

JOINT DISCUSSION ON STRESSES IN CYLINDER BLOCKS

MR. G. ELLIS¹.—I should like to ask a question of Messrs. King, Erickson, and Stockett. Just how much trouble in service was caused by the residual stresses in these castings?

MR. S. J. STOCKETT (*author*).—If you have a tensile residual stress in service and other tensile stresses are superimposed on that, it is very easy to exceed the yield or even the tensile strength. In the case of these blocks that we analyzed, quite a number of field failures were being experienced. So it was quite important in that case. In other cases the residual stresses may be beneficial. If you have a compression stress and a tensile load is applied upon it, they balance each other out and the residual stress had done a lot of good.

MR. T. E. EAGAN².—There is one question I wish to ask about the tests that were made.

Were these blocks given a stress relieving treatment or were they in the as-cast condition?

MR. R. J. KING (*author*).—In my case, as cast.

MR. MARTIN A. ERICKSON (*author*).—Same in ours.

MR. STOCKETT.—Ours were too. One thing I might add. Some of these blocks that we analyzed were rough machined, others were just as cast. They were

several series of blocks and we had several different conditions. But as far as I know, none of them were stress relieved—at least we didn't stress relieve them before we made our analysis. They were as the manufacturer supplied them to us.

MR. J. T. MACKENZIE³.—This question of combined stress is frequently one of bending and tensions, as Professor Schlick worked out some years ago the relation between them which is:

$$\left(\frac{w}{W}\right)^{1.7} = \frac{P - p}{P}$$

where:

w = transverse stress,

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p = tensile stress, and

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MR. ERICKSON (*author's closure*).—In answer to Mr. Ellis' question, we are convinced that residual stresses influenced the failures in the engine block discussed in the paper. We know also of other cases in large cylinder blocks and plastic castings where annealing had to be adopted in order to get us out of trouble.

In stressed areas where the operating stress fluctuates in tension and compression residual stress is usually relieved after a few cycles of operation provided the maximum stress value reached is sufficient to produce plastic flow. For a

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fluctuating load condition where a mean stress occurs, the effect of residual stress on failure becomes more significant as the magnitude of the mean stress increases.

In the case of the cylinder block where a high value of mean stress occurred as a result of the residual and assembly stresses, the operating or fluctuating stress was limited to a very small value (see the modified Goodman diagram, Fig. 6) if failure was to be prevented. Recognizing the dangerously high level of residual stress in this problem and the relatively high cost in its removal by annealing it was decided to reduce the magnitude of the operating stress by adding material to the critically stressed area. Since this change was made no failures have been reported out of many thousands of cylinder blocks produced.

In answer to Mr. T. E. Eagan, the cylinder block used in the investigation and those tested to failure in dynamometer tests were in the as-cast condi-

tion. Annealing of these blocks which are designed for high production would be an expensive item, and therefore, it was decided to reinforce the block at the critical section rather than to anneal. In some cases where it is not possible to add stock it may be necessary to anneal in order to avoid a major design change.

MR. KING (*author's closure*).—It might be well to state that there are other stresses present in the cylinder block in addition to the residual stresses. Dynamic stresses arising from gas pressures and inertia forces, and thermal stresses are also present in cylinder blocks. However, in this instance we found that the significant stress—the stress that might result in failure—was the residual stress. At the critical section as shown in Fig. 1 both the dynamic stresses and thermal stresses are quite low. Measurement of the dynamic stress in this area has indicated a maximum value of about 500 psi. The thermal stresses were almost immeasurable.