

The Analysis of a Vibrator Oil-stirring Phenomenon and Study on a New Structure

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Abstract: *The deep vibrator is an important equipment of foundation improvement. It works through eccentric masses with high-speed. But the traditional eccentric structure will stir the oil around it , and it will result in the loss of motor power. The paper analyzed the stirring phenomenon , and got the level and specific data of stirring and swirling through fluent software. After principle analysis , a new type of anti-churning eccentric structure was put forward , which can effectively avoid stirring phenomenon. Otherwise , the new structure will also not produce irregular vibration because of swirling , then it can work with a better performance. In addition , the contrast of dynamic performance between a traditional and new structure was carried out in the paper and proved that the new structure has a better working performance. Modeling data in the paper is from surveying and mapping , so the conclusion can be taken as guidance for vibrator designing.*

Key words: vibrator; eccentric weight; oil stirring; fluent; dynamic properties

1 Introduction

China is a large country with different kinds of soil type , so it often appears that the soil stiffness or the compactness of soil is not good enough to meet the building requirements and we need to improve the soil. Vibroflotation method is a new soil improvement method; it realizes the rearrangement and liquefaction or physical compaction of soil through the equipment set into the soil producing transverse vibration. It is simple , convenient , low cost , and with well compaction effect , and is the preferred method of deep foundation improvement. The vibroflotation method originated in War II Germany , and with the rapid development of the construction industry and high quality construction requirements , it gets a lot of applications in our country from the 21st century. The vibrator is the main equipment of the vibroflotation method , whose structure including high speed rotating eccentric quality that will cooperate with water rushed into the ground in the work process. High speed rotating eccentric quality will produce centrifugal force providing vibration sources for soil improvement. In the

process of working , in order to take away heat from the rotation , reduce noise , prolong service life , it will often set eccentric quality in a lubricating oil chamber to improve the performance of the vibrator. But traditional eccentric quality structure will stir oil , and high viscosity oil in the process of stirring will cause the loss of power , and the eddy current phenomenon may also lead to a irregular vibration , influencing the performance. Therefore , the study on vibrator oil-stirring phenomenon is very necessary^[1].

2 A new vibrator structure without oil-stirring

The traditional vibrator eccentric parts is of the semi-circle structure , and be seted in an oil chamber with abundant oil. The semicircle mass in the process of rotation will provide vibration for oil improvement , however , it will also stir oil at the same time causing certain power waste^[2]. According to the actual surveying and mapping data , a 3D entity model was established as shown in Figure 1. The shell and some components are simplified or transparently set for observation of the eccentric structure^[3].

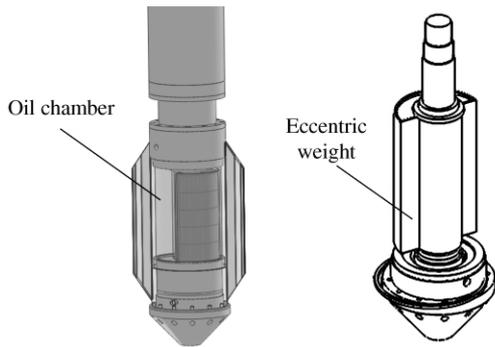


Figure 1 Traditional vibrator structure

Through the observation it is known that the rotating semicircular eccentric structure will stir the lubricant around and cause motor power waste. After the structural analysis, this paper proposed a new circular eccentric structure still in the oil chamber to produce the same centrifugal force but can avoid oil-stirring. The improved structure model is shown in Figure 2. The eccentric circle is designed into round, and filled the extra space with foam, which can avoid or reduce the loss of power and eddy current phenomenon.

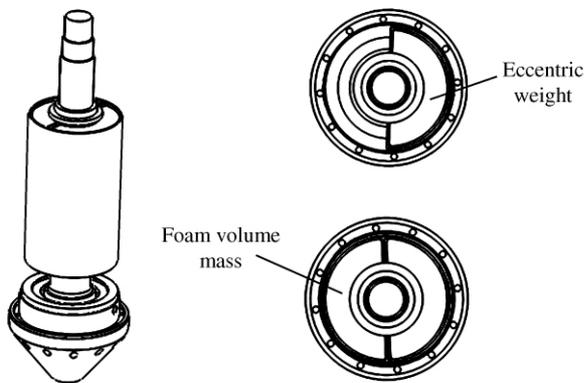


Figure 2 New eccentric structure and contrast picture

3 The analysis of vibrator eccentric structure oil-stirring

When the semicircle eccentric structure is stirring oil, it will not only produce power waste because of the high viscosity, but also will destroy the vibrator structure for the eddy current phenomenon. The paper makes a comparative analysis between traditional and new eccentric mass structure through Fluent software, and gets the relevant velocity and pressure division figures. Data setting in Fluent about the relevant parameters is shown in Table 1^[4].

