Figure 2. Location of fatigue fracture in a change of section on the pump shaft.

Figure 3. Appearance of pump shaft fatigue fracture surface.

Figure 4. Damage to first-stage casing, wear ring and bottom bush.

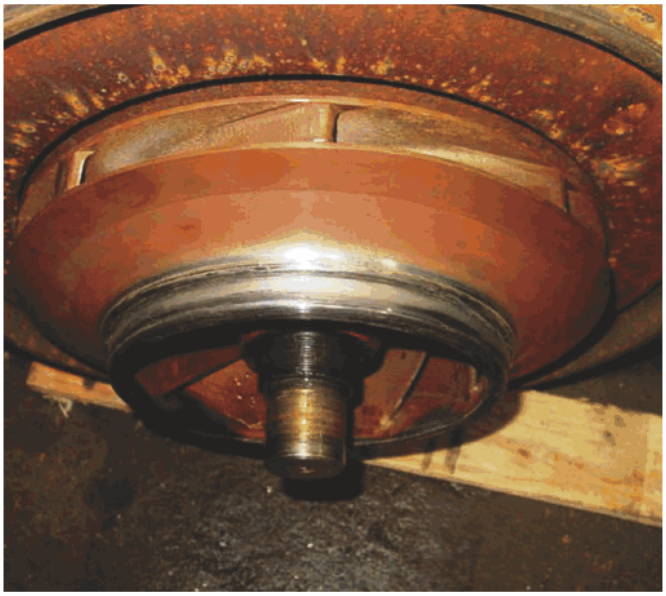

Figure 5. Damage to first-stage impeller front shroud and wear ring.

of symmetric bending stress in rotation acting over a low stress concentration factor at a moderate cyclic load (Figure 3).

The load causing the failure is assumed to be the bending stress caused by the actual angular misalignment being larger than that allowed by the over-running clutch coupling. The original motor support frame had been replaced and it is possible that a slight dimensional difference caused misalignment. Maintenance engineers ought to have recognized the additional care required by this type of coupling during alignment and demanded more accurate work from the maintenance operators and the use of more precise tools for the job. The change of section on the shaft behind the thread is the fully loaded stress raiser nearest to the load application point, the rest of the pump shaft being very smooth.

After the failure of the shaft, the coupling hub and the thrust bearing inner ring are free and the whole pump rotor is also free to move downwards, while still rotating at high speed, until it collides with the pump first-stage casing and bottom bush. Damage to the first-stage casing, first-stage casing wear ring and bottom bush are shown in Figure 4, while Figure 5 shows the damage to the first-stage impeller front shroud and wear ring.

Motor shaft fracture

The second case study examines the fatigue fracture of an electric motor shaft. Again, the problem was found to stem from the actual misalignment being larger than that allowed by the coupling type.

This case also occurred on a vertical condensate extraction pump using an old design of over-running clutch coupling. The pump involved was in fact a 'twin' to that discussed in the previous case study. This time the fracture was located not on the pump shaft but on the motor shaft immediately behind the coupling core (Figure 6). As in the previous case study, the appearance of the fracture surface suggested the presence of symmetric bending stress in rotation acting over a low stress concentration factor at a moderate cyclical load (Figure 7).

As with the twin pump, it is inferred that the load causing the failure arises from the actual angular misalignment exceeding that allowed by the over-running clutch coupling. As was the case with the first pump, the motor support