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ANALYSIS REPORT

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This analysis report covers the work request entitled
"Friction Binding of Sliding Parts."

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ABSTRACT

From the analysis of "Friction Binding of Sliding Parts" it was found that if the coefficient of friction varies from .2 to .4, the maximum stresses in the neck of the lateral support block are, 26.2 and 58 psi respectively for the bending stresses and about 9 and 4 psi respectively for the shear stresses.

The longitudinal expansion required to develop the maximum load in the neck of the lateral support is .035 and .075 in. for a coefficient of friction .2 and .4 respectively. If the longitudinal expansion exceeds these values the core with respect to the lateral support block will slip.

INTRODUCTION

Per mechanical reactor design section the analysis of the sliding seal for NRX-A has indicated that binding would occur for a friction coefficient equal to or greater than 1.0. Because of its significance in both the seal and lateral support designs, it is desirable to verify this conclusion.

The immediate problem here is to determine the maximum stresses in the lateral support block. This analysis is found in Appendix A.

It is noted from our derivation of the static equilibrium equations that if the coefficient of friction approaches unity the equations are not applicable. Further work in deriving an applicable equation when the coefficient of friction is unity is required.

DISCUSSION

Appendix A clearly shows how the maximum loads on the lateral support block and hence the stresses at the minimum section where found.

It is also desirable to know the relative longitudinal expansion between the core and lateral support block such that slippage will occur. This could be found by (1) knowing both the radial and longitudinal thermal expansion of the core as a function of temperature (see Fig. 2), (2) knowing the seal spring characteristic as shown in Fig. 3, and (3) by knowing the relationship of F_1 as a function of radial expansion and the coefficient of friction (equation 5). By employing these known quantities the longitudinal deflection that will cause slippage between the core and lateral support block was found to be .035 in. and .075 in. for a coefficient of expansion of .4 and .2 respectively (see Fig. 4).

RECOMMENDATION

Standard graphite, for example ATJ is sufficient for use in the lateral support block. Pyrolytic graphite is not necessary.

APPENDIX A

Problem: Find the maximum stresses in the Support Block, Lateral Inner Reflector (Dwg. No. 945C110)

Solution: Draw a free-body diagram of the seal due to the impending motion as shown in Fig. 1

Figure 1. Free-Body diagram of seal

Writing the equilibrium equations, we get

$$\begin{array}{ll} \Sigma Y = 0 & F_1 - N_2 = 0 \text{-----} 1 \\ \Sigma X = 0 & F_2 - F_s + N_1 = 0 \text{-----} 2 \\ \Sigma M = 0 & F_2 (r) - F_1 (b) = 0 \text{-----} 3 \end{array}$$

From the basic laws of friction, we have

F₁ = u N₁ - - - - - 4

Solving for F_1 in terms of u , F_s , and the given geometry of the seal we obtain

$$F_1 = \frac{u F_s}{(1 - u^2)} \text{-----5}$$

Substituting equation 5 into equation 3 and solving for F_2 , we obtain

$$F_2 = \left(\frac{u F_s}{1 - u r/b} \right) \text{-----} 6$$

N_1 could now be solved. Substitute equation 6 into equation 2 gives us

$$N_1 = \frac{u F_s}{1 - u r/b} \left(\frac{b}{r} + 1 \right)$$

Stresses at section A-B

$C = 0.75$ in. (Includes tile thickness)

$$I/c = \pi d^3/32 = 8.12 \times 10^{-2} \text{ in}^3$$

$$A = \pi d^2/4 = 0.692 \text{ in.}^2$$

If $u = .4$

$$F_1 = \frac{u F_s}{1 - u r/b} = \frac{.4 (12.)}{1 - .4 (.55/1.25)} = 6.27 \text{ lbs.}$$

$$N_1 = F_1 \left(\frac{b}{r} + 1 \right) = 6.27 (1.25/.55 + 1) = 20.5 \text{ lbs.}$$

$$\sigma_b = \frac{M}{I/c} = \frac{6.27 (.75)}{8.12 \times 10^{-2}} = 58 \text{ psi}$$

$$\sigma_c = \frac{N}{A} = \frac{20.5}{.692} = 29.6 \text{ psi}$$

$$\tau_{ab} = \frac{F}{A} = \frac{6.27}{.629} = 9.06 \text{ psi}$$

If $u = .2$

$$F_1 = 2.83 \text{ lbs.}$$

$$N_1 = 9.26 \text{ lbs.}$$

$$\sigma_b = 26.2 \text{ psi}$$

$$\sigma_c = 13.4 \text{ psi}$$

$$\tau_{a-b} = 4.09 \text{ psi}$$

Nomenclature

F_s = spring force, lbs.

N_1, N_2 = normal reaction forces, lbs.

F_1 = friction force due to longitudinal expansion of core, lbs.

F_2 = friction force due to radial expansion of core, lbs.

u = coefficient of friction.

r = radius of spherical portion of block ($d/2$) in.

b = moment arm, in.

M = bending moment, in-lbs.

σ_b = bending stress at section A-B, psi

σ_c = compressive stress at section A-B, psi

τ_{AB} = shear stress at section A-B, psi

FIGURE 2

SEAL SPRING CHARACTERISTICS

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FIGURE 3

FORM 1152

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QUANTITY

Axial Load, lbs.

12
11
10
9
8
7
6
5
4
3
2
1
0

Actual Spring Characteristics

Precompression

A

B

Longitudinal Deflection

0 .1 .2 .3 .4 .5 .6 .7

Figure 4

$\Delta y (u=.4)$
 $\Delta y (\mu=.2)$

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