AMMONIA REFORMERS AND THE TUBE DEVIATION ANALYZER

Although the failure rate of catalyst and reformer tubes will increase until an improved construction material becomes available, the T.D.A. can provide quality control to this area of reformer furnace operation.

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The Tube Deviation Analyzer, or T.D.A., has been used on over forty ammonia reformers since its inception two years ago. Based on correlations between actual tube condition and metallurgical examinations ofT.D.A. inspected specimens, we expect the T.D.A. to be of greater use to the ammonia industry in the years to come.

There are several reasons why this instrument was developed. Higher operating pressures and correspondingly higher reaction temperatures in ammonia processes have caused premature failure of catalyst tubes and riser tubes, where applicable. These tubes are almost exclusively centrifugally cast HK-40, a 25% Cr - 20% Ni, 0.35% - 0.45% C heat resisting austenitic alloy.

Present situation

Mr. Fred Jones of Canadian Industries Ltd. describes the present situation:

"Industry experience with the earlier, lower pressure reformers, has been very satisfactory with respect to catalyst tube life, frequently exceeding ten years service. The present indications are that the new reformers are not going to do nearly as well, with initial failures being encountered in the three to five year range of life.

"The probability is also that the large plant will find a continuing series of unscheduled shutdowns due to random failures in a large population of catalyst tubes an intolerable situation economically. On this basis, complete tubing change out may be undertaken after only 10% or so of the original tubing has failed. On this basis, relatively small failure percentages of total tube exposure assume increased significance.

"Even so, the present volume of replacement tubing known to the writer on high pressure reformers commissioned since 1965 runs into several hundred tubes, and within the next two years is likely to be several thousand (1).

Examining causes for these tube failures and recommending possible corrective measures to avoid these failures has been a most complex problem. Some of the variables are nearly impossible to isolate and it can almost be likened to solving ten equations with twentyfive unknowns.

Messers R. E. Gackenback and J. F. Shay of American Cyanamid summarize these variables in discussing their particular problems:

"Based on the data presented, the mechanism of failure appears to be carburization followed by oxidation (See Figure 1). The inner surface of the catalyst tube undergoes extensive carburization in a localized area. The resultant chromium carbides are selectively oxidized. The oxidized surface is not self-protective and oxidation proceeds uninterrupted until the tube wall is penetrated over a broad area. The effective wall area is greatly reduced and stress-rupture cracking occurs because of the reduced strength. .... It appears that the attack is initiated by contaminants within the process stream, or by physical defects in the tubes, or both. .... When HK-40 tubes contain excessive bore porosity or inclusions, they are more susceptible to oxidation. .... Even though the exact promoter or intiator cannot be identified at this time, there are several prime suspects. They are:

1. Sulfur in the form of hydrogen sulfide may have passed through the desulfurizer and acted as a poison.
2. Water treatment chemicals may have entered the reformer with the import steam.
3. Temporary process upset may have allowed deposition of carbon and promoted carburization.
4. The inhomogeneity of the I.D. surface of the as-cast tube may act as sites for local carburization and oxidation.
5. Microsegration within the inner surface of the catalyst tubes may cause local sensitivity.

"Corrective measures have been taken ....

1. A more effective catalyst has been charged to the desulfurizer and regeneration occurs monthly.
2. The use of import steam to the reformer has been minimized.
3. The process streams are being analyzed and monitored.
4. The tubes will be inspected with a tube scanner at every shutdown and suspected tubes will be removed.
5. More stringent controls will be exercised during welding of tube assemblies." (2)

To summarize the overall position on these tube failures it appears that the situation will get worse before any improved material, etc., comes along. The T.D.A. can supply the quality control check gap so vital in such a costly operation. The shortage of critical spares magnifies the problem considerably.

T.D.A. development

Since the prototype was turned out over two years ago, the third generation T.D.A. has evolved and now is considered to be a most reliable, accurate, and consistent instrument after over 3,000 hours of field operation on furnace jobs.

The T.D.A. is based on a modified eddy-current principle, and will detect tube wall sections which have become magnetic through the carburization/oxidation process. As with any non-destructive testing device, the operator always works or calibrates from a known good sample and one with artificial "flaws" injected into it.

The transducer, which contains the eddy current generator and sensing coils, is moved along the tubes to be inspected. These transducers are designed to fit any size tube in any type of reformer.

The transducer and associated amplifier-detector are balanced when calibrated. Any deviation in the tube while scanning will change the eddy current pattern, causing an unbalanced condition. The readout on the instrument panel or bell tone in the earphones will alert the operator that a trouble spot has been found. The extremely sensitive portion of the T.D.A. is then used to "classify" the defect, and this information is then used to quantitatively and qualitatively analyze the integrity of the tube wall section.

Each 30 - 40 ft. tube is "scrubbed" in approximately ten minutes each. A 180° sweep is generated on the first pass and the remaining 180° is checked on the return trip. The inspection is made with catalyst in the tubes but nulled out by the T.D.A.

Literature cited

1. Jones, F.S., "Some Practical Considerations in Steam Methane Reformer Tubing," 1 (1970).
2. Gackenback, R.E., and J.F. Shay, "A Study of Localized Massive Scaling on Interior of Reformer Tubing," pp. 7-8/57 N.A.C.E. (1970).

