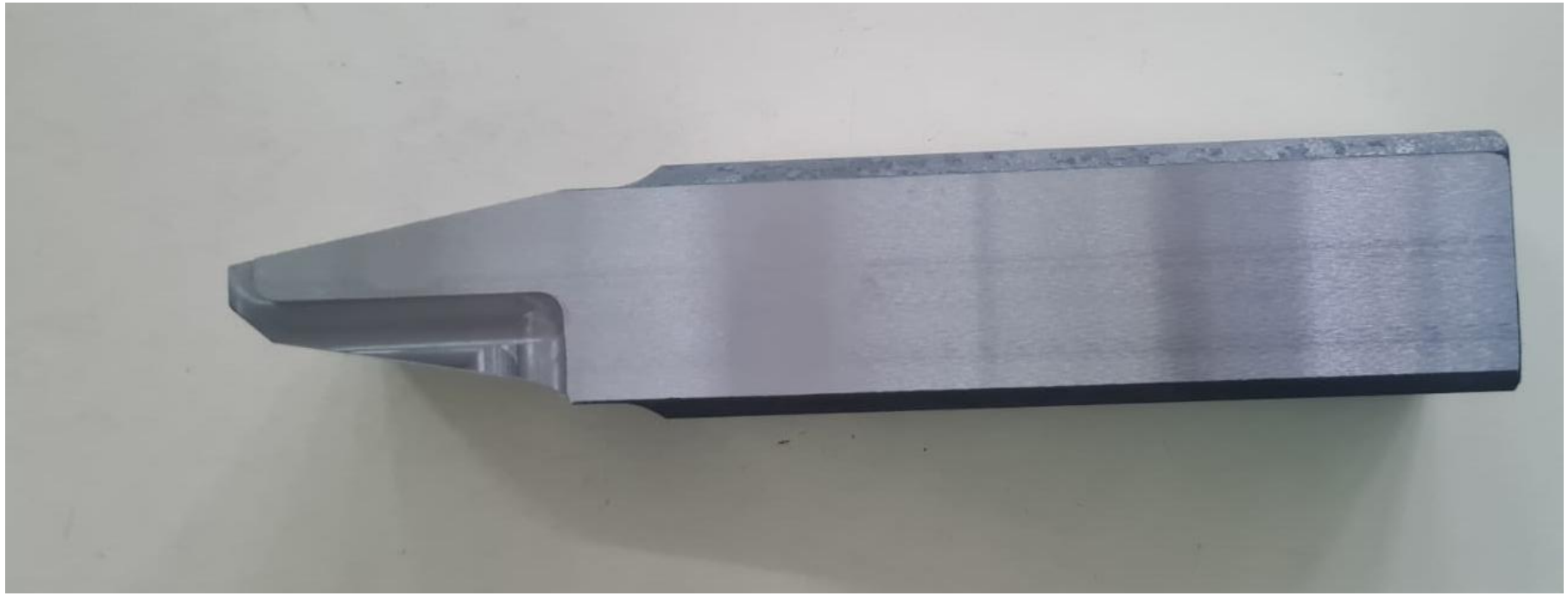
EN24

TUNGSTEN CARBIDE(WC)

MACHINING



CNC VERTICAL BORING AND MILLING MACHINE(BMV-50)



