If the elasticity solutions, Equations (14a) and (19a), for the u_n, and Equation (51a) for p_2 are substituted into Equation (52) and the resulting expression solved for p_1, then there results

$$p_1 = \frac{1}{g}\left\{ \frac{2p}{k_1^2-1} + 2\,\frac{E_1}{E}\,\frac{k_2 k_3^2 p_3}{(k_3^2-1)} + \frac{E_1 \Delta_{12}}{r_1} - \Delta T E_1 \left[k_2(\alpha_3 - \alpha_2) + (\alpha_2 - \alpha_1)\right]\right\} \tag{53}$$

where

$$\begin{aligned} g = {} & \frac{k_1^2+1}{k_1^2-1} + \frac{E_1}{E_2}\left[\frac{2(k_2-1)}{k_2+1} + \frac{M_1}{\beta_1}\Big((f_3(r_1) - k_2 f_3(r_2)\Big)\right] \\ & + \frac{E_1}{E_3}\left[\frac{k_3^2+1}{k_3 2-1} + \nu\right] - \nu \end{aligned} \tag{54}$$

The E_n are the moduli of elasticity at temperature. The parameters M_1 and β_1 and the function $f_3(r)$ have been defined previously in reference to Equations (19a, b). The procedure for finding q_1 is the same as that for finding p_1 except that $p = 0$ and q_3 replaces p_3, i.e.,

$$q_1 = \frac{1}{g}\left\{ 2\,\frac{E_1}{E}\,\frac{k_2 k_3^2 q_3}{(k_3^2-1)} + \frac{E_1 \Delta_{12}}{r_1} - \Delta T E_1 \left[k_2(\alpha_3-\alpha_2) + (\alpha_2-\alpha_1)\right]\right\} \tag{55}$$

A fatigue analysis of the high-strength liner is now conducted. The range in the hoop stress at the bore is:

$$(\sigma_\theta)_r = \frac{(\sigma_\theta)_{max} - (\sigma_\theta)_{min}}{2} = \frac{p}{2}\,\frac{(k_1^2+1)}{(k_1^2-1)} - \frac{(p_1-q_1)k_1^2}{k_1^2-1} \tag{56}$$

where Equation (13a) has been used. (p_1-q_1) is given by Equation (55), but an expression for (q_3-p_3) is needed before Equation (56) can be used to solve for p. The expression for (p_3-q_3) is obtained from Equation (32) with (p_2-q_2) replacing p and with $k_3^2 k_4^2 \ldots k_N^2$ replacing K^2 in Equation (31). There results

$$q_n = p_n - \frac{(p_2-q_2)\,(k_{n+1}^2\, k_{n+2}^2 \ldots k_N^2-1)}{(k_3^2\, k_4^2 \ldots k_N^2-1)}\,, \quad n \geqq 3 \tag{57}$$

Substituting for (q_3-p_3) from Equation (57) into (55), then substituting for (p_1-q_1) from Equation (55) into (56), equating $(\sigma_\theta)_r$ and $\alpha_r \sigma_1$ from Definition (10a), and solving for p/σ_1, one obtains

$$\frac{p}{\sigma_1} = \frac{2\alpha_r(k_1^2-1)^2(g-h)}{\left[(g-h)\,(k_1^4-1) - 4k_1^2\right]} \tag{58}$$

where

$$h = \frac{2E_1 k_n^2 (k_n^{2(N-3)} - 1)}{E_3 (k_n^{2(N-2)} - 1)} \tag{59}$$

($k_3 = k_4 = \ldots = k_n$ for the outer cylinders as shown by Equation (45). Therefore, $k_3^2 k_4^2 \ldots k_N^2 = k_n^{2(N-2)}$ in the expression for h.)

It is easily shown that (g-h) is independent of N, the number of components. Therefore, p/σ_1 given by Equation (58) is independent of N. However, p/σ_1 is dependent upon k_1 whereas for the multiring container it was not as previously shown by Equation (44). This dependence is also shown in Figure 49. From this figure it is evident that the ring-segment container cannot withstand as great a pressure as the multiring container if the overall size is the same. This result is believed due to the fact that the segments do not offer any support to the liner – they are "floating" members between the liner and the third component, another ring. The effect is more pronounced as the segment size is increased. This is shown in Figure 50 where it is seen that the pressure decreases with increasing segment size.

The detrimental effect of insufficient segment support to the liner can be reduced by using a high modulus material, tungsten carbide, for the segment material. This is shown in Figure 51. However, the improvement is not sufficient enough to increase the pressure capability of the ring-segment container to that of the multiring container. This conclusion is based on results for various wall ratios.

The fatigue analysis of the outer ductile cylinders is conducted in the same manner as it was done for the multiring container, except now the component numbers are n = 3, 4, ..., N. The result is

$$\frac{p}{\sigma} = \frac{\alpha_r (k_n^2 - 1)(N-2)}{k_n^2 \left[\frac{(\alpha_r - \alpha_m)}{2} \frac{(k_1^2+1)}{k_2 k_1^2} + \frac{(3\alpha_r + 2\alpha_m)}{k_2 (k_1^2 - 1)(g-h)} \right]} \tag{60}$$

This result is plotted in Figure 52, which shows the effect of increasing k_1 and comparison with the multiring container. Although p/σ can be increased by use of segments, the ring-segment container has the limitation of lower p/σ_1 as shown before in Figures 49 and 50.

The effect on p/σ of increasing the segment modulus was also investigated. However, the effects were found to be insignificant.

Ring-Fluid-Segment Container

The ring-fluid-segment container is illustrated in Figure 39c. This container is a combination of a ring-segment container for the inner part and a multiring container for the outer part. All of the equations derived for the multiring container can be used