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Vibration Noise Analysis and Optimization of Diamond Circular Saw Blade

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1. INTRODUCTION

Diamond circular saw blade is the main tool of cutting stone, it belongs to sheet tools, and the capacity of flexural is bad, serious vibration could be produced during it works. If the vibration is too strong, the noise pollution will be caused, this has a bad effect on the operator and the equipment.

In this study, the influence of the cutting parameters (blade rotational speed, depth of cut, feed rate), saw blade diameter, friction coefficient on the noise were analyzed. The formula which is about the influence of seven factors to the noise was got , and the seven factors contain the speed, feed rate, depth of cut, diameter, thickness, friction influence coefficient and tooth number . The dynamics equation of circular saw blades was established, dynamic signal testing system was used to capture the dynamic characteristics of circular saw blades. The model of diamond saw blade was optimized by the topological in workbench, according to the optimization results, the position of the holes on saw blade were determined, the shape of the hole was designed, and diamond saw blade with law vibration and noise was produced.

2. PROBLEM DESCRIPTION

The vibration noise analysis and optimization of diamond circular saw blade is presented. The position of substrate hole of the diamond circular saw blade with diameter of 500mm is established by analyzing the vibration and noise through experiment, and then making matrix topology optimization to the blade by ANSYS.

3. METHODS

3.1 The related basic theory about vibration and noise

The diamond saw blade's working mode vibration modes are shown in Fig.1. As transverse vibration is the main vibration form that leads to the failure of diamond circular saw blades. Therefore, this study focus on the transverse vibration of diamond circular saw blade.

Saw blades vibration
1. Radial vibration
2. Torsional vibration
3. Transverse vibration

Fig. 1. Vibration of the diamond saw blades

The diamond circular saw blade is simplified as a thin plate, which based on Kirchhoff's simplified theory of bending thin plate with small deflection. The noise of diamond circular saw blade is steady-state and wide-band noise, A weighted sound pressure level is used to evaluate the noise.

3.2 The analysis about noise of diamond circular saw blade

In the experiment, TEC—1352H noise meter is used to measure noise. There are two ways of frequency weighting characteristics: A and C, with the measurement accuracy of ±1.5dB and the resolution of 0.1dB .The sound level meter is fixed on the tripod, and the microphone is 30mm away from the cutting machine surface during the measurement. Slow gear is used to take the average reading with 1 second sampling interval .

Fig. 2. TEC—1352H sound level meter

According to all the factors that may affect the noise of diamond circular saw blades, an orthogonal experiment with seven factors and two levels is designed (as shown in Table1) to study the contribution of blade speed, feed speed, cutting depth, blade diameter, matrix thickness, tooth number and friction coefficient with cutting material to noise.

Table 1. Data of seven factors two levels orthogonal experiment

Test No.	Rotation speed	Feed speed	Cutting depth	Blade diameter	Matrix thickness	Friction coefficient	Tooth number
	V(r/min)	F(mm/r)	h(mm)	D(mm)	L(mm)	u	n
1	300	30	5	400	3	0.7	20
2	300	30	5	500	4	1.2	24
3	300	45	10	400	3	1.2	24
4	300	45	10	500	4	0.7	20
5	800	30	10	400	4	0.7	24
6	800	30	10	500	3	1.2	20
7	800	45	5	400	4	1.2	20
8	800	45	5	500	3	0.7	24

The empirical formula of cutting noise is obtained as follows:

$y = 5.381+0.02297x_1+0.154667x_2+0.775x_3+0.04795x_4-2.31x_5+5.89x_6+0.32x_7$

Where x_1 is rotation speed, x_2 is feed speed, x_3 is cutting depth, x_4 is blade diameter, x_5 is matrix thickness, x_6 is friction coefficient, x_7 is tooth number

3.3 The analysis about vibration modal test analysis

In this experiment, the pulse excitation method is used, which applies exciting force to circular saw blade first, and then measures vibration. The force hammer with force sensor can send out exciting force, and the vibration measurement signal can be received by the sensor magnetically attracted on the circular saw blade. The measured signal is transformed by FFT in the analyzer, and the modal parameters can be obtained according to the solved frequency response function. The type of the equipment is shown in Table 2.

Table 2. Information of modal test equipment

Instrument	Instrument model	Manufacturer	Effect
Hammer	FC43	Donghua dynamic testing company	Generating an excitation signal
Force sensor		Donghua dynamic testing company	Picking the force signals
Acceleration sensor	CQV9345	—	Picking vibration signals
Charge regulator	DH5857	—	Piezoelectric sensor signal transmission
Dynamic test analyzer	—	—	Collecting and analyzing signals
Analysis software	4633 dynamic signal test and analysis system	Donghua dynamic test technology co. ltd	Experimental modal analysis

After sampling, use modal analysis software to import the measured frequency response function. The superposition curve of frequency response function is shown in Fig 3.