MACHINED EN24 CUTTING TOOL

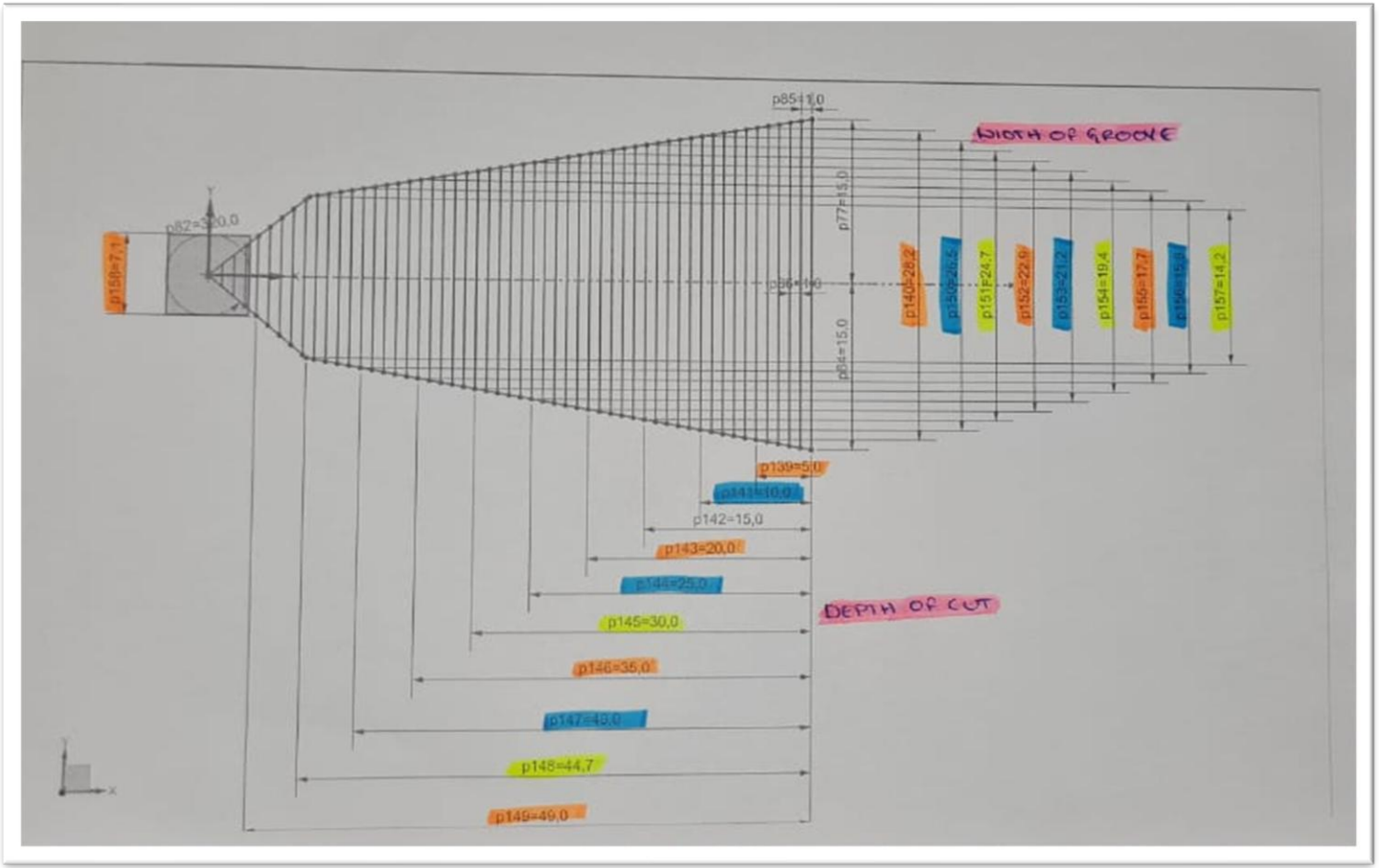
MACHINED WC CUTTING TOOL INSERT

ASSEMBLY OF CUTTING TOOL AND TOOL INSERT

Assembly of cutting tool after brazing

Strategy for Cutting profile

To align the longitudinal axis of the tool with axisymmetric profile which has been already grooved profile, And thereby plunging the profile tool with depth of cut of 0.1mm



