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Innovative Solving Process Problems of Micro-Turbine Machining Using Computer-Aided Innovation Method

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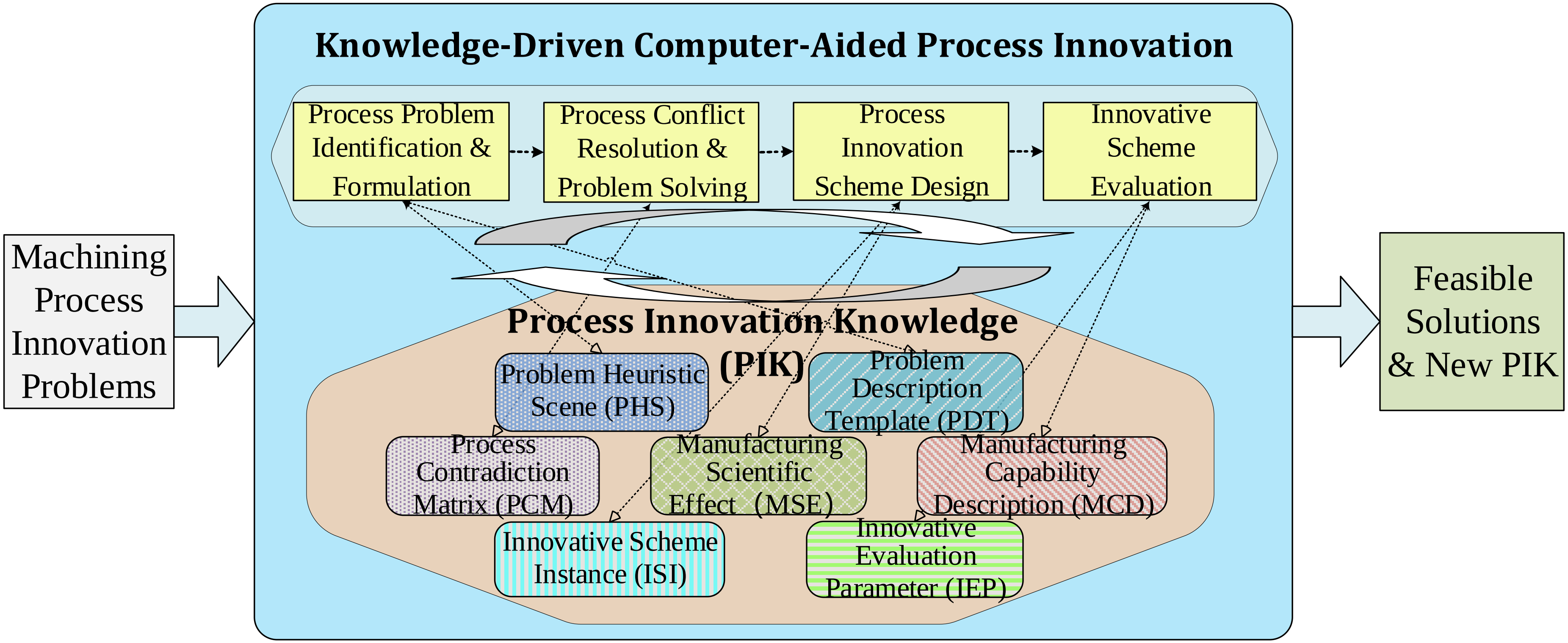
Background

In recent years, the development of my country's manufacturing technology is obvious to all. The rapid development of my country's national economy is inseparable from the rapid development of modern machinery manufacturing industry. The modern machinery design and manufacturing process pays more attention to the precision of the process. In the fields of electronics, aviation or medical equipment, the use of micro-machining technology is undoubtedly the most effective measure in the processing of small or micro workpieces.

Significance

In the microfabrication process, the processing technology and the processing methods used are very sophisticated. The use of reasonable processing procedures and processing methods is of great significance for manufacturing companies to reduce manufacturing costs, improve product quality, and gain competitive advantages. Manufacturing enterprises can also achieve industrial transformation and upgrading through process innovation, and process innovation is the basic guarantee for the ultimate realization of product innovation and the fundamental way to achieve sustainable development of the manufacturing industry.

Methods of Process Innovation



Innovative solution to the machining process of micro-turbine

Process characteristics of a micro-turbine

- （1） The thickness of the root of the blade is 1.1mm, and the thickness of the tip is 0.8mm. The blade is thin, easy to process and deform, and has poor process rigidity.
- （2） The blade has a distorted profiled surface, which may produce blind areas in processing, and the processing space is narrow, which is prone to cutting interference.
- （3） The non-through hole structure of the turbine center makes it difficult to clamp the workpiece, and the machining accuracy is not easy to guarantee.

A micro-turbine machining process problem

The four-jaw chuck that comes with the CNC machine tool cannot directly and effectively clamp the bosses and arc surface structures on the two ends of the turbine. For a turbine with a through-hole structure, after the two end faces of the micro-turbine are processed, a through hole is usually drilled in the center of the turbine to clamp the turbine.， for non-through hole turbines, this method will destroy the structural integrity of the parts themselves.

