Design and research on non-standard trapezoidal internal threading insert

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Design and research on non-standard trapezoidal internal threading insert

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Abstract. In order to improve the machining efficiency of non-standard trapezoidal internal thread of high-temperature alloy Monel K50 material, designed a kind of trapezoidal internal threading insert with strong targeting, used UG software establish 3D model of the insert, Vericut simulation checked the correctness of the threading size and shape, AdvantEdge simulation checked the cutting performance of different cutting tool materials, and finally obtained a non-standard trapezoidal internal threading insert with various excellent performance.

1 Introduction

With the rapid development of manufacturing industry, the manufacturing technology of our country also develops towards the trend of globalization, in the cutting system composed of CNC machine tools, cutting tools, fixtures, checking-tools and cutting workpiece, cutting tools play a very important role, their quality directly determines the level of machinery manufacturing industry, is also an important factor to improve production efficiency and product accuracy of manufacturing industry[1].

In order to solve Halliburton product’s non-standard trapezoidal internal thread with the material of high-temperature alloy K500, this paper will design a kind of non-standard trapezoidal threading insert to process the internal thread. Use CAD design the two-dimensional insert shape and use 3D software do solid modeling, then 3D model of insert is imported into Vericut simulation software to do simulation, to check whether the insert design is reasonable. AdvantEdge simulation checks various cutting performance of the insert with different coating to cut titanium alloy material, after comparison to select the coating material with superior performance, such design method can effectively shorten the product’s development cycle and save a lot of R&D costs.

2 Design of serrated threading insert

2.1 Product’s design drawings

The product is the series of parts in petroleum machinery of the U.S. Halliburton, the thread size is MODIFIED ACME-4TPI-3/8TPF, Figure 1 is local enlarged drawing of thread, it can be seen that, it is a non-standard trapezoidal internal thread.
2.2 Structural design of non-standard trapezoidal internal threading insert

The parts use the way of NC turning to process trapezoidal thread, the thread is non-standard, so for us, the thread cutting tools used by processing is a difficult problem, there is no ready-made insert, so we need to design the insert shape, according to drawing’s thread shape parameters MODIFIED ACME-4TPL-3/8 TPF and based on GB/T13576.1-2008 standards to calculate tooth size of the insert[2-3], the shape and size of metric non-standard trapezoidal internal threading insert are as follows:
By UG software to establish 3D tooth profile of special serrated thread cutting tools, parametric modeling is used to facilitate the subsequent optimization of insert size, the entity model of insert will be exported to be .stl file and provided to Vericut simulation as a cutting tool model, three-dimensional entity model is as shown in Figure (5):

![Figure 5: Three-dimensional entity model of non-standard trapezoidal internal threading insert](image)

**2.3 Vericut simulation**

Vericut simulation sets the blank model, can be imported by files (.stl) and can also build rotary parts in the software. Note: must design 3D drawing for parts imported from Design[^4^], which is ready for the follow-up detection, as shown in Figure (6):

![Figure 6: Vericut previous parameter setting](image)

When setting thread tool in tool manager, the tool library of the vericut has no special non-standard trapezoidal threading insert, so 3D insert established by 3D software needs to be imported into vericut as simulation tool[^5^], as shown in Figure (7):
After the completion of above matters and after setting machine tool, control system, processing coordinate system, work offset and program, procedure [6] is run and the thread is processed as shown in Figure (8):

![Trapezoidal threading insert is imported into Vericut](image1)

**Figure 7:** Trapezoidal threading insert is imported into Vericut

**Figure 8:** Trapezoidal internal thread peeled by simulation

2.4 Detection and comparison of thread tooth

In the analysis module, open the automatic comparison command to set various parameters, display design model in the Design to do automatic comparison with simulation parts, then can determine whether the designed threading insert is correct; the thread tooth can also be measured by the way of measurement. If the measured thread tooth has deviation with the designed, return UG to modify the size of the threading insert, repeat the above process until the processed thread meet the designed requirement. The two ways of measure thread are respectively shown in the following figures:

![Two ways of detecting thread size](image2)

**Figure 9:** Two ways of detecting thread size
3 Tool performance analysis based on AdvantEdge

AdvantEdge software is a CAE software and is used to optimize the process of metal cutting, can obtain the relevant information in the metal cutting, such as increase the removal rate of material, optimize the cutting force and cutting temperature, optimize the cutting formation, decrease the workpiece deformation in machining, reduce the residual stress, improve the product quality, the cutting performance, the cutting life, and reduce the times of site experiments\cite{6}.