Strategy for Cutting profile

Testing

IWCEP Machine

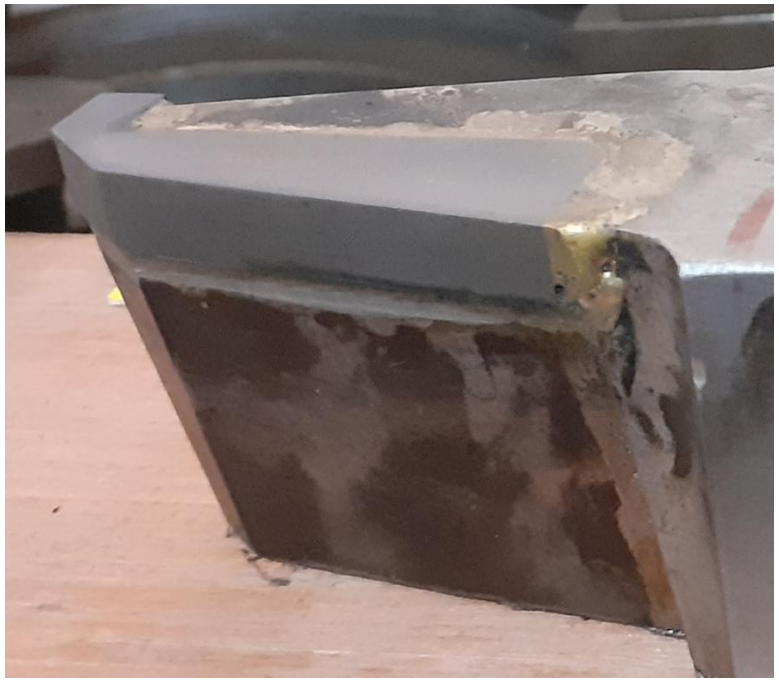
Machining Inconel shell

Machining profile on the Inconel shell

Cutting Profile

