Harmonic Response Analysis of Groove Vibration Polishing Machine

Xin Gao a, Yixuan Xiao b
Yingkou institute of technology, Yingkou, Liaoning 115014, China
a1124386359@qq.com, b1392336702@qq.com

Abstract. The groove vibration polishing machine is made of Q235A. The allowable stress value is
given by the yield limit. Its value is sigma s=235MPa. The harmonic response analysis of groove
vibration polishing machine is to analyze the deformation and stress distribution of the tank body
under different frequencies and excitation forces, so as to determine under which conditions the
groove vibration polishing machine has the best vibration effect. The harmonic response analysis
shows that, when the vibration frequency range is 0 ~ 25Hz and the exciting force is 50000N, the
maximum stress is 31.88 Mpa vibration polishing machine can meet the allowable stress
requirement of materials. And the overall deformation of the tank is not large, so it meets the design
requirements.

Keywords: vibration polishing machine; Frequency range; Harmonic response analysis.

1. Overview of Harmonic Response Analysis

Harmonic response analyst is a technique that used to determine the steady-state response of a
linear structure under sinusoidal loads varying with time. The purpose of the analysis is to calculate
the response of the structure at several frequencies, and to obtain the response value and the frequency
change curve. This analysis technique only calculates the steady-state forced vibration of the structure,
and the transient vibration occurring at the beginning of the excitation is not considered in the
harmonic response analysis.

Like modal analysis, harmonic response analysis belongs to linear analysis, and any non-linear
characteristics, even if defined in the analysis process, will be ignored. However, in the analysis,
asymmetric matrices can be included, such as fluid-structure interaction. Harmonic response analysis
can also be used to analyze structures with prestressing force.

2. Exciting Force Loading of Groove Vibration Polishing Machine

Harmonic response analysis assumes that the applied load varies with time according to the law of
simple harmonic (sinusoidal), so to specify a complete simple harmonic load requires input amplitude
(Amplitude, refers to the maximum load), phase angle (refers to the measure of load lag or lead and
reference time), and forcing frequency range (refers to the frequency range of simple harmonic load).
The vibration motor is mounted on the motor base on the left and right sides of the box body, and two
vibration motors are also mounted on the bottom of the box body. Fig. 1 shows the position where
the excitation force is applied to the slot vibration polishing machine.

![Fig 1. Loading](image-url)
3. **Harmonic Response Analysis of Groove Vibration Polishing Machine**

By analyzing the deformation and stress distribution of the groove body at different frequencies and exciting forces, it is determined under which conditions the vibration effect of the groove vibration polishing machine is the best. The present design scheme is as follows:

| Scheme | Frequency Range (Hz) | Load (F) |
|--------|----------------------|----------|
| 1      | 0–25                 | 50000    |
| 2      | 0–25                 | 60000    |
| 3      | 0–50                 | 60000    |

3.1 **Analysis Results of Slot Vibration Polishing Machine with Frequency Ranging from 0 Hz to 25 Hz and Load of 50000N**

**Fig 2. Deformation nephogram in Y direction**

**Fig 3. Equivalent stress nephogram**

X direction displacement harmonic response curve  
Y direction displacement harmonic response curve

(a)
Figures 2-4 show that when the vibration frequency ranges from 0 to 25 Hz and the excitation force is 50,000 N, the Y-direction displacement range of the groove body is 0.00019 mm to 0.0028 mm, and the equivalent stress range is 0.50511 Mp to 31.88 Mp. The overall average stress of the groove body is 0.05 Mp, and the main stress is concentrated on the bottom of the groove body and the front and rear steel plates.

3.2 Analysis Results of Slot Vibration Polishing Machine with Frequency Ranging from 0 Hz to 25 Hz and Load of 60,000 N
Fig. 5-7 shows that when the vibration frequency ranges from 0 to 25 Hz and the exciting force is 60 000 N, the Y-direction displacement range of the groove body is 0.0014 mm to 0.0028 mm, and the equivalent stress range is 0.101023 Mp to 63.762 Mp. The overall average stress of the groove is 0.1 Mp.
3.3 Analysis Results of Slot Vibration Polishing Machine with Frequency Ranging from 0 Hz to 50 Hz and Load of 50 000 N

Fig 8. deformation cloud diagram in Y direction

Fig 9. equivalent stress cloud diagram

X direction displacement harmonic response curve

Y direction displacement harmonic response curve

(a)

Stress harmonic response curve in X direction

Stress harmonic response curve in Y direction

(b)
As shown in Fig. 8 ~ 10, when the vibration frequency range is 0 ~ 50Hz and the excitation force is 50000N, the y-direction displacement range of the tank is 0.0007mm ~ 0.006mm. The equivalent stress range is 0.0755MPa ~ 31.94MPa. The overall average stress of the tank was 3.6MPa.

4. Analysis and Summary

Because the sieve body is made of Q235A, its allowable stress value is given according to yield limit, its value is $s=235 \text{ MPa}$, the general dynamic stress safety factor is $k_b=3~9$, and $k_b=6~9$, then

$$\left[\sigma\right]=\frac{\sigma_s}{k_b} = 39.2\text{MPa}.$$

when the vibration frequency range is 0-25 Hz and the excitation force is 50000 N, the maximum stress is $31.88 \text{ MPa} < \left[\sigma\right]$, so the vibration polishing machine can meet the allowable stress requirement of materials. And the overall deformation of the groove body is not large, so it meets the design requirements.

When the vibration frequency ranges from 0 to 25 Hz and the exciting force is 60 000 N, the maximum stress is $63.76 \text{ MPa} > \left[\sigma\right]$, so the vibration polishing machine cannot meet the material allowable stress requirements. Therefore, the design scheme does not meet the requirements.

when the vibration frequency ranges from 0 to 50 Hz and the exciting force is 50,000 N, the maximum stress is $31.94 \text{ MPa} < \left[\sigma\right]$, so the vibration polishing machine can meet the allowable stress requirements of materials. However, the deformation of the latter is larger than that of the former when the vibration frequency ranges from 0 Hz to 25Hz.

References

[1]. long shiqiu, finite element method, Beijing: people's education press, 1978.

[2]. Ni Dong, duan jin, xu jiucheng, general finite element analysis of ANSYS7.0, electronic industry press, 2003.9.

[3]. Li tiexiang. Domestic deburring and surface finishing technology. Dalian machine tool research institute, 1996.4.

[4]. wen bangchun, liu shuying et al. Theory and dynamic design method of vibration machinery. China machine industry press.2001.10.

[5]. Mechanical design manual. 4th edition, vol. 5. Chemical industry press.2004.1.