Sucker Rod Failures Can Be Reduced

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In recent years the petroleum industry has made concerted efforts toward reducing well costs wherever possible. One area of major concern has been sucker rod failures. The advent of corrosion control, with inhibitors, and a concentrated effort in educating both technical and operating personnel have brought about effective reduction of these unnecessary failures.

The most recent trend in sucker rod applications has been toward the use of the high tensile, low alloy rod. The operator can now take advantage of the additional loadings offered without adding materially to his cost. As in most areas of load applications, when one detrimental factor is eliminated, and expanded usage of the product is allowed, other factors which previously did not appear significant become the prime problem. This new area of concern appears to be pin failures in the high tensile rods.

Sucker rod failures -- including failures of rods of all manufacturers -- were investigated in our metallurgical laboratory over the past two years and were analyzed and segregated into three types: carbon, intermediate alloy and high tensile groups. It is interesting to note that while only 9 per cent of the carbon rods and 23 per cent of the intermediate rods were pin failures, they accounted for 81 per cent of the failures in high tensile rods. Of the total number of failures investigated, 62 per cent were in the high tensile rods, 22 per cent were in intermediate alloy rods and 16 per cent were in the carbon rods.

The result of this investigation shows that over 50 per cent of all the sucker rod failures were in the pins of the high tensile rods.

To reduce these pin failures a new approach in recommending rod loads was necessary. It has been known that pin failures in high tensile rods occurred well below recommended loads when high ranges of stress (load range) were prevalent. This knowledge was further studied and found to be true especially when no other explanation could be found nor any other contributing factors such as corrosion, improper make-up, etc., existed.

As three prime variables, fluid load, speed and stroke contribute to load range, a simple approach should be taken so that, regardless of the variables, the guide for recommended working stress with corresponding load range should be simple. Further it is intended only as a guide, for it is recognized that, when fatigue is considered, too many variables exist to recommend any fixed numbers for any condition.

In attempting to define a recommendation or guide for the effectiveness of load range in sucker rod strings, it was discovered that there existed a percentage decrease in allowed working stress versus percentage increase in load range (load ratio). Thus a more practical approach is this formula, rather than the recommendation of fixed figures, for there is absolutely no way to definitely state a certain figure for any fixed conditions where fatigue exists.

The method used to determine the curve is based on a modified Goodman diagram which compensates for the many factors affecting rod life, factors such as corrosion, surface finish, etc. Naturally, these are all empirical numbers but it is felt that there is sufficient past experience behind the use of averages as a basis.

First, the Goodman diagram shows that a relationship exists between the fatigue life of a material and the amount of stress variation imposed on it. An explanation for this diagram can be found in any engineering or metallurgical handbook.

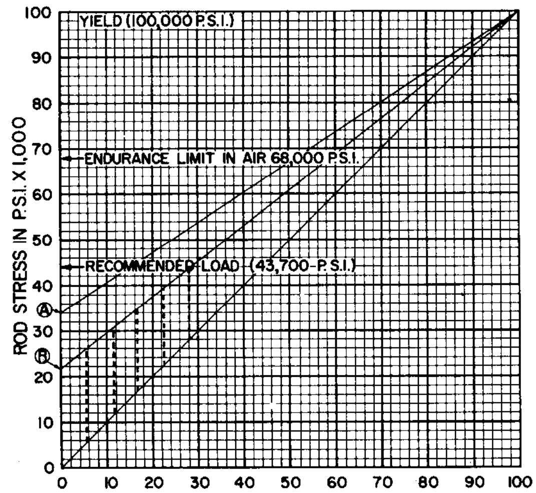

FIG.1

Figure 1 presents a modified Goodman diagram. One starts the minimum stress line at zero and extends it to the yield instead of the tensile of the material. This line determines the minimum stresses which can be used. Zero is used as the starting point for the minimum stress line for it is known that operating sucker rods in compression cause large unpredictable and disastrous stresses. The yield instead of the tensile is used as our maximum point for any load beyond the yield causes physical changes in the material.

Generally one uses half the endurance limit of a material as the maximum working stress where notch effect exists, i.e. threads (shown in Fig. 1 as A). In the diagram is used, instead, one-half of the maximum recommended working load so that the solution offers the per cent of maximum recommended load instead of per cent of endurance limit (point B in Fig. 1). Using high tensile rods of 100,000 psi yield, 68,000 psi endurance strength in air, and 43,700 psi as maximum recommended load, Figure 1 can be drawn.

In Figure 1, the dotted lines between the stress line and line B (one-half maximum recommended load) are the allowed range of stresses for 100 per cent, 90 per cent, 80 per cent, 70 per cent, 60 per cent, and 50 per cent of maximum recommended load (43,700 psi). These were plotted as (1) in Figure 2, and gave us the allowed load range in per cent of maximum recommended load. These were also plotted for other grades of material and close comparison was found! For convenience the 100,000 psi yield material was used, for 100,000 psi yield makes for simpler graphing.

In general, instead of using one-half maximum recommended loads, one-half the fatigue strength is used. If one would repeat the above procedure using the Point A line in Figure 1, curve 2 in Fig. 2 would result. However, this general method is not acceptable for no compensation is made for such problems as corrosion, fluid pound, and surface finish. Also it should be pointed out that in push-pull fatigue tests, results from 15 per

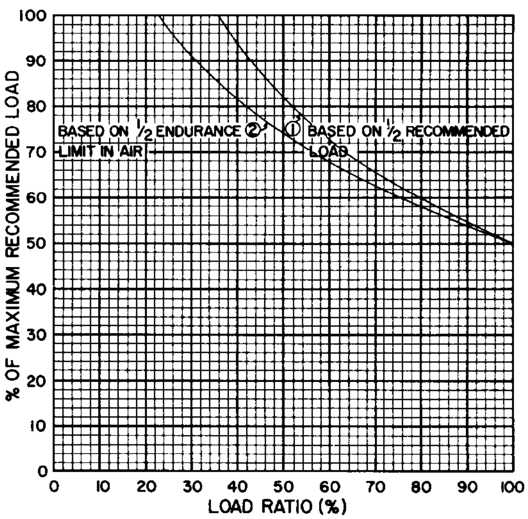

FIG.2

cent to 25 per cent less over the rotating beam are found.

In many articles one finds, for brine corrosion alone, a reduction to 80 per cent of the recommended load, and in hydrogen sulfide a reduction to 50 per cent to 70 per cent of the recommended load. Using 65 per cent as an average to compensate for any condition, one would multiply the 68,000 psi for fatigue strength by 65 per cent and find almost exactly (within a few hundred psi) the maximum recommended load. This figure should be true for the load recommendations do take into effect the usage to which the product will be put. So, regardless of direction or method, one ends up with curve (1) It is interesting to note that, regardless of method used, all systems are based on only 50 per cent of load whether it be fatigue strength, recommended working load, or what, at 100 per cent load range. This basis is felt to be a real and practical assumption for general field recommendations.

In general, the curve will be on the conservative side, but one cannot know ahead of time under what condition the rods are to be used. The operator should use this chart as a guide and not an absolute oriteria. It is up to the operator and his field personnel, depending on their experience and knowledge in the area in which they operate, to develop their own variation from the curves.

Conclusions

In conclusion it should be stated that (1) since this graph has been put into operation the author has found it to be very successful in reducing rod failures in troublesome high tensile rod installations and that (2) with the advent of the newly adopted undercut pins and rolled threads by the API we can look forward to further decreasing of pin failures in high tensile sucker rods.

Bibliography

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