Profile tool before and after machining

Before machining

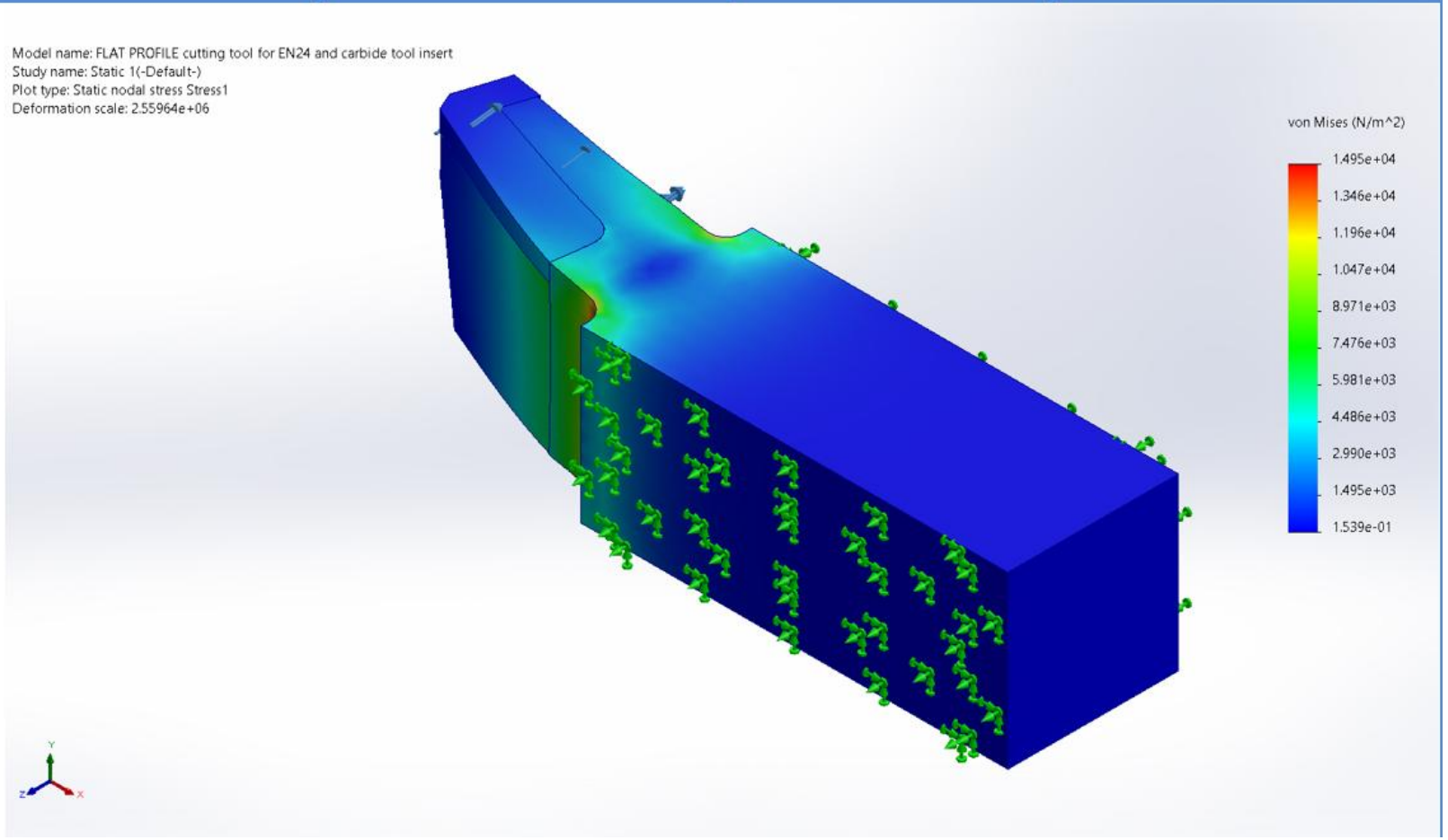


After machining

Simulation-Results

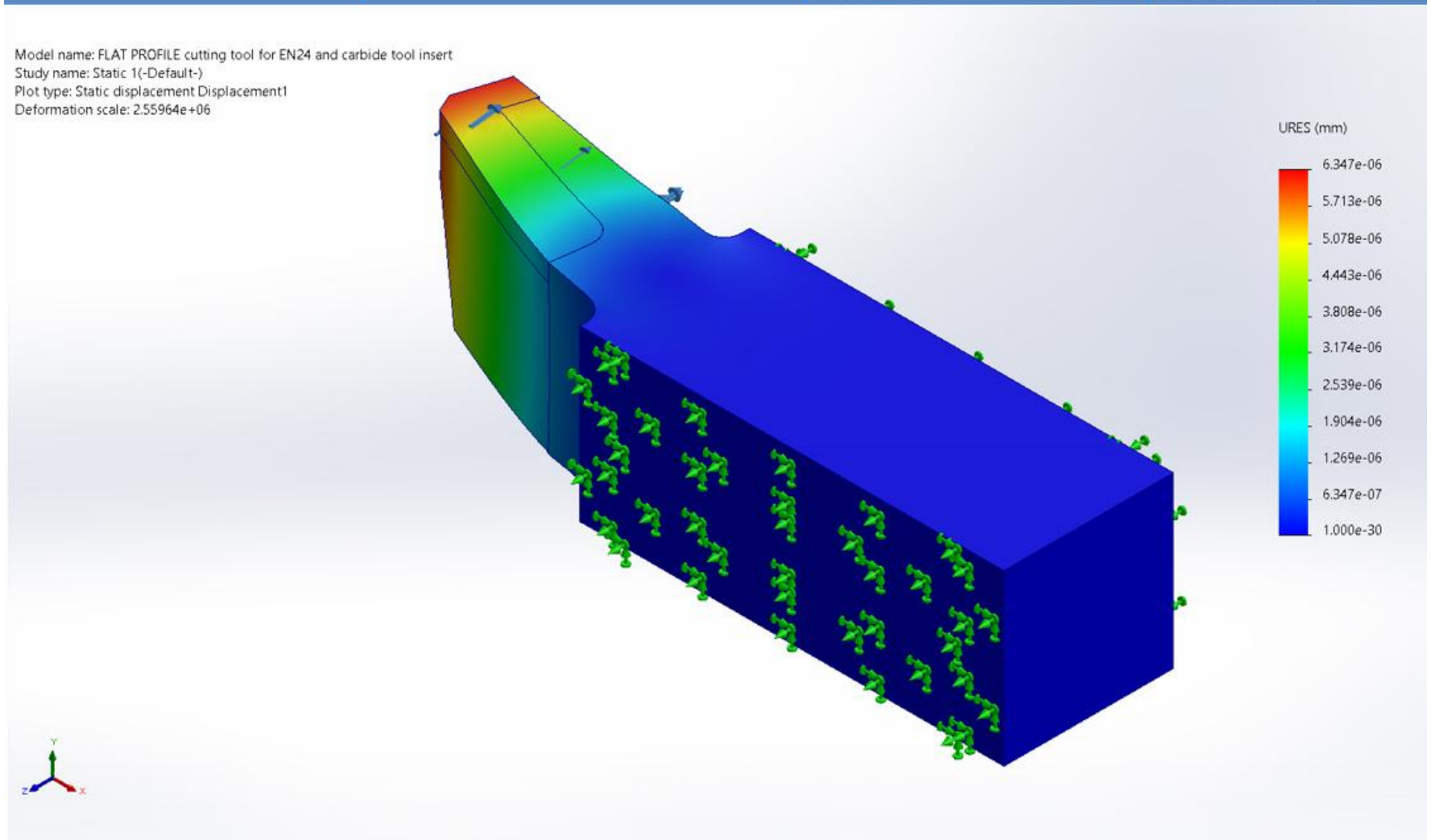
1. Stress(for load-Force 1.36N)

