NOISE AND VIBRATION SOURCES OF HANDHELD GRINDERS

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I- INTRODUCTION

Noise and vibration of handheld grinders is one of the most important health and safety problems at work in metal workshops, shipbuilding, ... The sound pressure levels of the grinding process are much higher than 90 dB(A) at the operator and the generated handarm vibrations (HAV) can cause serious diseases like "vibration white fingers".
The aim of this study is to characterize noise and vibration sources of portable grinders and grinding wheels and to define the ways to reduce them.

II- GRINDING FORCE

The grinding force is generated by the grinding wheel rotating at high speed on the grinded metal. This force excites both the grinding wheel and the grinded metal which can generate noise and vibrations.

A classical hypothesis was that the grinding force depends on the coarseness of abrasive grains and the hardness of the bounding. Actually, this is not true. Experiments clearly showed that the grinding force is mainly due to the buckling of the grinding wheel. This buckling can be very important, it exceeds 1 mm in some cases. Because of the buckling and the high rotation speed, the grinding is not in continuous contact with the metal work piece. The grinding force is generated when the wheel meets the work piece.

Figure 1 features a power spectrum of the grinding force measured in the axis of the wheel. The "distance" between two peaks is 100 Hz, which is the frequency of rotation in that case.

The plot of the grinding force versus time is a periodic signal (see figure 2). This signal can be divided in two components: a carrier frequency at the frequency of rotation and a random superposed oscillation. Each component has its own origin depending on buckling. The carrier frequency is due to the general or averaged buckling, and the oscillation is due to the surface roughness of the wheel.

Figure 3 presents the plot of the grinding force versus time after machining the grinding wheel to decrease the surface roughness. The machining has eliminated the surface roughness but not the general buckling: the oscillation has disappeared on the plot of the grinding force. Other experiments showed that the carrier frequency can de reduced in the same manner when eliminating the general buckling of the wheel.

Experiments also showed that the noise and vibrations can be significantly reduced when decreasing the buckling of the wheel. The noise has been experimentally reduced up to 5 dB(A) and vibrations up to 6 dB with a general buckling of less than 0.1 mm.

III- THE GRINDING WHEEL

Noise:

Figure 4 presents a typical sound power spectrum of the grinding wheel. It can be seen that the shape of this spectrum is similar to the grinding force power spectrum

A classical way of reducing the noise of vibrating objets is to add damping in the structure [1]. The modal analysis of grinding wheels has shown that the structural damping is very important. Damping is nearly 1% (and 5% in the case of specially designed grinding wheels). The damping required to obtain less than 90 dB(A) sound pressure level at the operator was calculated [2] and was found to be 15%. In practice, it is impossible to increase the damping so much, because the initial damping is already very high.

Vibrations:

The unbalance is the major source of vibrations when the grinder is running free. Experiments showed that there is a strong relationship between vibrations and unbalance of the wheel. Figure 5 presents the vibration levels measured at the handgrip versus the specific unbalance of grinding wheels.

For safe operation, vibration levels should not exceed 137 dB. This value is obtained for a specific unbalance of 250 g.mm/kg. Then, classical values of unbalance of grinding wheels is 600 g.mm/kg and higher. It must be mentioned that this unbalance is well above the norm according to the ISO 1940 standard [3]. Recommended unbalance should not exceed 63 g.mm/kg. Thus, the vibration reduction of free running grinders requires a better control of the unbalance of the wheel. This can be done setting tighter machining tolerances on grinding wheel runout and balancing with a maximum unbalance of 250 g.mm/kg which is still higher than the ISO 1940 requirements.

IV- THE GRINDER

The obvious source of noise of pneumatic grinders is the motor. The noise is generated by air discharge at the exhaust. The exhaust noise is a pure tone noise whose fundamental frequency is the frequency of rotation multiplied by the number of rotor blades. This noise can be reduced using a muffler. But this solution can generate other problems like a decrease in motor efficiency or ice buildup.

A survey study of manufacturers showed that this noise source can be eliminated by choosing the right technology for the pneumatic motor. It appears that air turbines (a new type a pneumatic motors) could advantageously replace pneumatic motors with blades. Using air turbines makes the pneumatic motor an unsignificant source of noise of in grinding process. Measurements on one grinder equiped with an air turbine reveals sound pressure levels

V- CONCLUSION

Noise and vibration reductions of the handheld grinders can be achieved by tighter control on the fabrication of grinding wheels and a better choice for the motor technology.

A decrease in the wheel buckling and runout brings about a reduction of the grinding force, thus a reduction of noise and vibrations. In the case of a grinding wheel, there is no obvious solution to reduce vibration generated noise using damping materials. The control of wheels unbalance leads to the reduction of the free running vibrations. And finally, the pneumatic motor becomes an insignificant source of noise when using an air turbine instead of a bladed rotor.