Table 1 Data in fluent software

Name	Value	Name	Value
Type of vibrator	75 kW	Interface diameter	320 mm
Rotate speed	1450 r/min	Chamber diameter	330 mm
Shaft diameter	140 mm	Lubricating viscosity	8650 kg/m•s
Eccentric diameter	312 mm	Oil density	865 kg/m ³

Through the reference coordinate system modules Fluent software, a fluid analysis was made, and the fluid flow situation in the vibrator oil chamber was obtained. The traditional fluid pressure cloud picture is shown in Figure 3, and the speed vector diagram is shown in Figure 4.

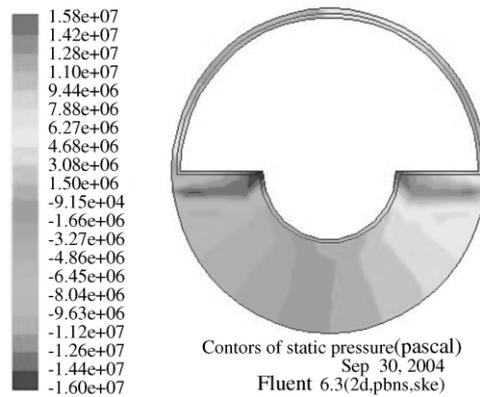


Figure 3 Traditional oil pressure distribution

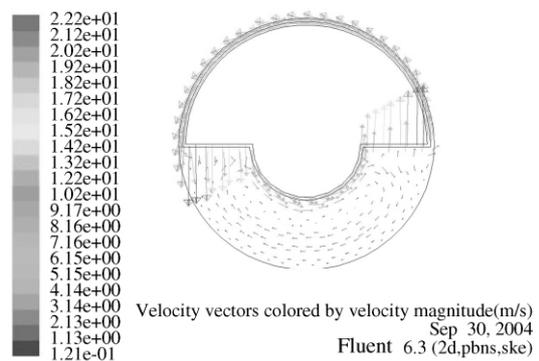


Figure 4 Oil velocity vector distribution

Through the pressure figure, it is known that the traditional structure of the eccentric structure will get greater hydraulic pressure in the two faces beside, with maxi-

imum pressure 15. 803 MPa and minimum pressure -16. 986 MPa. The pressure will produce a torque on the eccentric structure; the value can be calculated according to Formula (1) , $T = 114. 338 \text{ N} \cdot \text{m}$.

$$T = \int_a^b P \cdot Sdl \quad (1)$$

The velocity vector chart indicates that the oil gets the maximum velocity at the inlet and outlet of the gap between the eccentric structure and oil chamber wall. The maximum velocity value is 22. 24 m/s. Besides , the eddy current analysis shows that the turbulent energy in the gap is greater. In addition , the velocity vector chart indicates that the oil in the eccentric semicircle area will line to a counterclockwise backflow; such backflow of the eccentric structure will produce instant impact , and cause non-uniform vibration.

The paper changes the semicircle eccentric structure into circular , and fills the remaining space with a bubble. Then fluid analysis was made to get a new pressure and velocity vector map Figures are shown in Figure 5 and Figure 6.

