# Deformation Control Technology Research of Large Diameter Thin Plate Based on Fuzzy Evaluation Theory

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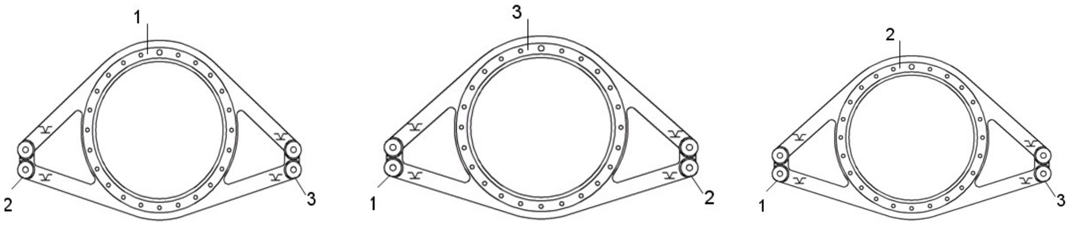
**Abstract.** Based on flexible deformation characteristics of large diameter lamella plate in high speed milling plane, it established 9 kinds of processing technology including sequence, clamping method and cutter path. Milling experiment was carried out, and got flatness value and parallel degree of three coordinate measuring machine. It used analytic hierarchy process to establish the structure analysis model of high speed milling deformation. The process plan was evaluated and optimized by means of fuzzy evaluation theory. It obtained the optimal technology method of control deformation.

## Introduction

Torque transmission plate is a typical large diameter lamella plate. It is one of key components of aircraft engine. Length of part was 1.2 m. The diameter was 60cm. The maximum thickness was 1.5cm.Due to material and structural, it had easily bended deformation easily in the actual cutting. It leaded to surface shape accuracy out-of-tolerance. It was difficult to meet the technical requirements of high performance aero engine. Therefore, how to choose the reasonable technology route is very important to control deformation of part.

## Establish processing plan of high speed milling torque transmission plate

According to the structural characteristics and process flow of torque transmission plate, it put forward three feasible machining sequence of planar milling. Machining sequence plans were shown in figure1.




a)first center again both sides b)first both sides again center c)from left to right

Fig.1 Processing order of milling plane

It chose two clamping ways by the clamping deformation mechanism and cutting experiment. First, chose pressure plate and block to clamp and fix, it was shown in figure2.Second, chose special clamp. The part was positioned on the fixture with four countersunk head screws, it showed in figure3.

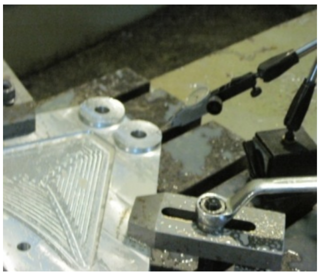
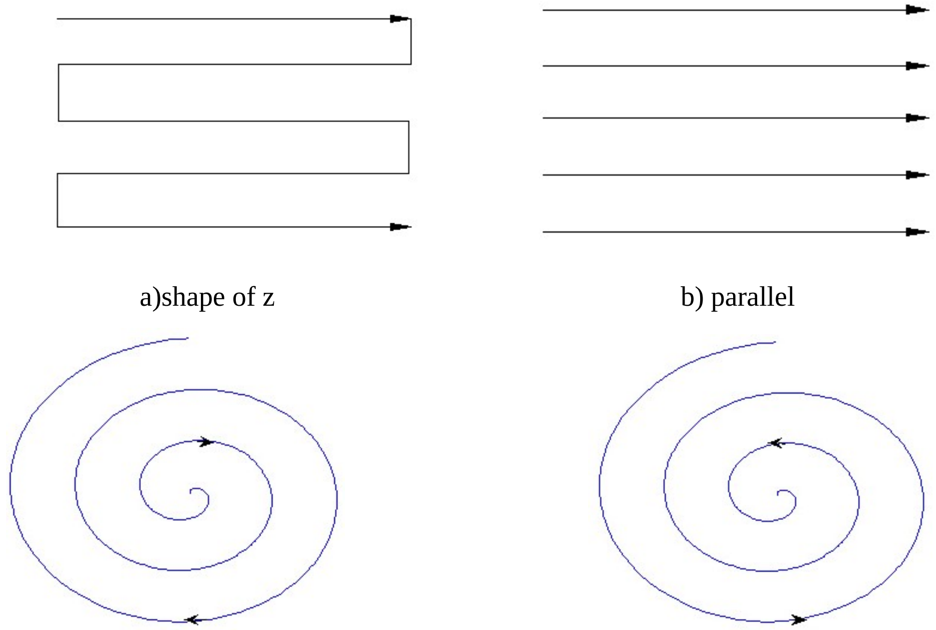


Fig.2 Platen clamp

Fig.3 Special clamp

Determined the feeding paths. Based on structure characteristics and practical experience of torque transmission plate. It selected four kinds of commonly feeding paths.It was shown in figure4.



a)shape of z b) parallel

c)inner ring d)outer ring

Fig. 4 Feeding paths

They combined into 9 kinds of processing technology with processing order, clamping ways and feeding paths.They were shown in tab1.