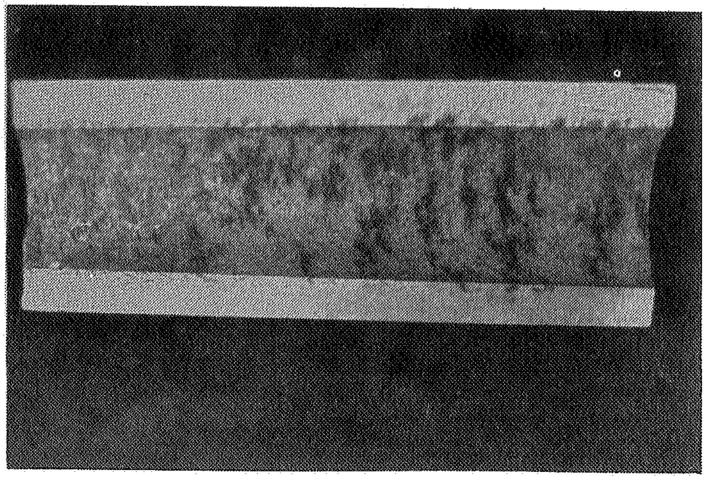

Figure 1. Cross section of an HK-40 ammonia reformer catalyst tube that failed due to carburization/oxidation.

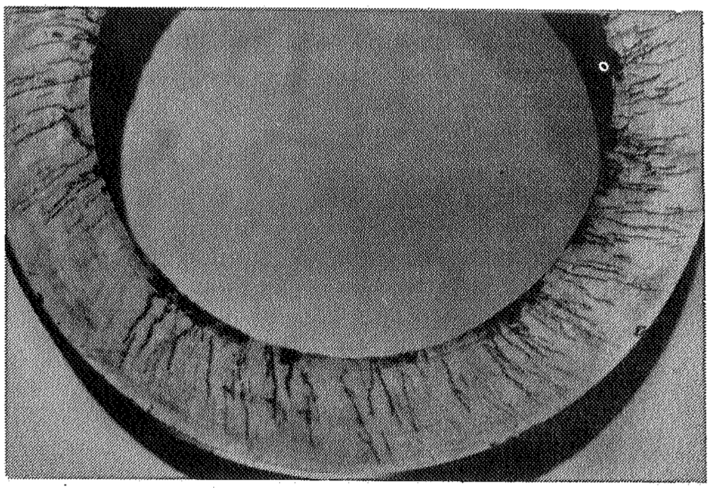

Figure 2. Ammonia reformer catalyst tube (HK-40), failed due to cracking containing oxidation.

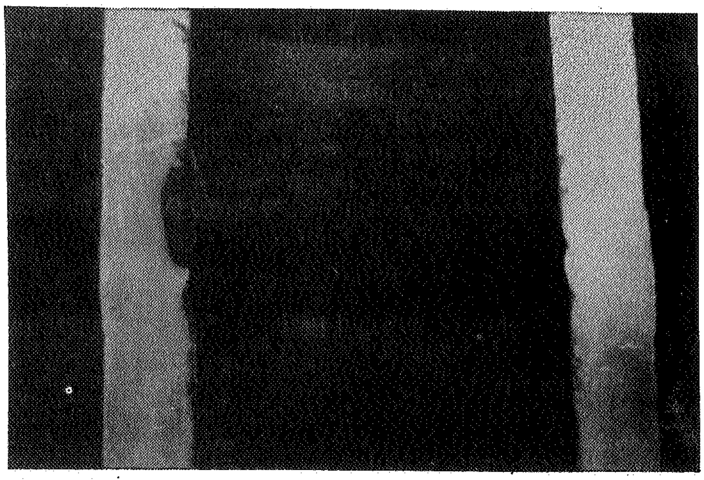

Figure 3. Ammonia reformer catalyst tube (HK-40), failed due to localized massive oxidation.

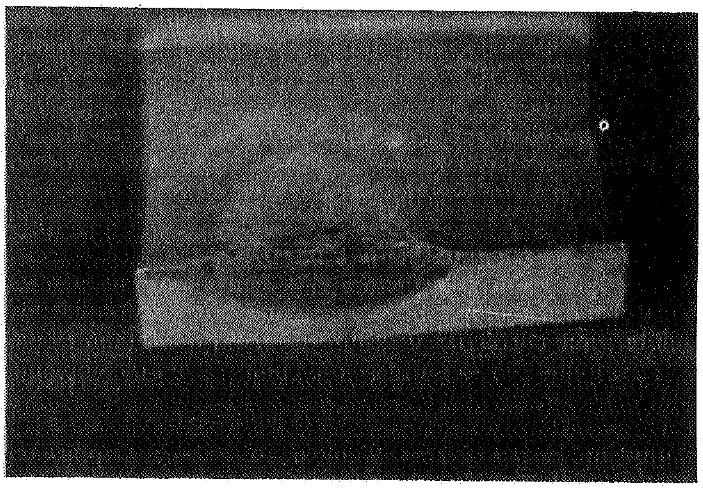

Figure 4. Ammonia reformer catalyst tube (HK-40), failed due to localized massive oxidation.