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THE INFLUENCE OF OVERLOADS ON THE FATIGUE LIFE OF NYLON TIRE CORD

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ABSTRACT: Laboratory studies were carried out to investigate the effect of single overloads on subsequent fatigue life of typical nylon tire cord. A simplified method was developed for fabricating end grips for tensile loading of tire cords. Test results showed little influence of significantly large overloads on the subsequent fatigue life of nylon tire cord.

KEY WORDS: Tire cord, fatigue, tires

INTRODUCTION

SINCE THE TEXTILE cords to a great extent govern the strength and service life of tires, the influence of large overloads on subsequent service life should be of general interest to tire manufacturers. One proposed method of examining tire carcasses for structural integrity is to proof test them under pressure to some fairly high internal inflation, several times that of normal inflation pressure. This raises the question of whether such a single tensile overload on the textile cord reduces subsequent fatigue life of the tire. A laboratory test program was undertaken to determine the effect of such large loads on the fatigue life of nylon tire cord. Such data also has implications for the influence of accidental shock or impact loads on a tire during service, in regard to its subsequent fatigue life.

GRIP SYSTEM

Special grips are available for performing tensile tests on tire cords. Usually such grips are large, require special electrical and air pressure connections, and are expensive. Lack of such a grip system generally causes tensile tests on tire cord to be unsatisfactory, since tensile breaks usually result at the gripping point of the specimen. It was found during the course of this work that a satisfactory distribution of gripping forces could be produced in a very simple and inexpensive way by use of a type of plastic tubing often used in electronics for sealing wire joints. According to manufacturers specifications, Irradiated Polyolefin Tubing shrinks to approximately 50% of its original diameter in 7 seconds under a temperature of 275°F. A piece of this tubing can be slipped over the end of a textile cord sample and then placed under a heat lamp. The tubing shrinks quickly onto the cord while the cord stays relatively cool. A larger piece of tubing can then be slipped over this and heat shrunk on. Several layers of tubing can be applied in successive steps. Thus cushioned, the end of the textile cord can be gripped in an ordinary clamp system in an Instron Machine and subsequent tensile tests will show little or no tendency for breaks to occur at the grip point. This is a much simpler system than conventional textile grips.

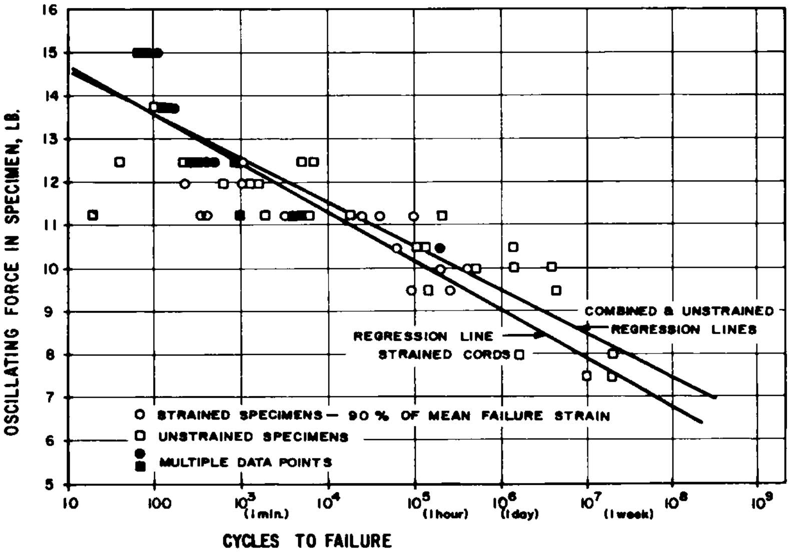
TENSILE AND FATIGUE TESTS

A common tire cord was chosen for these tests, namely 840/2 dipped nylon. A series of tensile tests carried out in an Instron Machine showed that the cord samples had a mean tensile strength of 43.6 pounds with a standard deviation of 3.8 pounds, in 51 tests. The first attempt to measure the effect of preload on subsequent fatigue life was carried out by loading a selected set of samples to 30 pounds tensile load each, or approximately 70% of their mean tensile strength. These samples were then subjected to fatigue to failure. Thirteen samples were so treated and tested. Thirteen more unloaded cords were also subjected to fatigue tests, and used as controls. Statistical analysis showed that there was a very small effect but that a much larger sample would be necessary at this preload level to obtain significant results. As a second series of experiments, a larger value of preload was chosen and a larger number of experiments were run. Twenty-seven cords were each loaded to 40 pounds of tensile force, which is approximately 90% of the mean tensile strength of the population. These were then subjected to a fatigue environment until failure under various levels of cyclic tension. Thirteen control samples from the previous experiment were used, as well as twenty-three more untreated samples in this sequence of experiments. This gave a fairly large control population to examine.

DISCUSSION OF RESULTS

A least squares regression using the data obtained indicates a logarithmic relationship between the level of oscillating force in the specimen and the number of cycles to failure, with the correlation coefficients of 0.885 for the control (unloaded) cords and 0.853 for the cord subjected to a preload. This implies that 72.8% of the data variation for the loaded cords is accounted for by a normal distribution around a straight line on a plot of oscillating force vs logarithm of cycles. Similarly, for the control group the regression line accounts for 78.3% of the variation. These data and regression lines are shown in Figure 1.

However, a regression for the combined data in both groups has a correlation coefficient of 0.874 and accounts for 76.3% of the data variation. This regression appears, to the scale of the figure, to be indistinguishable from the line for the control group. Part of this may be accounted for by the fact that four of the first



FORCE = — .437 (Ln Cycles) + 15.6 (Control Group)
FORCE = — .486 (Ln Cycles) + 15.8 (Preloaded Group)
FORCE = — .447 (Ln Cycles) + 15.6 (Combined Groups

Figure 1. Cycles to failure vs oscillating force level for dipped nylon tire cord.

thirteen controls were subjected to a cyclic tension of less than 9 pounds, and in these tests failure might not occur for several weeks. This data was included in the set, but no further tests were conducted at this low force level.

In the process of preloading the cords to 90% of the mean tensile strength, it was inevitable that some specimens were culled out due to failure. However, of those which survived, the results of this experiment imply that this single large overload had insignificant effect on subsequent fatigue life of the cord. Since the properties of the cords to a great extent govern the strength of a tire, these results may be extrapolated to the service characteristics of a tire, or to its action under pressurization. While subjecting a tire to a single large load may not imply an unchanged fatigue life, it does not significantly alter the total life of the tire.

CONCLUSIONS

There are many questions raised by this research. Fatigue tests were carried out in a region of the oscillating-force/cycles-to-failure diagram which facilitated rapid data collection; that is, failure occurred within a few seconds to a few hours in most cases. However, Walter [6] and Clark [1] have both shown that in service an individual tire cord will normally carry a load which varies between 0 and about 5 pounds. The extrapolation of the data of this report suggests that the fatigue life of cords under these conditions may be as high as 500 billion cycles, the approximate equivalent of 500 million miles of tire service.

The extension of the results obtained here to normal tire service may not be entirely valid because the region of normal operation, in which cord loads vary from 0 to 5 pounds, is so far from the region in which data was collected, in which the cord loads varied from 8 to 12 pounds. In addition, other studies on single fibers and yarns [2], [3], [4], [5], have suggested that while the log-normal distribution fits the center of the curve, a Weibull distribution provides a better fit for data in the short life and low load regions of the curve.

While the tests described here strongly imply that a large preload had insignificant effect on fatigue life of the nylon tire cord, further and much more extensive test work at low loads is required to definitely prove this hypothesis.

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