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SUBJECT: Run 300A-8 Initial Slurry Run of 300A Pump and Loop

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SUMMARY

The 300A pump and loop were operated for 2862 hr with thorium oxide slurry at 1500 psi and 280°C to determine the effects of vane inlet and exit geometries on impeller wear, the wear rate of aluminum oxide bearings in this size pump, and the operating characteristics of the loop. The thoria, a 1600°C-fired oxide, had a mean particle size of approximately 2 μ . Average circulating slurry concentration was approximately 450 grams of thorium per kilogram of water and average flow rate was approximately 300 gpm.

Attack on the titanium impeller surfaces was so slight that no effects of the various vane configurations could be determined. No measurable bearing wear, either thrust or radial, occurred during the run. Loop operation was deficient in two respects; there was a tendency for thorium oxide to leave the circulating stream and collect in the pressurizer, and the purge-producing capacity was limited. Changing to a pressurizer having full loop flow through the lower end, similar to that of the 200A loop, should eliminate the accumulation tendency.

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INTRODUCTION

As a part of the continuing effort to increase the operating life of slurry circulating pumps, Run 300A-8 was conducted to determine the effects of different impeller inlet and discharge configurations on impeller wear, and to determine the wear rate of aluminum oxide bearings. Since this was the first extended slurry run for the loop, its operating characteristics were also viewed with interest.

CIRCULATING PUMP EXPERIENCE

The circulating pump was fitted with a 5-in. diameter fabricated titanium impeller which had various vanes modified to present more continuous guiding surfaces to the flow. Figure 1 shows the vane inlet modifications that were made. Figure 2a shows the original vane exit configuration and Figure 2b shows the modification made on all seven of the vanes. The 15° angle corresponds to the "actual" discharge angle determined as outlined by Stepanoff(1). In addition, four of the vane exits were further modified as shown in Figure 2c.

The pump was completely equipped with aluminum oxide thrust and radial bearings. The thrust runner and radial bearing inserts were made of sintered aluminum oxide and were shrunk into place in the same manner as used previously for Graphitar. The segmented thrust shoes contained shrunk-in inserts of sintered aluminum oxide, as shown in Figure 3. The journal installation used common-apex conical mounting rings as shown in Figure 4. This mounting system should eliminate stresses due to differential thermal expansion between the ceramic journal and the stainless steel shaft, since the longitudinal expansion counters the radial expansion.

Figure 5 shows the impeller after the run was completed. The attack was so slight that no definite effects due to the vane modifications could be observed. The outside diameter of the lower hub of the impeller was reduced one mil where it extended into the stationary wear ring. The apparent weight loss for the impeller during the run was 1.8 grams. However, it is believed that a large part of this is due to weighing error, since the visible attack was so slight. The maximum relative velocity in this type of impeller is at the vane inlet and has been calculated to be 48.6 fps(2).

Samples taken from the motor cavity of the pump during the run had a concentration of approximately 100 grams of thorium per kilogram of water. In spite of this "dirty" lubricant, no measurable wear occurred on any of the various bearing surfaces. However, a full-length longitudinal crack was found in the lower journal. It is felt that this crack was caused by a large temperature gradient which is believed to exist in the shaft at the lower journal location. The conical mount can compensate for expansion only if the shaft is at a uniform temperature throughout the journal length. It is encouraging to note that the bearing apparently continued to operate satisfactorily with the journal cracked.

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- (1) A. J. Stepanoff, Centrifugal and Axial Flow Pumps, 2nd Ed., John Wiley and Sons, 1957, Chap. 9.
 - (2) C. H. Gabbard, "Velocity Study of Centrifugal Pump Impellers," ORNL-CF-58-8-84, August 22, 1958

LOOP OPERATION

The loop was charged with Batch DT-6, 1600°C-fired thoria at the start of the run. While the run was in progress, an additional nine kilograms of Batch DT-13, 1600°C-fired thoria were added. The particle size distributions at various times during the run are shown in Table I.

TABLE I

Slurry Particle Size Distribution

<u>Slurry</u>	Weight Percentage of Particles Less Than Stated Size				
	<u>< 5 μ</u>	<u>< 3 μ</u>	<u>< 2 μ</u>	<u>< 1.5 μ</u>	<u>< 1 μ</u>
DT-6	99	82	49	12	3
DT-6 After 1400 hr operation	97	67	30	8	3
DT-13	98	84	57	34	10
Blend of DT-6 and DT-13	99	89	42	24	7
Blend of DT-6 and DT-13 After 990 hr operation	99	86	50	16	5

The circulating concentration as determined by sample analyses during the run are given in Table II.