Name	Type	Min	Max
Stress1	VON: von Mises Stress	1.539e-01N/m^2 Node: 13608	1.495e+04N/m^2 Node: 6856



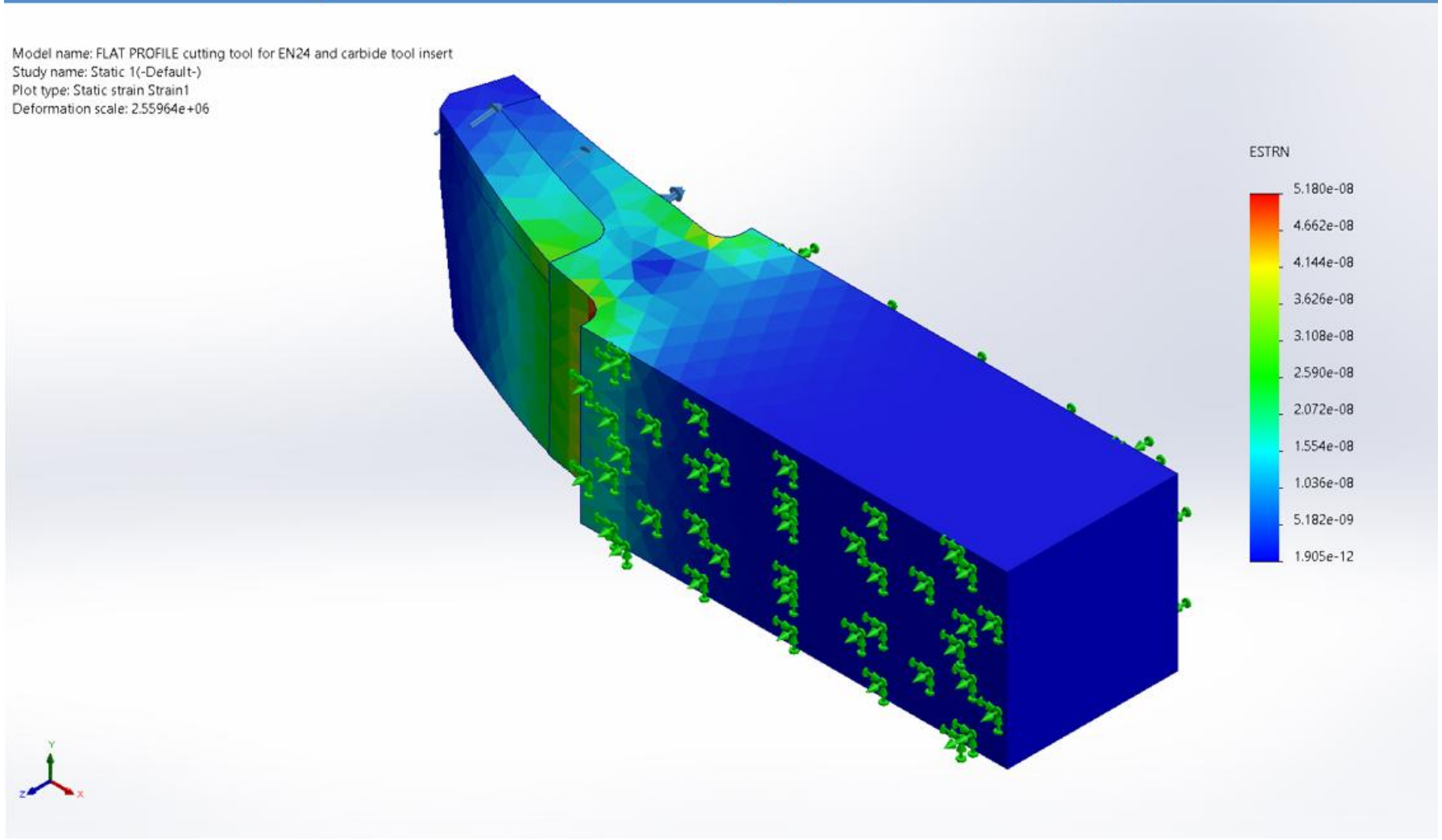
2. Displacement