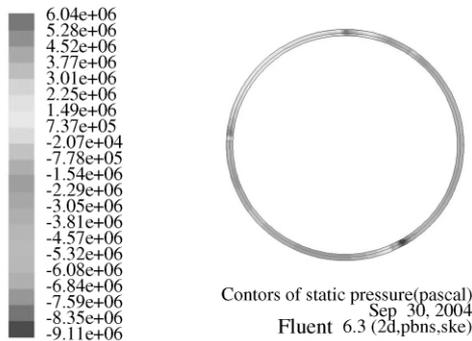


Figure 5 Pressure distribution of new structure

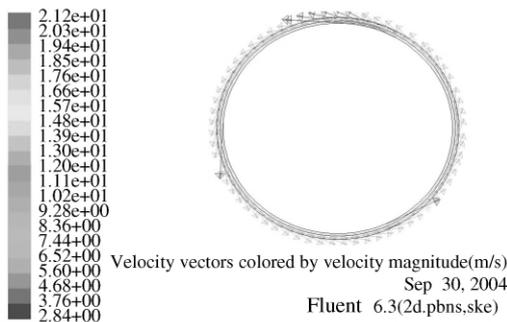


Figure 6 Oil velocity vector distribution of new structure

Analysis found that the new type of structure is of the oil pressure ranging from -9.11 MPa to 6.04 MPa. Comparing with the traditional structure , it reduced about a half , the hydraulic foreign wall requirement will become low , and round structure will not be introduced torque. The maximum speed in Figure 6 velocity vector graph is 21. 236 m/s , slightly less than the traditional structure.

The value of how much power will be saved can be calculated comparing the new and traditional structure as P_s

$$P_s = T \times \omega \quad (2)$$

The oil stirring power was calculated to be 17.7 kW; take the traditional vibration of 75 kW , the requirements to motor power will be lower 23.6 % , that the vibrator working performance can be greatly improved.

4 Analysis and contrast of dynamic properties with different structures

Through the Fluent software analysis , it shows how the eccentric structure stirs oil and gets some data , but the overall structure dynamic properties also need to be analysed to know how much the dynamic properties have been improved. The contrast of dynamic properties can be reached after analysis through the finite element software; the paper analyses the simulation of oil pressure before to add to the eccentric structure , analysis and comparison between the traditional type and new structure. Analysis of the harmonic response contrast curve is shown in Figure 7.

Through the harmonic response displacement curves , it can be known that the overall performance of the new structure was improved , and the significance is great. In addition , the requirements for the motor power become lower with the new structure. It can break through a series problems due to the motor power shortages. In 75 kW vibrator work frequency , the displacement which can represent the vibrator performance increased from 16. 163 mm to 19. 395 mm with 3 mm greater that is expected for structure design.

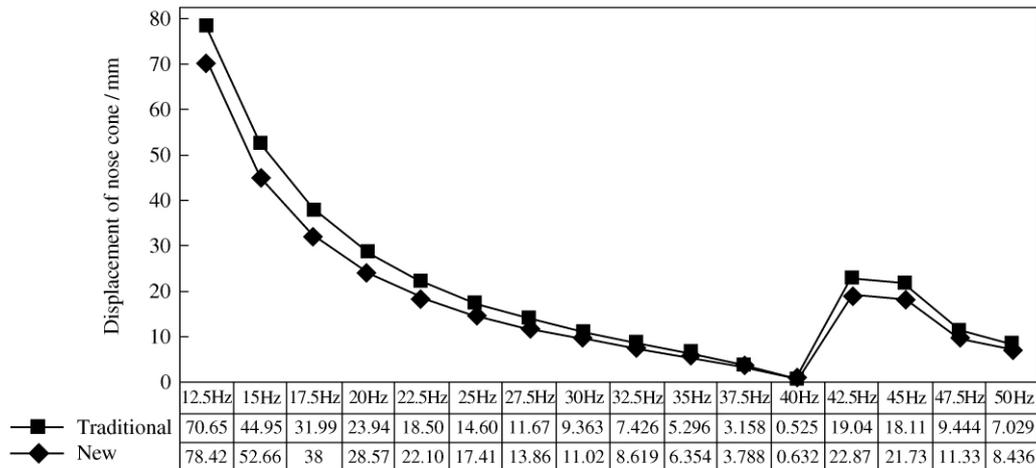


Figure 7 Harmonic response contrast curve of nose cone

5 Conclusions

This paper mainly analysed the oil stirring phenomenon of a traditional structure, and put forward the new structure through the analysis. A series of conclusions are as following:

- 1) Vibrator eccentric structure of traditional work will produce an oil stirring phenomenon, wasting a lot of motor power, and the high speed rotation will produce eddy current that will lead to an unexpected vibration.
- 2) A new structure was put forward that can greatly avoid oil stirring phenomenon, as is shown in Figure 2.
- 3) Through the Fluent software and theory analysis, it is proved that the new structure can save power for 17.5 kW, which takes 23.6% of the total motor power for the 75 kW vibrator.
- 4) Contrasting the dynamic performance between the traditional and new structure, the harmonic response curve shows that the new structure is better, and the amplitude of the nose cone increase 3 mm at the working frequency 24.2 Hz. It shows that the dynamic performance is improved.

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