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SOUND INTENSITY MEASUREMENT AND ANALYSIS APPLIED TO NOISE CONTROL OF A NEW TYPE OF HIGH SPEED LATHE

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1. INTRUCTION

The research work discribed in this paper is aimed at analyzing and controlling noise of a new type of high speed lathe. The main characteristic of this lathe is that its headstock was designed with a separate model, which ensures a high rotational precision and good dynamic performance to spindle. The lathe is with a highest spindle rotational speed of 2000 r.p.m. and main motor power of 11kW. According to the empirical formula[1] obtained from statistical data of noise of ordinary lathe, it is estimated that the highest noise level of the lathe would be about 88dB(A), so its noise is serious. In order to adopt a reasonable measures of noise control, it is necessary to analyze quantitatively sound field around the lathe.

This paper states the application of sound intensity to noise analysis and control of a new type of high-speed lathe. Traditionally, sound field of lathe is measured by sound pressure level, which can not supply the accurate data of sound field distribution. Otherwise, by using sound intensity measurement, not only the precise result of sound power level whole lathe, but also the Intensity Map, which indicates the distribution of sound field around the lather and amplitude and position of the highest level, can be obtained.

By intensity measurement, it is known that the highest sound power level of whole lathe was 96.6dB(A). The Intensity Maps point out that the noise are mainly from spindle box, feed box and exchangeable gears set, and the noise from the motor also is not negligible. According to the results of intensity measurement, a light metal installation used to insulate sound was designed to control the noise of the lathe. The damping treatment of the sound insulation installation have been done for reducing its sound ratiation, and whole sound power level was reduced to 88.4dB(A). By the results of instensity measurement after damping treatment, the sound absorbing material was add in the instsllation to further improve the insulation sound performance, and decrease the sound leak of holes on it and reverberation in it. Final measurement shows that the highest sound power level of entire lathe is reduced from

96.5dB(A) to 83.2dB(A).

The research work described in this paper has shown that sound intensity can supply the quantitative and location analysis of sound field around lather, which is useful to industrial noise control.

2. SOUND FIELD ANALYSIS OF THE LATHE

The B&K Dual Channel Signal Analyzer Type 2032 and B&K Sound Intensity Probe Type 3519 are used to measure the sound power level of whole lathe and sound field distribution around it. The experiments were done at various spindle rotational speeds and experiment conditions. A cubical-shaped measurement surface, which involes the headstock and is near to the container of lathe (200mm interval), was used (Fig.1). The measurement results can give the best information about the distribution location and strength of the noise sources. Thus the source location and source ranking is very easy to carry out.

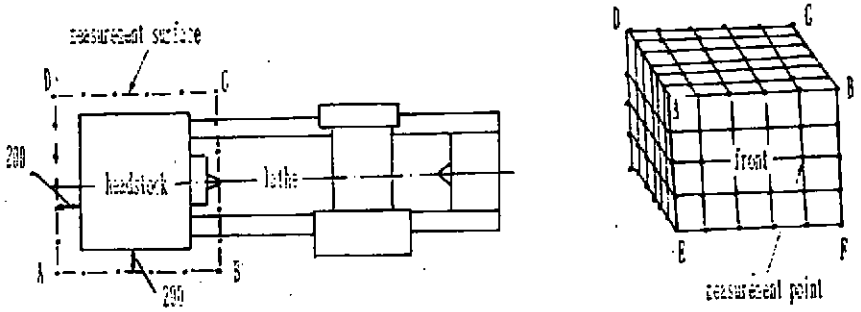


Fig.1 The sketch of measurement surface and measurement points

2.1 The Sound Power Level of Whole Lathe

By the intensity data obtained at each points on measurement surface, the overall sound power of the lathe was obtained. The spindle rotational speed under experiment are respectively 800 r.p.m. and 2000 r.p.m.. Table 1 lists the measurement results of sound power and sound

power level at various spindle rotational speeds and experiment conditions(I--There is no installation, II--There is a damping installation, III--There is a damping and sound absorbing installation). It is shown that the overall sound power level rises with the increase of spindle speed and the highest sound power level of lathe without treatment of sound insulation is 96.63dB(A).