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 8	6.347e-06mm Node: 15633

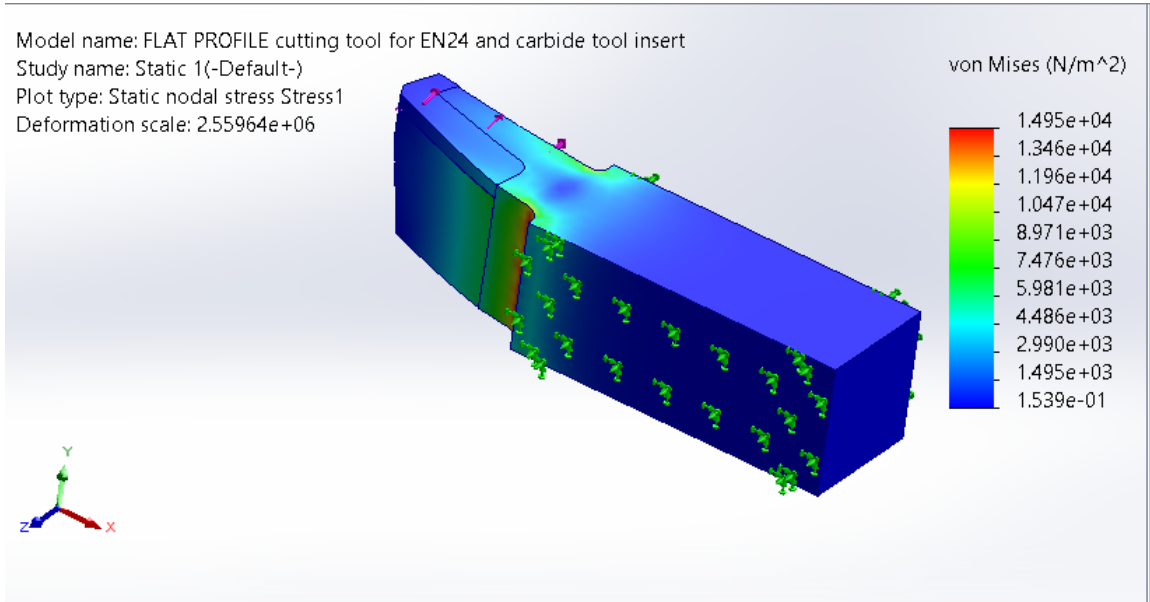


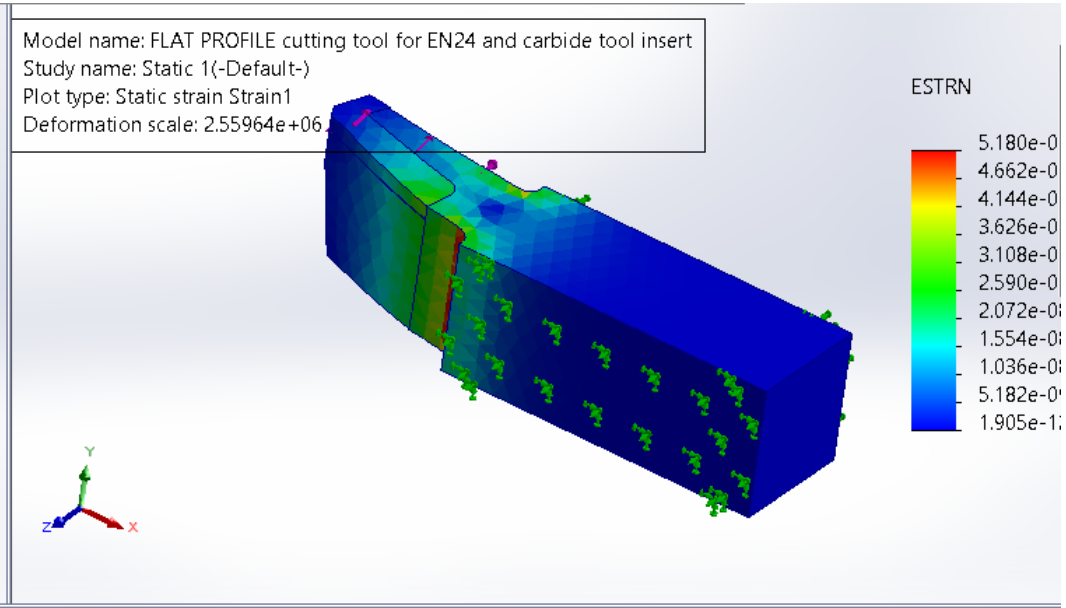
