Compressor Oil System Problems

How one operator of ammonia plants has met and solved a series of problems in the lubricating oil systems of his compressors and turbine drivers

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A number of problems with the compressor lubricating oil systems in the ammonia plants at Imperial Chemical Industries, Billingham works have been solved satisfactorily over the years since the units went onstream. This article discusses the problems and what was done.

The ammonia plants have each a common lube oil system for bearings, gear couplings, floating-bushing seals, and control systems on the process gas compressors, air compressor, and the turbine drivers. The system capacity is 2,000 Imp. gallons. Figure 1 shows one of the compressor units.

Before the plants were started up, the systems were thoroughly cleaned. Flushing oil was drained off, and the systems were refilled with the running charge, a proprietary conventional steam turbine oil containing oxidation and rust inhibitors. Initially, one portable centrifuge was available for the three systems. Because there were problems in controlling condensate leaks from the steam turbine glands, the oil systems tended to be somewhat wet.

During this period, there were no major problems with the oil. However, there was some concern with rusty sludge deposits in the gear couplings and turbine control systems. Although the turbine oil contained a corrosion inhibitor, it was apparently not effective in preventing corrosion of carbon steel in free spaces in the oil system where there was gross separation of water.

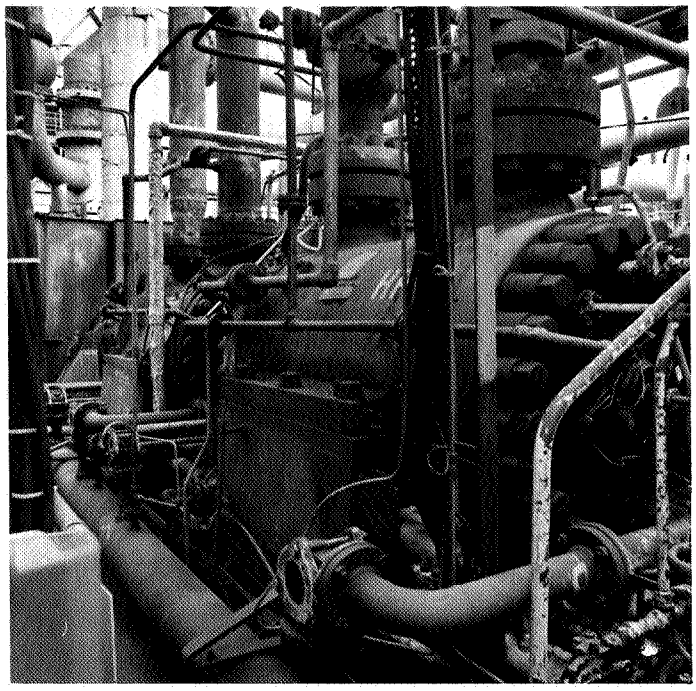

Figure 1. One of the compressor installations at Billingham.

First problem was sludge in couplings

After about two years of operation, centrifuges were installed on each of the three systems and were operated continually. To deal with the coupling sludge problem, the original couplings (the type in which there is a lip to retain oil so that the teeth are immersed) were changed to the type in which no oil is retained, the lubricant being fed through the male teeth.

This was impossible in the case of the couplings between the process gas compressor casings, and these were modified by having drain holes drilled in the sleeves. Together with improved centrifuging, this has relieved the coupling sludge problem, although the modified couplings still tend to collect some small amounts of sludge.

After about three years of operation, problems began to appear with lacquering of the bearings and seals on the process gas compressors. This caused the seal rings to stick, and both wiping and fatigue failures occurred. Investigation showed the deposit to be a reaction product of one of the oil additives (a succinic anhydride used as a corrosion inhibitor) and ammonia.

Contact between oil and ammonia occurs at the high-pressure seal ring adjacent the recycle wheel, and with the high temperatures in the seal this is a likely site for reaction to happen. Although sour seal oil is not recycled, there is evidence from a number of machines with floating-bush seals that gas transfer takes place across the seal so that the system becomes contaminated. The high temperatures in the bearings and other high-pressure seal rings makes those also likely sites for reaction.

The reaction product is water-soluble, and it was not until satisfactory centrifuging had been established and the water content of the oil maintained at a low level (less than 200 ppm.) that reaction products were able to deposit. A consequence of the seal problem had been contamination of the process gas stream with oil. This coated out on the chillers and reduced heat transfer.

New type of oil helped for a while

After some experimentation, it was decided to try an oil without additives in case of further unforeseen reactions with ammonia. The first choice was a naphthenic oil

with a pour point sufficiently low to prevent solidification in the chillers in case of carry-over. However, this proved difficult to obtain, therefore a straight paraffinic oil with a pour point depressant additive was adopted.

This oil operated satisfactorily for about one year. Then, in one of the plants, high temperature developed suddenly in several of the bearings, relays started sticking in the turbine control system, and there was massive removal of sludge by the centrifuge. While this was under investigation, similar events occurred in the other two plants.

The sludge was found to be oil oxidation products. Laboratory tests subsequently confirmed that the oxidation stability of the oil was reduced by the presence of ammonia, water, and a copper catalyst. The pour point depressant apparently contributed also, although glassware tests carried out before it had been adopted had indicated no reaction with ammonia.

The next move was to revert to a turbine-type oil that passed the standard tests for oxidation stability (IP 157/ ASTM D943) and rust preventing characteristics (IP 135/ASTM D665) with the additional requirement that it should be inert to ammonia. A special test based upon IP 157 was developed for this. In the test, the temperature is increased from 95 to 125°C and ammonia is added to the oxidizing gas stream. The requirement is that there should be no development of sludge nor acidity after 150 hr.