Innovative solution process of technological problems

Step one

- **Formal description of process problems**

Formal description

expectation

Subject (S)	Verb (V)	Object (O)	Parameter (P)
Turbine	Maintain	Structure	Complete

cause

Subject (S)	Verb (V)	Object (O)	Parameter (P)
Fixture	Improve	Complexity	Significant

prevent

Key words

Industry field	☑ Aviation	☐ Navigation	☐ Medical treatment	☐ Other
Manufacturing Technology	☐ Grinding	☑ Milling	☐ Drilling	☐ Other
Product/Part Type	☑ Aircraft	☐ Car	☐ Precision Instrument	☐ Other

Step two

- **Obtaining process problem solving ideas**

Process contradiction matrix unit

Parameter

Strengthening parameters		Weakening parameters	
Nature:	Single factor parameter	Nature:	Single factor parameter
System:	Artifact	System:	Fixture
Subsystem:	Workpiece structure	Subsystem:	Fixture structure
Parameter Name:	Workpiece structure	Parameter Name:	Fixture complexity
Description:	The structure of the workpiece is comple	Description:	Requires complex tooling
TRIZ Theory:	Manufacturability	TRIZ Theory:	Device complexity

Theory

Solution principle		
☐(V) Transformation (O) Workpiece structure/function	☐(V) Extract (O) Useful structure/function	☐(V) Adopt (O) periodic vibration
Corresponding to TRIZ solution principle		
☐segmentation	☐copy	☐Use cheap instead of noble

Key words

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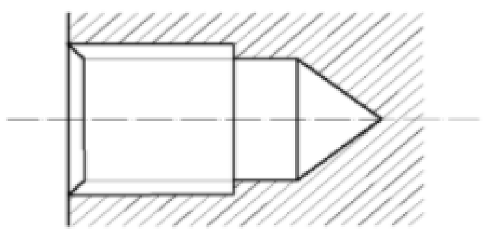
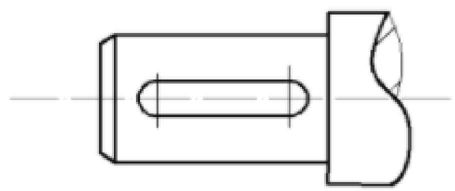
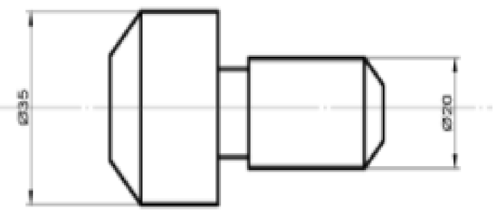
Step two

- **Create scientific effects**

Title	Manufacturing process structure ▾ [Refresh]
Principle	Change the structure of parts to improve the fixability and manufacturability.

Annex I	Annex II	Annex III
		

Typical Application

No.	Realizable function	Typical structure	Annex	
1	(Verb) change/transform (Noun) design structure	3	3	Annex
2	(Verb) add/extract (Noun) process structure	2	3	Annex

Key words

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Step three

- **Iterative solution of process problems**

For the machining of the boss on the end face of the turbine A, if the turbine is clamped by a pressure plate, it will cause the deformation of the blade; if the blade is not clamped, it will not be able to be processed. At this time, the machining quality of the turbine blades and the clamping capability of the turbine constitute a contradiction, which requires innovative solutions. The analysis shows that it is possible to make full use of the threaded hole structure of the B end surface, and self-made tooling with threaded connection to cooperate with it, thereby milling the technological boss and processing it into the final shape.

Step four

- **Innovative plan design and process test**

Under the guidance of the above-mentioned innovative principles and solutions, a simple self-made tooling was designed to realize the clamping and positioning of a certain micro-turbine blade. The clamping and machining plan of the turbine was designed in detail, and a complete technological process was formed. Then the software was used for numerical control programming, and the machining experiment of the micro turbine was carried out using the carved SmartCNC500 five-axis linkage numerical control machine tool.

Step four

Process test flow

1.Milling micro-turbine A end face to form process boss

2.Clamping process boss milling the end face of micro-turbine B

3.Clamping process boss milling micro turbine blade

4.Simple clamping and self-made tooling for milling arc surface of micro turbine A end face

- **Comparison of the machining effect of turbine blades between the process innovation design scheme and the original mandrel positioning scheme**

The rough machining turbine blade of the original plan

Rough machining of turbine blades with innovative design

Conclusion

Based on computer-aided technology, this paper establishes a formal representation model of process contradiction matrix, and proposes a process contradiction matrix construction method that obtains principle and innovative knowledge from process patents. This method not only improves the process accuracy of micro-turbine machining, but also avoids deformation. At the same time, it is of great significance to stimulate the innovative thinking of craftsmen and assist the knowledge-based systematic technological innovation design, thereby reducing the randomness, trial and error and technical difficulty of technological innovation activities, and improving the efficiency and success rate of technological innovation.

- **Thanks**