3. Strain

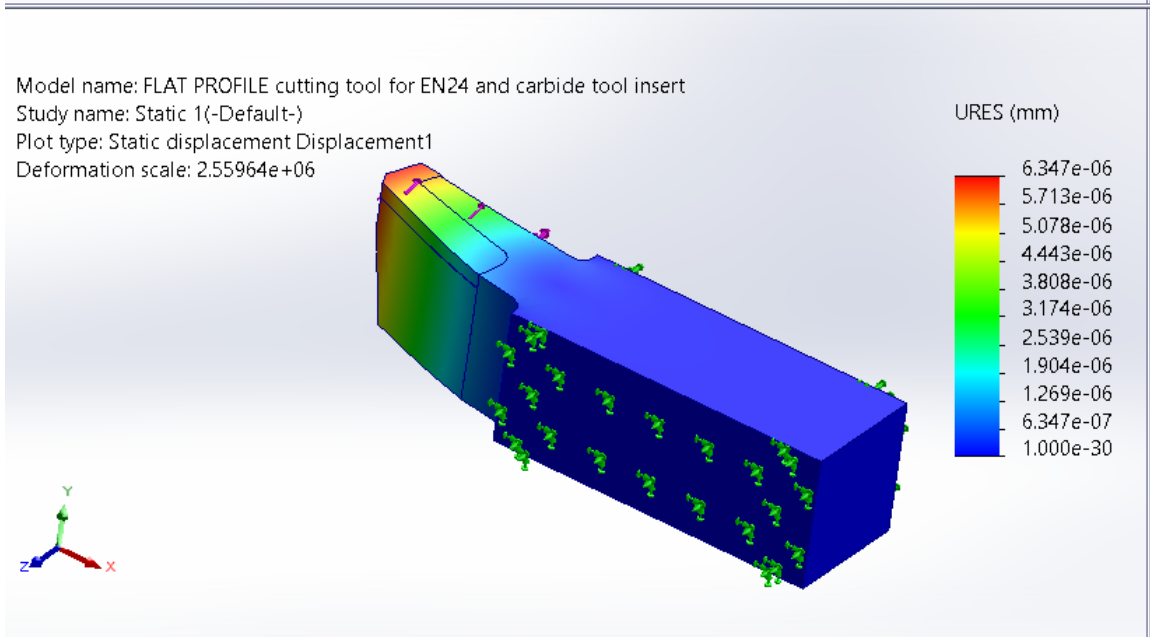
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.905e-12 Element: 4445	5.180e-08 Element: 2202