Tab. 1 The processing scheme

| No. | processing order | clamping ways | feeding paths |
|---|---|---|---|
| 1 | first center again both sides | platen clamp | shape of z - inner ring |
| 2 | first center again both sides | special clamp | parallel - outer ring |
| 3 | first center again both sides | special clamp | shape of z - outer ring |
| 4 | first both sides again center | Platen clamp | parallel - inner ring |
| 5 | first both sides again center | special clamp | parallel - inner ring |
| 6 | first both sides again center | platen clamp | shape of z - outer ring |
| 7 | from left to right | platen clamp | parallel - inner ring |
| 8 | from left to right | special clamp | shape of z - inner ring |
| 9 | from left to right | special clamp | parallel - outer ring |

High speed milling experiments conditions as follows:face milling tool was diameter of 100mm and 50mm. $v$=1500m/min, $f_z$=0.06mm/z, $a_p$=0.3mm. Measuring instruments: three coordinate measuring machine. The flatness and parallel degree values were shown in table2.

Tab. 2 Measured results of high speed face milling unit:mm

| No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| flatness degree | 0.050 | 0.044 | 0.03 | 0.062 | 0.056 | 0.046 | 0.072 | 0.052 | 0.04 |
| parallel degree | 0.044 | 0.034 | 0.04 | 0.054 | 0.048 | 0.04 | 0.052 | 0.04 | 0.042 |

### Established fuzzy hierarchy analysis model

The deformation factors were weight analyzed with analytic hierarchy process[1]. The analytic hierarchy structure model was shown in figure5.

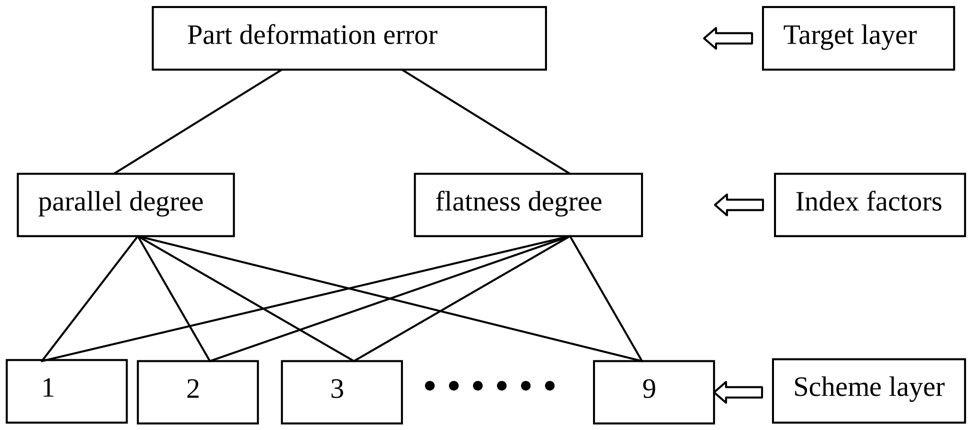



Fig. 5 Hierarchical structure model of milling deformation

### Judgment matrix of high speed milling deformation

Determine factor set and evaluation set [2]. Factor set: $X=\{x_1, x_2, x_3\}$. $x_1$ were for processing order, $x_2$ were for clamping ways, $x_3$ were for feeding paths. Evaluation set: U= $\{Y_1, Y_2\}$.
$Y_1$ was for flatness degree. $Y_2$ was for parallel degree. The level of evaluation had been divided into 9 levels. $V=\{V1, V2, \cdots, V9\}$.

Plane degree and parallel degree error value were smaller the better in evaluation index[3]. According to two index satisfaction degree, membership function was established.It was shown in formula 1:

$$r_{in} = \frac{\max(Y_{in}) - Y_{in}}{\max(Y_{in}) - \min(Y_{in})} \tag{1}$$

Among,i was for which indicators. Fuzzy relation matrix was composed of the membership value. It was shown in formula 2:

$$R = \begin{bmatrix} 0.524 & 0.786 & 1 & 0.119 & 0.31 & 0.595 & 0 & 0.452 & 0.69 \\ 0.615 & 1 & 0.538 & 0 & 0.462 & 0.269 & 0.308 & 0.5 & 0.846 \end{bmatrix} \tag{2}$$

Determined weight distribution. Used Saaty1-9 scaling method to construct judgment matrix $Am=[a_{ij}]n\times n$[4~5]. It was normalized processing for judgment matrix. It had got A′. It was shown in formula 3.

$$A' = \begin{bmatrix} 0.67 & 0.67 \\ 0.33 & 0.33 \end{bmatrix} \tag{3}$$

The largest eigenvector was weight W. It was shown in formula 4.

$$W = (0.67 \quad 0.33) \tag{4}$$

Formula of membership degree was for B=W·R . The membership value was following:
B=W·R=(0.554, 0.826, 0.847, 0.08, 0.36, 0.488, 0.102, 0.468, 0.741)

According to maximum principle of the membership degree value, plan optimization order was for3-2-9-1-6-8-5-7-4. The conclusion showed:No.3 was the optimal processing plan. The clamping way and processing order had a great effect on part deformation. The influence of tool path was smaller.It was shown that processing order change affected the redistribution of residual stress, will affect part deformation.

## Conclusions

The processing of torque transmission plate was comprehensive evaluated with fuzzy evaluation theory and milling deformation test. Used maximum membership degree principle to obtain the optimal technology method of control deformation.The method provides forecast effect for setting processing route of large diameter thin plate. It may improve original process through the optimization results. It reduces fraction defective of products and saves cost of production.

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