(30) STOVE SHELL STRESSES

A. E. Anderson Construction Corp.
Buffalo, New York

F. A. Berczynski

Average stove refractory operating temperatures have been increasing. Accompanying this has been a series of stove shell failures, ranging from 360° horizontal cracks, to severe bottom plate dishing. These difficulties could not be attributed to normal forces. Systems experiencing difficulty had one thing in common - the linings were being operated at a temperature higher than that employed prior to the difficulty. Hence, the problem was related to temperature.

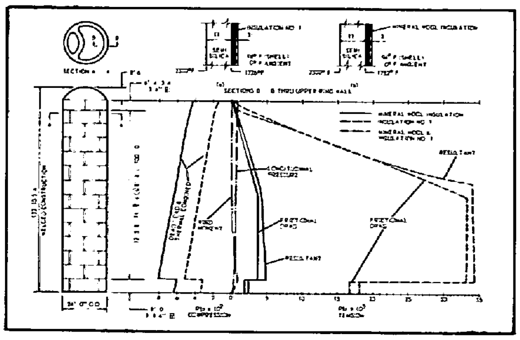
The design of the stove shell was influenced by the hoop, or circumferential stress. Little attention was paid to the axial stresses which were thought to result from blast pressures, dead load of the shell, wind load, and thermal differentials across the shell. Today's higher average operating temperatures require a re-evaluation of that assumption.

Most stove designers provide for radial and vertical refractory expansion. When the stove is heated, a flammable material is consumed, leaving a void for expansion between the checkerwork and the stove ring or pilaster wall. The amount of expansion provided for is limited to prevent undue misalignment of checkerwork. Stove dome operating temperatures of today require more allowance. Radial expansion must be taken up by the deformation of the refractory or the insulation. Considering physical properties, it is more likely that compression of the insulation takes place.

Theoretically the range of insulation compression required for most stoves at 2300°F is about 5 to 10%. Radial shell pressure caused by compression can be as high as 125 psi. Pressure created by radial expansion and vertical expansion, creates a high axial stress through the friction between the insulation and the shell. The force, fF, where f is the friction factor, and F is the total force per unit area, causes an axial stress, termed the "Frictional Drag Stress". This stress is in excess of 30 times the combined axial stresses resulting from shell dead load, wind load, thermal differentials, and internal pressure.

An examination of the factors making up the "Frictional Drag Stress" indicates two possible economical methods of reduction. The friction factor, f, could be lowered, or F, the force due to pressure could be reduced by using a more compressible insulating material. The latter is most desirable.

New mineral wool insulating materials with the necessary properties can be obtained from major refractory manufacturers. The pressure for deformation is about 16 psi, or 87% less than that required in conventional insulating materials. Therefore, a reduction in the "Frictional Drag Stress" can be realized by the application of high temperature mineral wool insulation.



STOVE SHELL STRESS

The theoretical reduction of "Frictional Drag Stress" through the application of mineral wool base insulations is illustrated in the figure. Two identical stoves are compared at the same conditions. The stove utilizing mineral wool insulation had the lower stress -- the difference in the maximum resultant axial stress is approximately 85%.