PENTAIR

WHITE PAPER

COOLING SUBMERSIBLE WASTEWATER PUMP MOTORS

EVALUATING METHODOLOGIES

This paper compares two methodologies for cooling the squirrel cage A/C induction motors that are used in submersible wastewater centrifugal pumps.

The heat generated by the motors, which are enclosed in cast iron housings, must be transferred to the surrounding environment to prevent the motor from overheating and to increase motor efficiency.

Additionally, efficient cooling significantly impacts the lifetime of the motor since components such as bearings and motor insulation materials are particularly vulnerable to overheating.

The two common methods for heat transfer are:

1. Transferring the waste heat through dielectric transformer oil that fills the motor cavity.

2. Using a closed loop cooling (CLC) solution in which a cooling fluid (propylene glycol solution) is circulated through the jacket by an expeller attached to the main motor shaft. The coolant is pumped through an integrated heat exchanger in the base of the motor whenever the motor is running, allowing excess heat to be transferred to the process liquid.

Oil Filled Solution

A large portion of the electrical energy supplied to the motor is converted into mechanical output. The remaining part of the electrical energy is lost in the form of heat (i.e., waste heat). Waste heat is generated in the copper windings, the laminated steel stack, and the inner rotor.

In the oil-filled solution, most of the waste heat is transferred directly from the windings through the oil to the motor housing, and then to the environment. The waste heat in the steel stack is transmitted through direct contact with the motor housing, and then out to the environment. Some of the heat in the rotor is also transmitted through the shaft. Additionally, there is heat transfer from the stack and rotor through the oil to the housings.

The oil-filled solution provides an excellent transmission medium to transfer heat away from the motor. Another advantage of this method is that bearings and other moving parts are constantly lubricated reducing heat buildup and aiding in heat transfer.

Ultimately, a cooler running motor is a more efficient motor.

Closed Loop Cooling Solution

The CLC solution utilizes a water and propylene glycol mixture instead of oil. An internal expeller circulates the cooling fluid up past the exterior of the motor housing, and back down through a heat exchanger to remove some of the latent heat from the fluid. Also, the expeller also draws a small amount of horsepower to operate.

There is some direct contact of the laminated steel stack to the motor housing which helps transmit some heat. However, the windings, most of the stack, and most of the rotor are only exposed to insulating air which does a very poor job transmitting heat away from the motor.

When heat rise lab tests were performed on a 40 HP oil-filled pump versus a 40 HP CLC pump both running at 38600 watts, the results indicate the heat rise of the CLC pump was 30-40°C higher than an oil-filled unit.

Oil Filled Benefits

1. Heat increases the resistance of the copper stator windings which reduces efficiency.
2. Premium efficient, Class H, oil-filled motors can run up to 40°C cooler than CLC motors, which extends the life of the windings, bearings, seals, and lead wire.
3. Oil cooled motors continually lubricate bearings, eliminating the need to regularly repack bearings (i.e., requiring less maintenance)
4. In a premium efficient oil-filled motor, a greater portion of the input energy is directed at creating work rather than wasting heat energy. A premium efficient oil-filled motor can and should be designed to be more efficient than an air-filled motor.

Added Parts, Complexity, and Seal Surfaces

1. The design of the CLC system requires more parts, which may increase the possibility of component failure due to added complexity.
2. Since there are more parts, there are more places that need to be sealed, which means more chances for a leak to occur.
3. Lower bearings are completely encapsulated in cast iron, requiring a thermal sensor on the bearing housing to monitor how much damaging heat the bearing can tolerate.

Seal Leak Detection

1. With an oil-filled pump, the seal leak detector is mounted in the cavity between the first and second seals. If a sewage leak occurs, the sewage is confined in the seal cavity separated from the motor and bearings. Thus, a warning is received that a seal leak occurred. Due to the early warning detection, steps can be taken to resolve the leak before more damage is encountered.

   However, on a CLC pump, the cooling fluid flows between the first and second seal. On CLC pumps without an early warning system, if the first seal leaks, sewage will make its way into the internal cooling system clogging small passageways. The leak detector will not recognize water intrusion until the second seal is compromised, at which point damage has already occurred.

2. On a CLC motor, the lower motor bearing will need a lip seal or bearing shield for additional protection should sewage make it past the second seal.

Efficiency Trade Offs

1. An oil-filled unit has viscous losses due to the motor rotor turning in oil.

   While it is true that an equal sized and designed motor will have some losses (as high as 1.5%) due to viscous drag, the CLC motor will have similar losses due to the expeller that pumps the cooling fluid.

   Also, the efficiency losses increase due to the motor running 40°C hotter, which increases the winding resistance.

Summary

Oil-filled pumps run considerably cooler, last longer, are simpler to operate, and require less maintenance.

Finally, they notify you sooner of a leak, and in the long run, they cost you less with fewer complications.

About the Author

Jack Bevington is a 49-year veteran of the pump industry. He worked as the Water Systems Engineering Manager and as a Development Engineer at Pentair for 42 years. He has a BSMET from Purdue University. He has designed and developed numerous hydraulic pumps, from 4" well to 12" solids handling pumps; his work has resulted in 11 patents. Additionally, Jack was a board member (1983-84) and Technical Committee Chairman (1985) of the Sump and Sewage Pump Manufactures Association (SSPMA), and has authored an article for National Drillers Magazine (March 2000) titled "Diagnosing Well Pump Problems".

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