A New Detection Method for Self-lubricating Spherical Plain Bearing Woven Liner Bounding Quality

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Abstract：In this paper, base on the analysis of the present detection device for spherical plain bearing liner bounding quality, a constant peel angle detection method（CPAD Method) is provided, which can detect the self-lubricating spherical plain bearing liner bounding quality more correctly. In this   new method   by exerting the peel force matched the spherical face, liner is peeled from sample at a constant peel angle , also the peel force doesn't fluctuate theoretically at a constant peel velocity. Moreover, a liner bounding quality detection device for self-lubricating spherical bearing is constructed in order to record the peel force along with peel length changes digitally.

Key words: spherical plain bearing; liner bounding quality; CPAD Method; detection device

I.   Introduction

The self-lubricating spherical plain bearing, which consists of an outer ring, an inner ring and a liner, the outer ring whose inner surface is bounded by the layer of self-lubricating woven liner [1-3]. The proprieties of self-lubricating woven liner makes the bearing achieve self-lubricating requirements in aerospace, railway mechanics etc. The main failure of liner is loosen or broken of the woven liner, which result in increasing of friction coefficient of liner and losing self lubricating function. From the background information, it was determined that the research on how to accurately evaluate the bonding quality of self-lubricating spherical plain bearing woven liner is very important in order to improve its operation performance and extent its service life[4-6].

According to the analysis of the current state of the art in peel strength detection device, this paper provides a new method (CPATM) to test the self-lubricating spherical plain bearing liner bounding quality by exerting peel force to peel liner from sample at a constant peel angle. Moreover, a liner bounding quality detection device for self-lubricating spherical bearing is constructed.

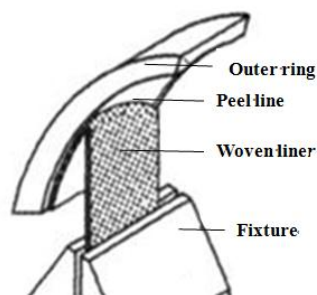## II. Analysis of the present detection device

Fig.1. Principles of the present peel strength detection device

The present detection device can be used to evaluate the liner bonding quality of self-lubricating spherical plain bearing is shown in Fig.1.The basic parameters of a test spherical plain bearing areas follows the outer ring

diameter is ϕ 35 mm, the outer ring width is 12 mm, inner ring diameter is ϕ 20 mm, the inner ring width is 16 mm, the ball diameter is ϕ 29 mm. The materials of inner and outer ring are made of GCrl5 steel and the liner is the mixed woven material of the Kevlar and PTFE fiber[7-9]. To some extent, the method can detect the woven liner bounding quality, but there are still somewhere can be improved. For example, the peel angle always changes along with the peel length changing. During peeling the liner from outer ring, it inevitably leads to the peel force detected fluctuates largely along with the peel length changing.
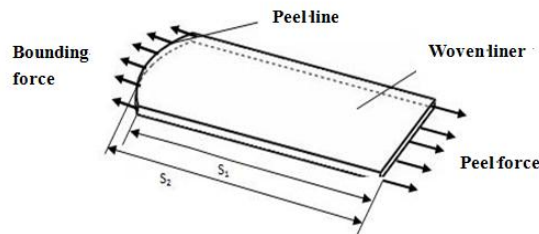
Fig.2. The force of liner at current test method

From the current peel strength test as shown in Fig.1, the free end of liner was fixed by line shape clamper, while the peel line appears like a camber as shown inFig.2. As shown in Fig.2, the distance from different points on the peel line to the corresponding points are unequal（$S_1 \neq S_2$）,which will result in that different point on peel line suffered the different peel force. Moreover, the peel angle changes during the test in current peel force test. On account of the two reasons above, the liner cannot be peeled steadily and the woven liner bounding quality cannot be accurately evaluated.

III. Constant Peel Angle Detection Method (CPAD Method)
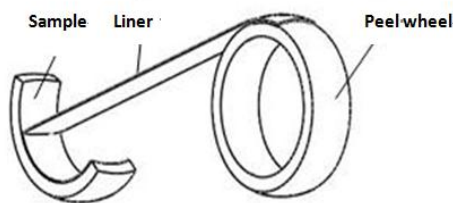### 3.1 Principles of CPAD Method

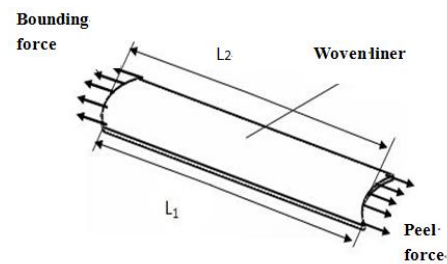**Fig.3.**Principles of the new peel strength detection device   **Fig.4.** The force of liner

This paper provides a constant peel angle detection method (CPADM), which can test the self-lubricating spherical plain bearing liner bounding quality. In the new method, which exerts the peel force matched the spherical face that can peel liner from sample at a constant peel angle and the peel force doesn't fluctuate theoretically at a constant peel velocity.