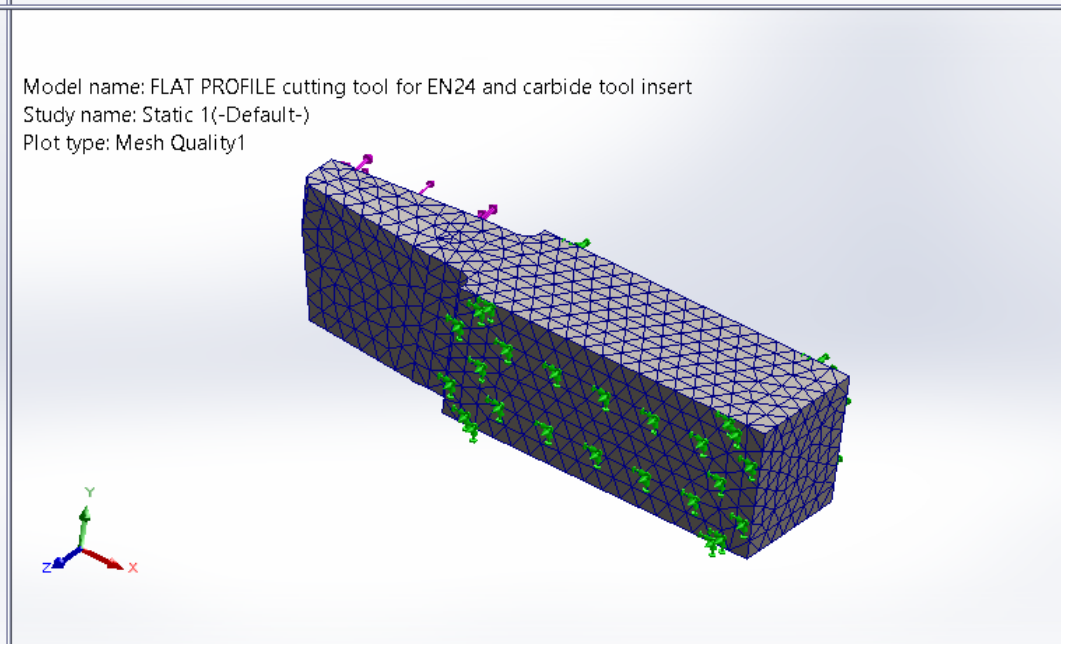


Analysis Results









Conclusion

The design and manufacturing of the cutting tool for machining the profile on the inconel shell have been completed. The cutting tool was designed based on the requirements of the machining process and the material of the shell. The cutting tool was manufactured using CNC machining techniques, and the results of the machining tests showed chip clogging in the cutting tool and noises occurring in the machine because of that side clearance angle and cutting parameters must be changed. But the cutting tool offers a long service life, good cutting performance, and a low wear rate. It is expected that the cutting tool will provide satisfactory performance in the production machining of the inconel shell.

References

1. K. Chang, D. Chiang, and B. Li, “A Study on the Design and Manufacturing of Cutting Tool for Machining Profile on Inconel Shell,” International Journal of Cutting and Forming Technology, vol. 7, no. 1, pp. 35–42, 2017.
2. K. Chang, “Design and Manufacturing of Cutting Tools for Machining Profile on Inconel Shell,” Master’s Thesis, National Taiwan University of Science and Technology, Taipei, Taiwan, Mar. 2017.
3. S. Huang and Y. Wang, “High Speed Machining of Inconel 718,” International Journal of Machine Tools and Manufacture, vol. 50, no. 8, pp. 791–798, 2010.
4. A. M. P. Almeida and M. A. P. Almeida, “High Speed Machining of Inconel 718 Using Ceramic Inserts,” Materials & Design, vol. 30, no. 8, pp. 3168–3174, 2009.
5. J. M. White and J. A. Shaw, “Influence of Edge Preparation on the Performance of Carbide Inserts in High Speed Machining of Inconel 718,” in Proceedings of the 25th International MATADOR Conference, Manchester, UK, Jul. 2011, pp. 127–132.
6. A. R. Bandyopadhyay, “Prediction Model for Tool Life in Machining of Inconel 718 with Coated Carbide Inserts at High Cutting Speeds,” International Journal of Machine Tools & Manufacture, vol. 43, no. 11, pp. 982–992, 2003.
7. Y. Zhang, Y. Yang, Z. Chen, and P. Liu, “Design and Manufacture of Cutting Tool for Machining Profile on Inconel Shell,” in Proceedings of the International Conference on Advanced Technology in Manufacturing and Materials Engineering, Taiyuan, China, Jun. 2017, pp. 1–7.
8. K. Chang, D. Chiang, and B. Li, “Tool Wear Modeling in High Speed Machining of Inconel Shell,” International Journal of Advanced Manufacturing Technology, vol. 94, no. 5–8, pp. 2395–2412, 2017.

THANK YOU

Chemical composition of EN24 Steel

Country (Region)	Standard	Steel Grade	C	Si	Mn	P, ≤	S, ≤	Cr	Ni	Mo
Britain	BS 970-1955	En24 (En24T)	0.35-0.45	0.10-0.35	0.45-0.70	0.050	0.05	0.90-1.40	1.3-1.8	0.20-0.35
	BS 970-1991	817M40	0.36-0.44	0.10-0.40	0.45-0.70	0.035	0.04	1.00-1.40	1.3-1.7	0.20-0.35

Applications

Alloy 600 is used for

- Retorts
- Muffles
- Roller hearths
- Furnace components
- Heat treating baskets and trays
- Jet engines
- Airframe components
- Lockwire
- Exhaust liners and,
- Turbine seals