VI- REFERENCES

[1]: J-L. Wojtowicki, O. Beslin, J Nicolas,"Design of circular saw blade for quiet operation", *Proceeding of Canadian Acoustics 1994*, Vol. 22, No. 3, 1994, pp. 105-106

[2]: A. Côté, N. Attala, J. Nicolas, "Forced vibration of a thick rotating annular plate", submitted to *JVA*

[3]: ISO 1940 standard, "Qualité d'équilibrage des corps en rotation"

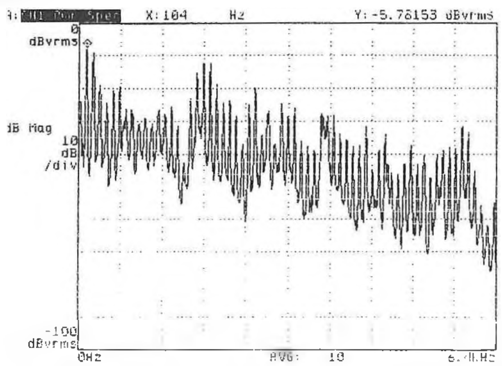
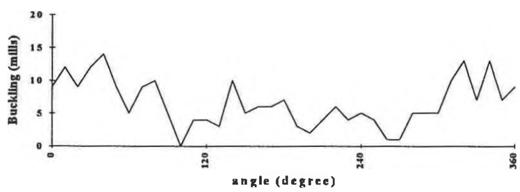
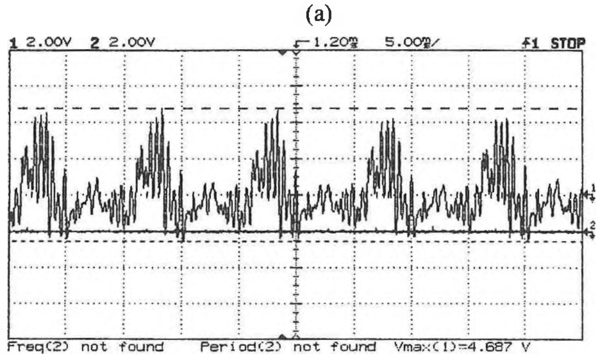


Figure 1- Power spectrum of the grinding force

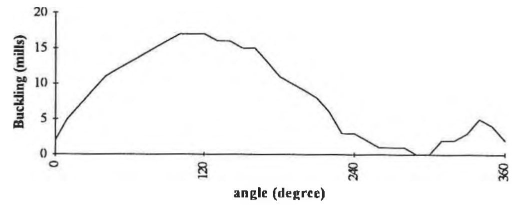


(a)

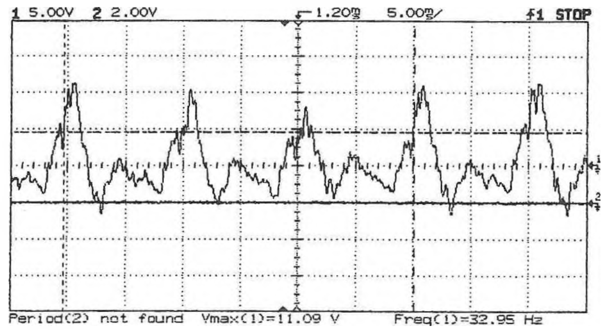


(b)

Figure 2- Buckling (a) and grinding force (b)



(a)



(b)

Figure 3- Buckling (a) and grinding force (b) after machining

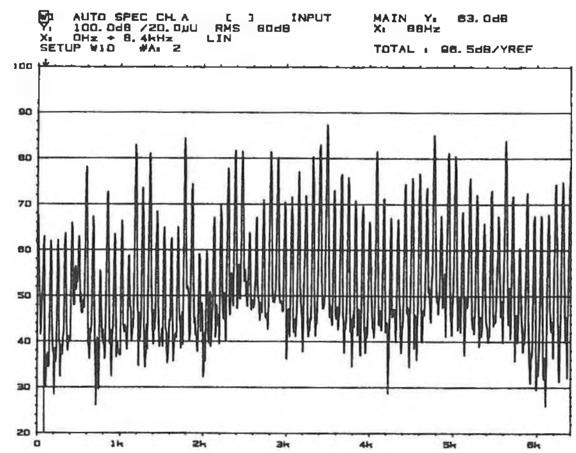


Figure 4- Typical sound power spectrum generated by grinding wheels

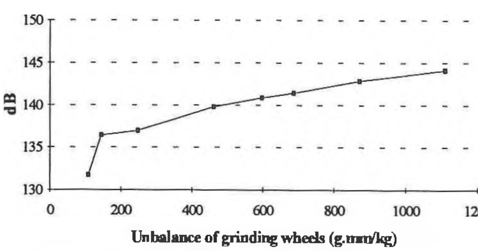


Figure 5- Vibration levels *vs* specific unbalance