The new peel strength detection device, which includes a peel wheel whose outside spherical surface diameter is the same as the sample's inside spherical surface diameter, shown in Fig.3. As shown in Fig.4, both the surface shape of the peel line and the free end of liner was clamped by a clamp is camber. The distance from different points on peel line to the corresponding point are equal（$L_1 \neq L_2$）, which will lead every point on peel line suffered the same peel force. In this way, the peel force does not fluctuate largely during the test. Therefore, the new peel strength detection device can accurately peel liner from outer ring and effectively evaluate the liner bounding quality [10-12].

3. 2 Analysis of liner elastic deformation and compensation of the liner elastic deformation
Since the liner is made of knitted fabric, the liner elastic deformation will occur during peeling liner from sample as shown in Fig.5. Therefore, the liner elastic deformation should be considered and compensated.
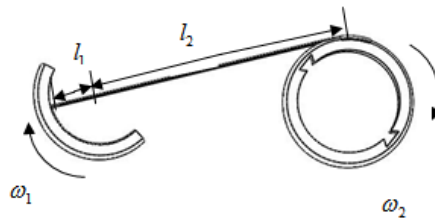
Fig.5. Principles to compensate liner elastic deformation

In order to peel the liner from outer ring steadily, it should considered how to coordinate drive peel wheel and sample to compensate the woven liner's elastic deformation. Supposing the radius of the liner's inner surface is R_1 (mm) and the sample's angular velocity is ω_1 (rad/s), the radius of peel wheel's outer ring is R_2 (mm) and the angular velocity is ω_2 (rad/s)，the length of liner free end is l_2 and the length of liner already peeled from sample is l_1 (mm), and the length of liner's total elastic deformation is Δl (mm), the strain coefficient of the liner is ε. At this time t gives

$$\omega_2 R_2 t = \omega_1 R_1 t + \Delta l = \omega_1 R_1 t + \left(l_1 + l_2\right)\varepsilon \qquad (1)$$

Therefore $\omega_2 = \dfrac{\omega_1 R_1 t + \varepsilon\left(l_1 + l_2\right)t}{R_2 t} = \omega_1 + \dfrac{\left(l_1 + l_2\right)\varepsilon t}{R_2}$ \qquad (2)

Since the R1 is the same as R2 from Fig.5, from equation (1) can get equation (2) and get the clear relationship between ω_2 and ω_1 during the test. Moreover, peel wheel and sample can be coordinately driven to satisfy the relationship between ω_2 and ω_1 in order to peel liner from sample stably.

IV. The new detection device

This paper proposes a new detection device to evaluate the liner bounding quality for self-lubricating spherical plain bearing digitally according to the analysis above.
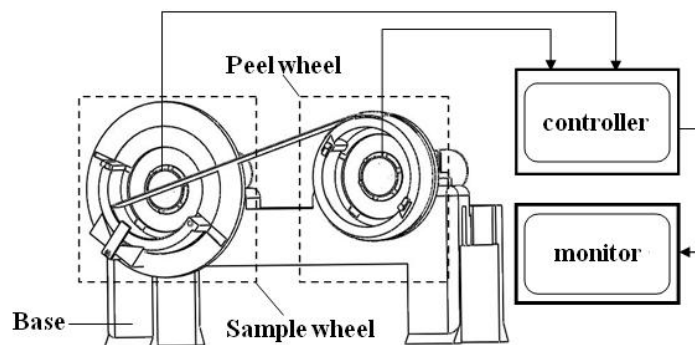

Fig.6. The new detection device

This new device is shown in Fig 6, which consists of base and sample wheel, peel wheel, controller, monitor and so on. The control mode, by which can coordinate driving peel wheel and sample wheel to make ω_1 and ω_2 satisfy the mathematical relationship in formula (4)during testing.

The peel length sensor and peel strength sensor can send signal of the peel length and peel force to monitor through controller, which makes the test digitally records the real-time peel force along with the peel length changing.

V. Conclusions

The self-lubricating spherical plain bearing woven liner bounding quality is a key factor of bearing's life time, which can provide the basis for improving bearing lifetime. This paper includes following work.

Based on the analysis of the current detection device, this paper provides CPATM to test the self-lubricating plain bearing liner bounding quality. The influence that the liner's elastic deformation has impact on the peel force is compensated during testing. In order to make the peel force along with the peel length changing can be monitored digitally a new detection device is constructed.

VI. Acknowledgments

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