CENTRIFUGAL SLURRY PUMP

WEAR & HYDRAULIC STUDIES

Quarterly Technical Progress Report

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1.0 INTRODUCTION

The following report marks the fourth quarter of the third phase of the centrifugal slurry pump improvement program. The program was begun in 1982 for the purpose of improving the operating life of centrifugal slurry pumps for coal liquefaction service. The first phase of the work reviewed pilot plant experience with centrifugal slurry pumps and identified, with the help of a literature search, the critical design parameters and materials required for such improvement. The second phase encompassed a) extensive small-scale testing of several hydraulic design concepts and b) testing and selection of materials - the results being incorporated in a prototype slurry pump design.

This third phase of the work has included i) prototype slurry pump testing against a state-of-the-art coal liquefaction slurry pump, wherein substantial reduction of wear was obtained at 60% higher speed at the same head and flow rate therefore at 60% higher specific speed - and ii) an investigation as to whether still higher specific speed is possible. The prototype pump tested in (i) had a specific speed of 600. Another pump of this same design was re-fitted for investigation (ii) with a smaller impeller and associated liners so as to operate at a specific speed of 1000. Table 1 contains the significant design features and operating conditions these two pumps.

Both the 600 and 1000 impellers and liners for this latter investigation (ii) were made of mild carbon steel to accelerate the testing time. The two pumps were run in series in the slurry test loop utilizing AFS #110 sand ($\approx$ 110 mesh) at a concentration of 30 percent by weight in water at 80°F.

As previously reported, twenty-four (24) hours of test time revealed a slightly lower overall wear rate for the 1000-specific-speed pump; however, excessive local wear occurred in the impeller eye area of that pump. This was attributed to too large a clearance between the pump-out vanes and the suction side of the volute liner. Wear elsewhere in the pump was uniform and comparable to that of the 600-specific-speed prototype pump.

2.0 TECHNICAL PROGRESS

During the current reporting period, the specific speed (N_s) comparison testing was completed, with a total of forty-eight (48) hours of test time having been accumulated. As in the first twenty-four (24) hours of this testing, both pumps operated at a suction pressure of 25 - 30 psig a head of 300 ft. at 260 gpm on sand-water slurry with 30% sand by weight. The higher speed pump had 61% efficiency at 300 gpm in clear water vs 46% for the 600- N_s pump.

The soft steel impellers and liners wore quickly (as desired) and uniformly vs time during the test. Table 2 contains the weight loss history expressed in percent of the original weight

of the associated component. This table shows that there was less total wear on the 1000-Ns pump; however, Set 3 of the accompanying photographs show that this pump suffered highly localized wear and actual perforation of the blades at the impeller eye. Examination of Sets 1 and 2 of the photographs reveals that other areas of the 1000-Ns pump fared better - in fact possibly better than did the 600-Ns pump.

The backside liner of the 600-Ns pump had a design flow in which the bolt heads were exposed to active slurry recirculation behind the impeller. This was corrected in the 1000-Ns design. It is likely that both pumps would have performed similarly in this regard had the 600-Ns backside liner also been corrected.

The severe eye wear of the 1000-Ns pump is attributed to excessive leakage between the suction-side of the volute liner and the impeller pump-out vanes. This is believed to be the consequence of a larger clearance about 0.130 inch (instead of 0.030 to 0.060 inch as planned) between these two elements (which also experienced excessive localized wear) and was caused by a machining error. On the other hand, almost no wear occurred on the other side of the impeller, where the backside liner also faces impeller pump-out vanes. Zero leakage occurs through this clearance (which was about 0.060 inch). Thus, if the suction side clearance had been 0.030 to 0.060 inch as planned; the pump-out vanes would have restricted the leakage more, leaving reason to believe that much less wear would have occurred in the impeller eye region. The 1000-Ns pump would then have been more nearly equal to the 600-Ns pump in terms of wear.

With this completion of the specific speed effects testing, all work on this program has been completed except for the final report.

3.0 CONCLUSIONS

Since the higher speed pump experienced more localized wear in the eye region, it is easy to conclude that this machine exceeded the practical limit for blade speed in this region. However, improper clearance is undoubtedly the cause of this poor result. In all other respects except for those directly associated with this clearance, the 1000-specific-speed pump performed as well as or better than the 600-specific speed pump in terms of wear.

The higher speed machine also had over ten (10) points more efficiency than the lower speed pump. This fact, together with the above analysis, leads us to the tentative conclusion that full-scale coal liquefaction plants can indeed benefit from the smaller pumps that would be obtained at 1000 specific speed (or

more) than would result if the lower specific speeds of this study and of the pilot plants (still lower) were used. These benefits are higher efficiency and wear rates that do not exceed those of lower specific speed pumps containing the same hydraulic improvements that were proven in the earlier testing of this program.

TABLE 1

Design Features and Operating Conditions
of Slurry Pumps Used in Specific Speed Investigation

	<u>Original Prototype</u>	<u>New Prototype</u>
Specific Speed	600	1000
Design Flow Rate, GPM	300	300
Head, Ft. (in water at above flow rate)	320	320
Flow Rate When Operating On Slurry (30% sand; Density = 75 lbm/ft ³ , GPM)	260	260
Head at Slurry Flow Rate, ft.	300	300
Speed, RPM	2700	4500
Impeller Diameter, in.	11.25	7.00
Ratio of Cutwater Diameter To Impeller Diameter	1.46	1.34
Impeller Exit Tip Speed, ft/sec	133	137
Impeller Inlet Absolute Velocity, ft/sec	36	47

TABLE 2

Centrifugal Slurry Pump Component
 Weight Loss vs Time. Comparison is made
 of two pumps of different specific speed, N_s .

<u>Component</u>	<u>Cumulative Weight Loss, %</u>	
	<u>600-N_s Pump</u>	<u>1000-N_s Pump</u>
<u>1. 24 Hours</u>		
Impeller	4.4	7.8
Suction Liner	3.4	2.0
Main (Volute) Liner	4.0	2.4
Backside Liner	8.1	5.1
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Total	19.9	17.3
 <u>2. 48 Hours</u>		
Impeller	7.8	17.6
Suction Liner	4.0	2.4
Main (Volute) Liner	8.3	3.8
Backside Liner	16.3	9.2
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Total (Cumulative)	36.4	33.0

Photographs of Carbon Steel Pump Internals After 48 Hours of Testing in 30% Sand-Water Slurry. (Flow Rate Was 260 GPM and Head Was 300 ft. per Pump.)

1.) Volute and Cutwater

Above: 600 Specific Speed Pump

Left: 1000 Specific Speed Pump

Photographs After 48 Hours of Testing (Continued)

2.) Impeller Exit

Top: 600 Specific Speed Pump

Bottom: 1000 Specific Speed Pump

Photographs After 48 Hours of Testing (Continued)

3.) Impeller Eye

Top: 600 Specific Speed Pump

Bottom: 1000 Specific Speed Pump