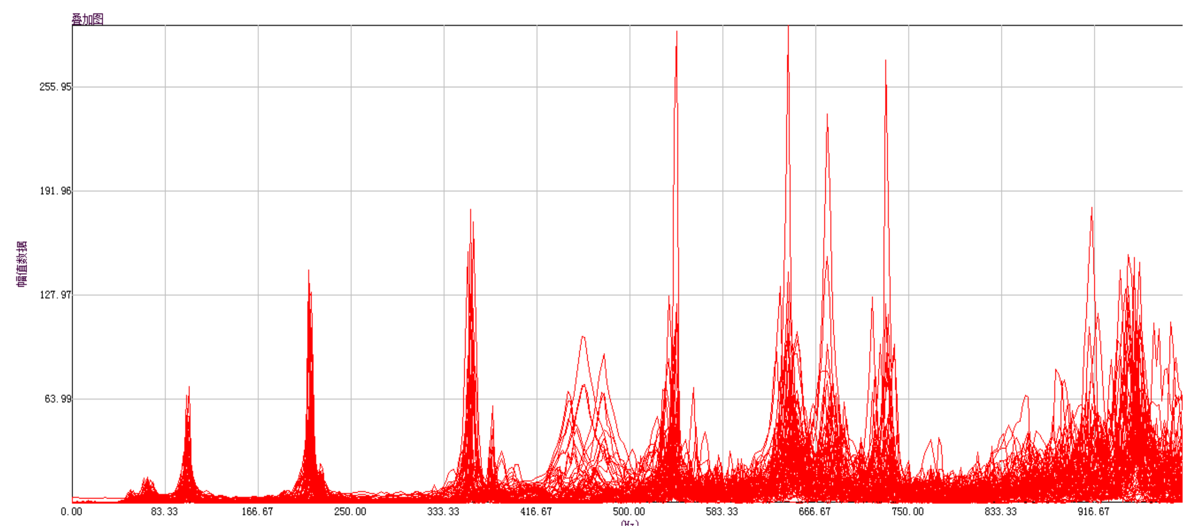

Fig. 3. Superposition of frequency response function curve

After analysis by real modal software, the natural frequencies and damping of various modes of diamond circular saw blades are shown in Table 3.

Table 3. Modal nature frequency and damping of ϕ500 saw blades

Modes	1	2	3	4	5	6	7	8	9	10
Frequency/Hz	35	57.5.	67.5	152.5	285	312.5	357.5	445	565	614
Damping ratio	6.85	8.13	8.83	4.16	2.55	6.09	1.75	2.41	2.22	6.85

3.4 Optimization design

Through topology optimization of diamond circular saw blade with diameter of 500mm, the saw blade has 24 serrations, and every three adjacent serrations can be divided into eight groups, and each group of serrations is optimized. Finally, the position of the opening on the saw blade base is determined as shown in Fig.3.

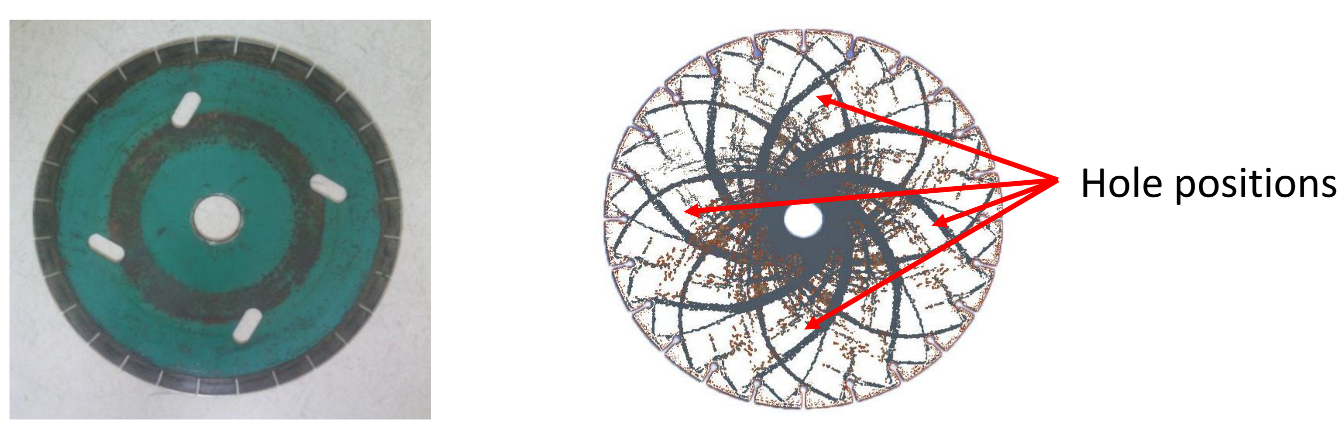

Fig. 3. The positions of the holes

4 Conclusions

In this study, the noise and vibration characteristics of diamond circular saw blade are analyzed. Based on the analysis results, the topology optimization function of ANSYS Workbench is used to optimize the diamond circular saw blade with four holes in the matrix. After optimization, the noise of saw blade can be reduced by 4.8%.

References:

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