TABLE II

Circulating Slurry Concentration

<u>Sample No.</u>	<u>Run (hr)</u>	<u>Grams Th/Kg H₂O</u>	<u>Remarks</u>
1	170	460	
2	442	218	
3	1053	446	Loop had been shut down for 2 days.
4	1487	193	
5	1949	435	After addition of 9 Kg of DT-13.
6	2382	607	After vibration.
7	2862	338	

Throughout the run, there was a tendency for thoria to leave the main circulating stream and collect in the lower part of the pressurizer. The location of this accumulation was confirmed by a gamma survey. From the

sample analyses, it appeared that the amount of thorium which accumulated was approximately nine kilograms. This was further substantiated by the fact that the addition of nine kilograms of thorium brought the circulating concentration back to its original value.

With the hope that chromate addition might increase the flocculation and the settling rate thereby preventing the slurry from accumulating in the pressurizer, provisions were made for continuously transferring chromate-rich supernate from the pressurizer to the loop stream. However, this approach and that of increasing the bypass flow through the lower end of the pressurizer failed to reduce the amount of the accumulation. The thorium could be re-introduced into the circulating stream by vibrating the pressurizer, but this was only a temporary measure and could not be recommended as a continuous or frequent operation.

The natural circulation loop which produces condensate for circulating pump purge was very erratic in operation during the run. At times, the loop appeared to stagnate, with very little condensate being made. This condition could usually be remedied by turning off the cooling water to all of the condenser coils for a short period of time and then, by turning all of the cooling coils on again, "shocking" the loop back into operation. At other, less frequent times, the condenser loop would produce condensate at a very rapid rate, exceeding the heater capacity and resulting in a severe downward pressure excursion. These excursions could only be arrested by stopping the cooling water flow to the condenser coils.

It was thought that the usual sluggishness of the condenser system was caused by the oxygen present in the vapor space blanketing the condensing surfaces. Accordingly, at one startup during the run, the oxygen overpressure was reduced from 290 psi to 75 psi at room temperature. With the same pump purge rate as that used previously (one gallon per hour), the only result of the lower oxygen pressure was the lowering of the equilibrium liquid level in the condensate tank. Batches of oxygen were then injected at intervals which allowed the operation to stabilize between injections. Each injection raised the equilibrium liquid level in the condensate tank, until overflow started with an oxygen overpressure equivalent to 200 psi at room temperature. There was no appreciable change in the maximum possible purge rate during any stage of this operation. The condenser loop contains approximately 15 feet of 1-in. pipe, numerous bends and discontinuities, and has a total vertical height of only 32 inches. One contributing factor to the sluggishness of the condenser system is probably the low circulation rate caused by the high frictional resistance and low driving force present in the loop.

The oxygen content of the circulating stream was rather high throughout the run. Bomb samples taken from the loop had from 1500 to 3700 ppm oxygen. It is probable that this high concentration resulted from oxygen being carried from the condensate tank, with its high oxygen partial pressure in equilibrium with the purge water, through the pump motor and into the circulating stream.

CONCLUSIONS AND RECOMMENDATIONS

No conclusive results were obtained from the impeller vane modifications. Further tests with longer runs or using an impeller material which is more susceptible to attack, should be made to determine the optimum vane configuration.

The aluminum oxide bearings appear to be an answer to the bearing wear problem. However, a more reliable method of mounting the radial bearing journals should be developed.

The pressurizer on the loop is poor in that thorium tends to accumulate in the lower end. This accumulation can be removed by vibration, but was unaffected by raising the chromate concentration of the bypass stream through the accumulation. The pressurizer design for this loop differs from that used on other loops in that only a small bypass stream flows through the lower end of the pressurizer. Changing to the conventional design, where the full loop flow is directed through the lower end of the pressurizer, should eliminate the accumulation tendency.

The purge-producing natural-circulation loop is inadequate and erratic. More vertical height of the condenser leg, with a less tortuous flow path, might increase the circulation rate and result in better operation.

FIGURE 1 - SCHEMATIC OF IMPELLER SUCTION EYE SHOWING VANE INLET MODIFICATIONS

(a)

(b)

Corner Blended

(c)

FIGURE 2 - VANE EXIT CONFIGURATION

Fig. 3. Thrust shoes with Alumina inserts

FIGURE 4 - CONICAL MOUNTING FOR ALUMINA JOURNAL

Fig. 5. Impeller after completion of rod 300 A-B

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