High-temperature alloy material has good high-temperature strength, thermal stability and thermal fatigue resistance property, it is one of materials difficult to be machined and the machining features are as follows: The cutting force is larger and is 2-4 times of ordinary steel; The cutting temperature is high and can be up to about 1000°C; Has serious work hardening, the surface hardness is higher 50% -100% than the matrix hardness; Plastic deformation is large and the elongation rate at room temperature can be up to 30%-50%; The tool is easy wear, the common includes diffusion wear, boundary wear tip plastic deformation, crater wear and bue\cite{7,8}. Therefore, the material of tools used to cut high-temperature alloy should have high strength, high red hardness, good wear resistance and toughness, high thermal conductivity and adhesion resistance, etc.

AdvantEdge analysis should consider the tool materials and the test analysis of this paper is for three kinds of tools, which have the same cutting parameters and different materials, through comparison of temperature and stress to choose one of them as the material of insert. Workpiece size and material are set in AdvantEdge software, imported UG software to design 3D insert (.stp file), the insert materials are set: Carbide-Grade-k; Carbide-general+TiAlN (coating); Carbide-Grade-H10F.the detailed parameter set as shown in table 1:

| Number | Work piece Material | Tool Material         | Cutting Speed | Feed    | Depth of cut |
|--------|---------------------|-----------------------|---------------|---------|--------------|
| 1      | Monel K500          | Carbide-Grade-k       | 260m/min      | 0.2mm/re| 0.5mm        |
| 2      | Monel K500          | Carbide-general+TiAlN | 260m/min      | 0.2mm/re| 0.5mm        |
| 3      | Monel K500          | Carbide-Grade-H10F    | 260m/min      | 0.2mm/re| 0.5mm        |

For the tool of Carbide-Grade-k material, the simulation results of cutting temperature and force are shown in figure 10:

![Figure 10: Tool’s temperature and force](image1)

For the tool of Carbide-general+TiAlN (coating) material, the simulation results of cutting temperature and force are shown in figure 11:

![Figure 11: Tool’s temperature and force](image2)
For the tool of Carbide-Grade-H10F material, the simulation results of cutting temperature and force are shown in figure 12:

![Figure 12: Tool’s temperature and force](image)

The simulation diagram of cutting temperature and force of different tools is got through simulation research to three tools with different materials. When choosing the first kind of material Carbide-Grade-k, the highest cutting temperature of the tool is up to 782.498°C and at the same time, the cutting force of tool in X and y directions is relatively stable; when choosing the second kind of material Carbide-general+TiAlN (coating), the highest cutting temperature of the tool is up to 806.842°C and at the same time, the cutting force of tool in X and y directions is relatively stable; when choosing the third kind of material Carbide-Grade-H10F, the highest cutting temperature of the tool is up to 775.783°C, however, at the same time, the cutting force fluctuation of tool in X and y directions is large. Too high temperature easily causes the deformation or wear to the tool, to reduce the machining precision; when the cutting force fluctuation is large, the tool is easily broken, to cause parts waste. Based on comprehensive consideration to tool temperature and force, the first kind of material Carbide-Grade-k is chosen as the material of tool[9-10].

4 Conclusion

(1) The practical problems in manufacturing process are used as the object of study, by CAD software to design the size and shape of non-standard trapezoidal thread.

(2) By UG software to establish 3D entity model of cutting tool, use Vericut simulate the environment of actual processing and detect whether the designed tool shape meets the actual requirements.

(3) By AdvantEdge simulation to analyze and discuss the cutting temperature and force of tool under different materials, to choose the appropriate material.

Based on the above three points to complete the whole process such as: tool’s structure design, size detection and material selection. The above contents provide effective theory and simulation research for the design of non-standard internal threading insert, and lay a good foundation for subsequent processing and manufacturing of the thread.

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