SOME STUDIES IN STRESS DISTRIBUTION IN PRESSURE VESSELS AND IN GEAR TEETH

Synopsis

The subject matter of the investigation can be divided into two parts. The first part is concerned with the stress analysis of thickwalled cylindrical pressure vessels with hemispherical ends some with a thickness equal to that of the cylinder and some with a reduced thickness. Some of the pressure vessels had a circular manhole in the end or the head whereas the others had full heads. The second part of the study deals with the tooth strength of involute spur gears. Photoelasticity method of stress analysis has been used in both the cases.

Since the frozen stress method of photoelasticity has been used in the study of the pressure vessels and the two dimensional photoelasticity method in the case of the gears a concise review of the principles and the techniques of the photoelastic method of stress analysis is included in the thesis. An account of the theory of photoelasticity, the two dimensional photoelasticity method, the frozen stress method, the calculation of the individual stress components, the materials used in making the photoelastic models, the techniques of model

making and of stress freezing is given.

In the work on pressure vessels the possibility of achieving a fairly constant maximum stress distribution in the cylindrical drum and the drumhead is investigated. About eighteen pressure vessels with full or pierced heads have been studied. The mean diameter to wall thickness ratio of these models varied from 3 to 13 and all the models had a mean diameter of 3.25 inches. The stresses in the models due to an internal fluid pressure loading were frozen by using the frozen stress technique. The meridional and the hoop stresses on the inner and the outer walls of the models were determined by examining the meridional and the hoop slices cut from the frozen stress models in a photoelastic polariscope. In the case of the model with the diameter to wall thickness ratio of 5 the experimental values have been compared with a theoretical solution that is available. The main observations are that the hemispherical heads of reduced thickness are effective in achieving a uniform stress distribution for a diameter to wall thickness ratio of more than 5 or 6. For a ratio of less than 5 or 6 a significant increase of the hoop stress on the inside of the vessel is noticed.

A paper based on this work was presented at the Symposium on 'Pressure Vessel Research Towards Better Design' arranged by the Institution of Mechanical Engineers, London in 1961. A copy of this paper is enclosed.

In the second part of the study the stress distribution in 20 degree pressure angle involute AGMA full depth proportion spur gear teeth with different numbers of teeth and minimum and maximum permissible values of addendum correction has been determined using two dimensional photoelasticity method. About 20 tooth forms with 4 mm module pitch and the number of teeth varying from 20 to 100 have been investigated. The study indicates that the shear stress has an influence and therefore it cannot be neglected in the calculation of the maximum root stress. The inclusion of the shear stress seems to make the stress concentration effects at the tooth root fillet independent of the load position. A method of calculating the maximum root stress and the strength factors which is based on the experimental results for this series of tooth profiles has been suggested. This method seems to give better estimates than the conventional Lewis and other methods. A paper based on some initial work that was done in this connection was presented at the Seminar on Aeronautical Sciences held by the National Aeronautical Laboratory, Bangalore, India in 1961. A copy of this paper published in the Journal of Science and Engineering Research, Vol.VII, Part I, 1963 is enclosed.