The oil that met these requirements has been in service two years and has performed reasonably satisfactorily. From time to time, there have been instances with sticking relays and higher-than-normal removal of sludge by the centrifuges, particularly in the first few days after a stoppage. This appears to be associated with higher-than-normal water and ammonia levels in the oil, and it is attributed to the mobilization of sludge remaining in the system from earlier operation that had not been possible to remove by normal flushing at shutdowns.

Paper element filters helpful

During the period of oil problems, the control and lube oil filters were also changed. The original filters were of wire mesh type, designed to remove particles over 60 microns. As confidence in the cleanliness of the oil increased, the control oil filters were changed to remove particles above 35 microns and these have operated without problems since 1970. After the installation of the individual centrifuges and demonstration that water contamination could be maintained below 100 pp., the lube oil filters were changed to paper elements able to retain particles above 40 microns.

At present, the plants are operating with paper elements in lube and control oil filters, with the spare filters being the original wire mesh type with 60-micron cut levels. It is planned to move toward complete paper filtration with 25-micron cut as operator confidence in these filters is raised.

Problems have also occurred in the lubrication systems of other large compressors through contamination of the oil by process gases. For example, small amounts of methanol in certain oils can oxidize to formic acid and cause corrosion. The modified oxidation test using methanol instead of ammonia has been used to select a suitable oil for use on methanol plant machines.

Acknowledgment

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DISCUSSION

Q. I'd be very interest in any comments you might have on your fire protection systems. I noticed that you obviously used foam on the fire afterwards and I was wondering if you have any new thoughts on how you protect against a fire that might happen in the future there, particularly as it relates to water sprinkling?

LIVINGSTONE : We have on his plant the philosophy of energize to trip and we felt that in this particular fire it was quite on the cards, if the operator hadn't been as quick as he had, of him pressing buttons for trips that would not have been available to him in that sort of fire. So we have gone now to a water sprinklering arrangement to protect all cables along the whole length of the plant, particularly around the main machines. And if anybody wants details, let me know and I can give you them.

We have tested them. People are very nervous about testing water spraying on line on cables, but we have successfully tested them and we feel very confident that water spraying particularly of the major trip devices, to protect them for this sort of incident, is a good insurance. Dr. Clark is going to talk about foam usage on ammonia spills.

So, in fact, we have great confidence in foam; we have used it and indeed it was used very successfully on this occasion. That was one of the reasons for showing what I did—that the fire was contained very well indeed. And only local severe damage occurred. So we would in fact stick with foam, but in addition use the water sprinkler to

protect the trip devices.

JAN BLANKEN, UKF-Holland: I would like to give our experience. We operate the syn gas compressor of the Pernis plant for seven years with Shell turbo 29 and had some problems with gum formation. We went to the extreme in trying to keep oxygen out of the system, for instance by installing an oil seal in the vent line from the lube oil tank and do not have many problems.

The plant in IJmuiden is in operation now for about four years, we experienced gum formation and went from Shell turbo 27, which we used there, to Gulf 1343, check the dope as you have indicated regularly and add dope as required, and until now have no problem. Again we keep the oil as far as possible under nitrogen.

Because of a fire which we had in the plant which is now part of our company we went to the precaution of installing a switch for the electric motor driven oil pump and a steam shut off valve for the steam turbine driven oil pump outside of the compressor building such that in case of fire you do not put all the oil you have in your oil tank into the fire, and cannot easily extinguish it.

In one of the plants where the oil sets are in a basement we installed chicken mesh and foam generators such that we can put the oil equipment under foam and the chicken mesh prevents the foam moving the compressor building. The question I have is that we took very much precautions to keep oxygen out of the oil system, and as far as I learned last week preparing for this symposium, found that if we did not purge the oil system sufficiently with nitrogen we found a higher corrosion rate.

Now I understand that you have a common oil set for air and synthesis gas compressors whereas we have a separate oil set for the synthesis gas compressor.

Am I right in saying that in your case you cannot remove oxygen from the system and that this could have contributed to your problem.

D SUMMERS-SMITH: Certainly the answer to the last question is that we have this combined system for the turbines and the compressors. Therefore we have the problem.

LIVINGSTONE: Yes you are right, we have a combined system for the compressor and therefore we can't do the sort of isolation that you have mentioned. I'm not really clear that I understand your corrosion problem. If you have a corrosion inhibitor in the oil, I don't see why you should have corrosion, whether there's oxygen present or not. The corrosion inhibitor ought to cope with that. The problem we had initially with the corrosion inhibitor as I mentioned was that it reacted with ammonia and gave deposits in the system. The corrosion inhibitors we now have in the Gulf 1343 oil are not affected by ammonia and I can't see any reason why they should not be effective in a system where there is excess of oxygen.

JAN BLANKEN, UKF-Holland: I can only repeat what we found: a higher than normal corrosion rate was found by the ASTM method, the nitrogen purge was checked and found not to be working properly, the nitrogen purge was improved and the corrosion rate went down again. Now this is a process engineer talking about a subject he is not familiar with.

LIVINGSTONE: Well the only thing I can say is that excluding our earlier problems, when we did have the high water content in the oil, since we have installed the centrifuge and are maintaining the water content below 200 ppm, we do not have a corrosion problem.

ANON: I've been watching a couple of ammonia plants with very similar sludge problems. On one particular plant we tried many efforts to overcome the problem but never got out of the problem. We were contemplating changing to a diaphragm type non lubricated coupling. Could you tell me whether or not there is any experience at all in the ammonia business in this type of coupling? Have you any idea at all?

D SUMMERS-SMITH: I don't know of any experience with diaphragm couplings on ammonia plants, though we do have a diaphragm type coupling on one of our hydrocarbon plants, on machines which, in terms of the torque and speed, are very similar to the ammonia machines. It has been now in for something like 18 months, and we've had no problems with it.