Table 1. Sound Power Level of Whole at Lathe Various Experiment Conditions

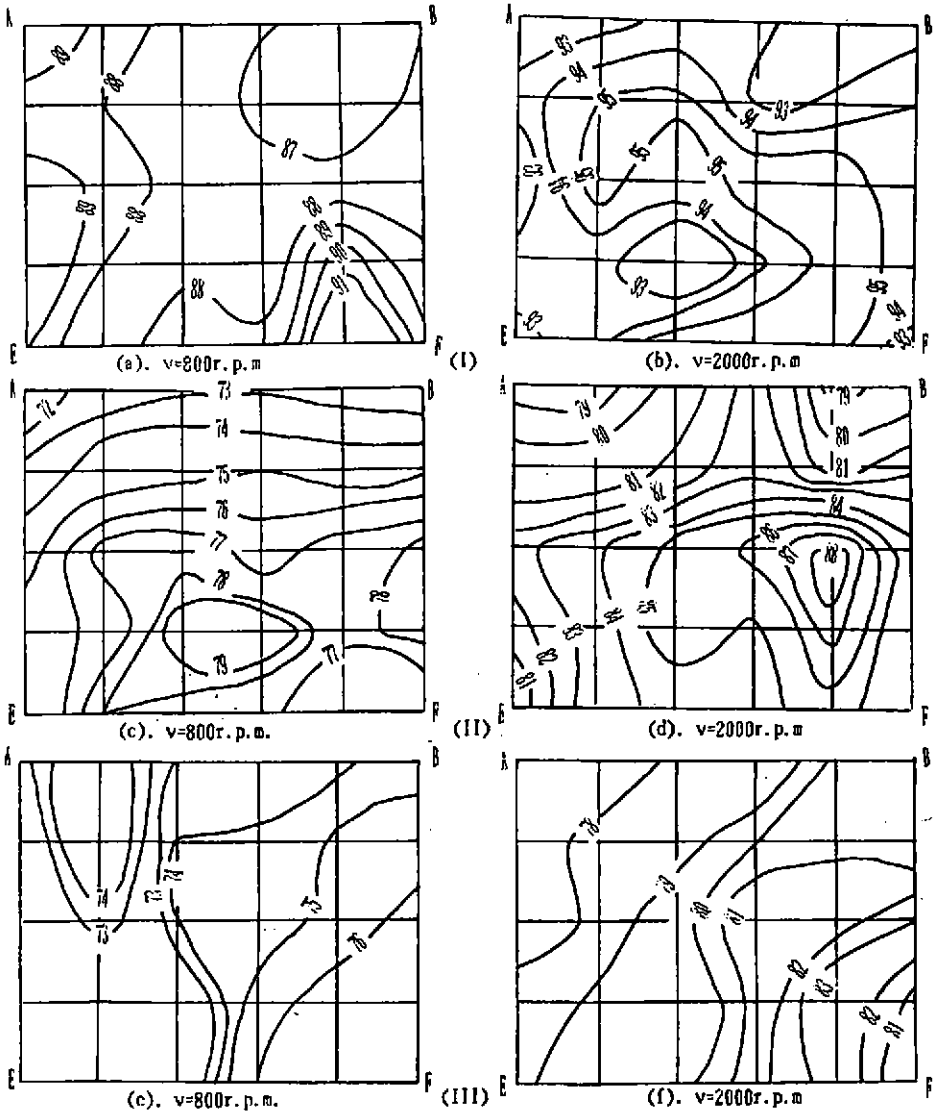
experiment conditions	I		II		III	
spindle speed (r.p.m.)	800	2000	800	2000	800	2000
sound power (mw)	1.56	4.61	0.21	0.69	0.064	0.21
sound power level(dB(A))	91.94	96.62	83.24	88.41	78.08	83.24

2.2 Noise Sources Identification

Based on the sound intensity data measured at each point on measurement surface, the sound intensity map of headstock are given. Fig.2(a).(b) is the map in the front of lathe without installations. Because near field measure method was used, the location of sound sources, sound levels and sound field distribution can be determined accurately by intensity map. From Fig.2(a), it may be shown that the regions with higher intensity levels (91dB(A)) and 89dB(A)) are respectively corresponding to the location of right end of feed box and exchangeable gears set at the spindle speed of 800 r.p.m.. When spindle speed increased to 2000 r.p.m., location of highest level (95dB(A) ,Fig.2(b)) is changed due to change of engage relation and the main source are spindle box. Moreover, the motor become one of main source with increase of the spindle rotational speed.

3. ANALYSIS OF SOUND INSULATION PERFORMANCE OF LATHE INSTALLATION

The Insertion Loss(IL) is used to indicate the sound insulation effect of installation,



v-- spindle rotational speed

Fig.2 Suond intensity map in the front of the lathe

SOUND INTENSITY ANALYSIS

$$IL = Lw_1 - Lw_2 \qquad dB(A)$$

where Lw_1 ---- overall sound power level of lathe without installation

Lw_2 ---- overall sound power level of lathe with installation.

