inMotion
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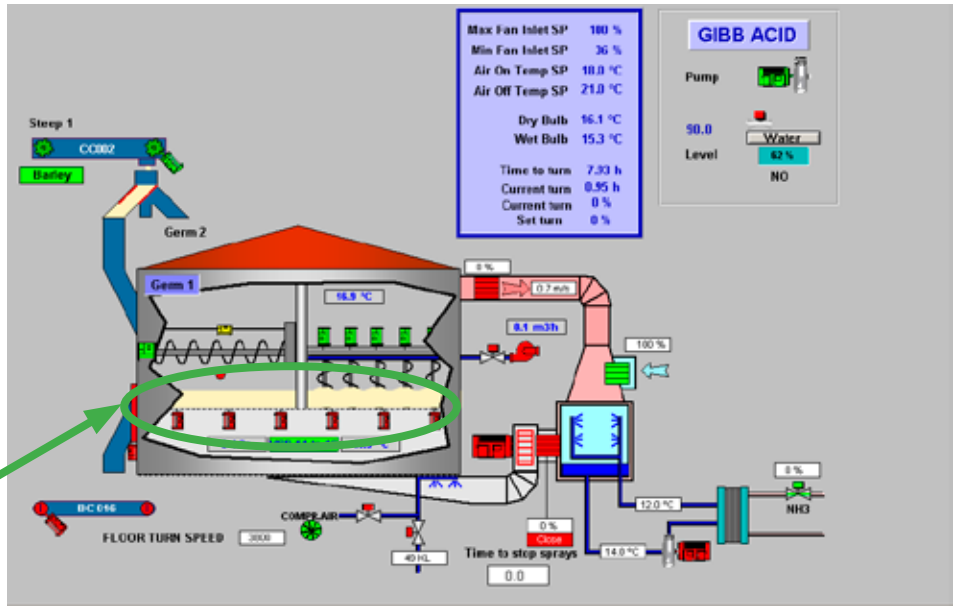

The rotating beams of each germination vessel are driven by 6 motors with gear boxes (Gear ratio: 2400:1)

VLT® AutomationDrive optimises germination vessel at SAB Maltings in South Africa

Benefits from from a VLT® solution for Caledon Malting: substantially reduced maintenance costs as the wear on gear pins is reduced, operational reliability is higher, risk of gearbox failure is eliminated due to the even load on all six motors and gear boxes, and automatic monitoring function detect any cable and motor failure. This is fully controlled from the SCAD screens in the control room without disrupting the process.

The Caledon Plant

The Caledon malting plant is one of the biggest and most modern plants in the world. It was built in 1981 and is supplying approx. 80% of the malt used at SAB Millers breweries in South Africa. The annual production of malt is 180 thousand tons/year.

The plant is highly automated to handle the huge volumes and obtain effective process control for consistent quality.

The Caledon Malting plant has 6 flat-bottomed and round concrete germination vessels which take 360 tons of barley. There are false floors (sieve material) in the germination vessels to allow the flow of temperature regulated air and/or water from beneath.

Some of the floors rotate and some are fixed with a rotating beam from the centre to allow the turning of barley and the loading and discharge of barley or malt. The floors and rotating beams are powered by six 2.2kW motors spaced at 60 degree intervals around the gear rack of the prop shaft. The gear rack has a diameter of 24 metres and there are 720 equally spaced gear pins round the circumference of the rack.

The electrical motors are connected to the gear rack via five-stage gearboxes with a combined ratio of approximately 2400:1. This corresponds to an output gearbox speed of approximately 0.6 rpm when the motors are running at their nominal speed of 1 440 rpm.

Before the Danfoss VLT® AutomationDrives were installed

The original installation chose 2,2kW two-speed motors that allowed operation at 100% and 50% of nominal speed.

However, to achieve optimum performance for the different operations required the motors were required to run at 16%, 20% and 50% of the nominal speed (forward and reverse). Therefore, a variable speed drive, which was not Danfoss, was installed. All six motors were connected in parallel to the single drive allowing the motors to operate at the required speed.

Problems arose when only five of the motors could be used, due to ground leakage fault tripping on the variable speed drive (possibly as a result of the parallel connected motor cables' capacitance to ground), and the humid operating environment of the electrical motors.

After some time it also became apparent that the remaining five motors did not distribute the load/torque evenly on the gear rack. This resulted in excessive wear

on the gear pins. Severe overloading on the 2.2kW motors also resulted in them being replaced by six 3kW motors.
Excessive wear on the gear pins led to them becoming unmatched, which meant that the pitch-spacing of all 720 pins became unequal. The variation in pitch affected the even speed of the motors, aggravated by the slow speed at which the germination vessels were turning (4h/rev @ 8 Hz, i.e. 16% of nominal speed).
The risk of failure of the gearbox was therefore extremely high.

The Danfoss Drives solution

The new design concept included six Danfoss VLT® AutomationDrive FC302 variable speed drives capable of flux vector torque control, each connected to only one motor. One of the drives is set as the master, to which a speed reference is given from the PLC/SCADA. The remaining five slave drives use the master drive's torque output as reference in torque mode with speed feedback.

The drives are connected to the PLC/SCADA via DeviceNet. In the event that one motor needs to be mechanically disconnected, the affected drive can be disabled via the SCADA screens with no rewiring necessary and the torque sharing between the rest of the drives will not be affected.

The SCADA screens were also used to set the P, I and D parameters for each drive. This allowed for the parameters to be the same for each inverter drive and to be adjusted simultaneously, allowing for the fine tuning of a specific inverter drive if required.

Due to the relatively low operating speed of the drive system (8, 10 and 25 Hz), an incremental shaft encoder was mounted in the motor shaft. To minimise the effect of vibration, the drive perform low-pass filtering on the speed feedback signal for each slave inverter as well as on the torque reference signal from the master inverter. The torque limit of each drive is easily adjustable.

The available status parameters of the drive is monitored by the PLC/SCADA to detect inverter/cable and motor failures. If the inverter output frequency of any slave drive is substantially higher than the frequency of the master drive, it could imply a broken shaft, and the PID controller will try to increase the output frequency until the required torque reference is reached. However, if the output frequency is substantially lower than the frequency of the master drive, this could indicate bearing failure or seizure. In that case an alarm will be activated and the germination vessel will stop.

Features of the Danfoss solution:

- variable speed operation
- all six motors run consistently, in order to lower maintenance and enhance reliability
- in case of emergency the operation is able to continue with five, or even four, motors
- equal torque sharing between all the motors (nominal 5%, maximum 10% during transients)
- a maximum torque limit of 35Nm is set for each motor
- the torque is limited to 30Nm during start/stop or forward/reverse operation, to allow for controlled soft-starting/stopping/reversing of the germination vessel
- condition monitoring/failure detection of the inverter, electrical motor and gearbox
- interface to the existing Allen-Bradley 5/25 PLC via DeviceNet)
- interface via the PLC to the InTouch SCADA system from Wonderware.