The IL is the difference of sound power level of lathe without and with installation. The larger the IL is, the stronger sound insulation capacity of installation is.

On the basis of above measurement data of the new type of high speed lathe, a light metal installation was designed. It is made of thin steel sheet and shown in Fig.3. To restrain the intense sound radiation of thin steet excited by sound and vibration, a optmization treatment of damping for installation has been done. Fig.4 is the curves of insertion loss of the specimen of insulation. The speciment is a sheet of steel panel with size of 1m×1m×1.5mm and was treated by constrained damping. Damping treatment has restrain the resonance of installation, so it insulation ability was improved. The specimen is conducted in a special sound exciting equipment and the test setup can be seen in Fig.5.

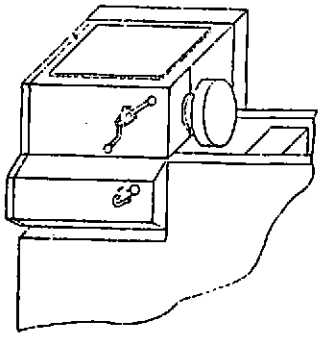


Fig.3. Sketch of installation contour

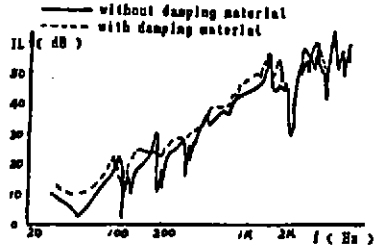


Fig.4 Sound insulation performance test of a 1.5×1.5×1000 mm steel plate

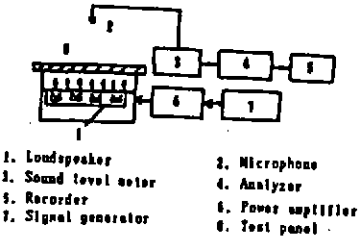


Fig.5 Setup of sound insulation test

After lathe is fitted with damping installation, the same measurement mentioned above was done. The sound power level of lathe with damping installation are listed in Table 1 (3th column). Compared with that without installation, it may be seen that the insertion loss (IL) of damping installation is about 8dB(A), which indicate that it has a good effect to reduce noise. Fig.2(c)(d) show the sound intensity map in front of lathe with damping installation. Contrasting Fig2. (c)(d) to Fig.2(a)(b), there are a obvious changes of sound fields. By Fig.2(c)(d), it is known that the highest levels is due to leakage sound at joining of installation when the spindle speed is 800 r.p.m., and highest level (88dB(A)) is also due to leakage at hole made for need of operation mechanism when speed is 2000r.p.m. The experiment results indicate that leakage sound is main cause interfering further improvement on noise reduction ability of installation.

Because surfaces of headstock and installation are all flat and they are parallel, a strong reverberation sound field was produced, which not only strengthens leakage sound also excited the installation to radiating noise. For this reason, the sound absorbing material was add in damping installation to decrease the sound leak of holes on it and reverberation in it, and further improve the insulation sound performance of installation. Finall measurement results can be seen in Table 1 (4th column) and Fig.2(e)(f). The IL of installation with damping and absorbing material is about 13 dB(A). Comparing Fig.2(e)(f) with Fig.2(a)~(d), it is shown that sound fields around lathe become even and sound level is decreased. Reverberation is weaken after addition of absorbing material, so sound leak is not still the main factor influencing sound insulation performance of installation.

4. CONCLUSION

To control the noise of a new type of high speed lathe, the sound intensity was used to measure and analyze its sound characteristic and overall sound power level. By intensity map of the lathe, the sound field distribution, intensity level and noise source location, before and after installation is fitted, can be point out accurately. The results indicate that the noise of lathe studied in this paper is main from its gear drive system. This lathe have a complicated drive system and large motor power, so adopting a damping installation to reduce its noise would be convenient and effective. In the design of installation, the constrained damping

treatment and absorbing material were used. The insertion loss of light metal installation is about 13dB(A). The highest sound power level of lathe is reduced from 96.6dB(A) to 83.2dB(A).

5. REFERENCES

[1]. Weak <<handbook of Machine tools>>, 1984

[2]. B&K <<INTENSITY MEASUREMENTS--The analysis technique of nineties>>, English BA 7196-11, Sep. 1985