NEW TECHNOLOGY
&
OTHER INITIATIVES FOR
MOTOR CONTROL
AT
AUSTRALIAN GOLD REAGENTS
SODIUM CYANIDE SOLIDS PLANT

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1. INTRODUCTION

A number of initiatives were taken with motor control for the new solid cyanide plant built in the first half of 2002. These initiatives were taken principally with a view to saving costs through use of current technology and to learn first hand about the benefits of the new technology.

The new technology and initiatives included the following:

i) In lieu of standard bimetallic strip operated current operated overload units, Siemens Simocode motor control units were used for direct on line (DOL) started motors

ii) In lieu of hard-wired DCS I/O, Profibus was used to communicate digital and analogue signals to/from the Emerson Delta V DCS to the following equipment:

    Siemens Simocode units for DOL started motors
    Danfoss variable speed drives for motors requiring speed control
    Toledo weigh transmitter for process information

iii) In lieu of Form 4 motor controls for drives smaller than 5.5kW, Sprecher and Schuh's "Advanced Control System" Form 1 motor starter components were used

iv) In lieu of fuse switches, Terasaki and Sprecher and Schuh circuit breakers were used to provide motor starter short circuit protection

v) Use of variable speed drives with contactor isolation of the output of the VSD

The basic design had to provide for 58 drives as follows:

29 DOL drives 5.5kW or smaller
15 DOL drives 7.5kW or larger (largest = 185kW)
2 VSD controlled drives 5.5kW or smaller
9 VSD controlled drives 7.5kW or larger (largest = 200kW)
2 DOL drives 5.5kW or smaller with emergency generator back up
1 DOL drive 7.5kW or larger with emergency generator back up

The drives were all controlled via Profibus link to the DCS. 3 Profibus networks were used with the drives split 19, 26, 13 across the networks.

A total of 208 digital and 0 analogue signals were hard-wired to the Simocode and VSD units. A total of 728 digital and 69 analogue signals were sent to/from the DCS across the Profibus networks.

The DCS chosen for this project was the Emerson Delta V system. This is a current generation of DCS and has interface cards to various BUS networks. For this project, Foundation Fieldbus and Profibus were chosen to allow use of equipment using these platforms.

2. DIRECT COST SAVINGS

Costs are difficult to quantify given the non-routine nature of this project. Overall however it was judged that it is unlikely that any bottom line cost savings were made on this project. There are however some deferred cost savings and other benefits as noted in Section 3, which make the change to the new technology worthwhile. The direct cost variations are listed below:

2.1 ADDITIONAL COSTS

The new technology incurred extra costs in the following areas:

i) Simocode more expensive than normal motor overload
ii) Additional engineering costs to understand the new product and costs to engage resources with expertise in programming Simocode units
iii) Design and construction of Simocode test box.
iii) Factory testing of the Simocode
iv) Development and factory testing of the VSD and Simocode interface to the DCS was roughly 25% longer than the "standard" motor control scheme – in part due to learning about interfacing the new devices to the new Delta V DCS. Provided the developed templates are re-used then this will be cost neutral for future projects using this technology.

2.2 COST NEUTRAL ITEMS

The following items did not save or incur additional costs on this project:

i) Factory testing of the MCC took a similar time as a standard control scheme.
ii) MCC manufacture price similar
iii) Use of circuit breakers in lieu of switch fuses

2.3 COST SAVINGS

The following items had definite cost savings:

i) The Profibus interface to the DCS in lieu of hard-wired I/O cards. Only about 3% of the DCS I/O was traditional hard-wired
ii) Profibus cabling for 3 networks in lieu of multicore cables and cable supports
iii) Site commissioning was slightly quicker (estimate 10%)

3. INDIRECT COST SAVINGS AND OTHER BENEFITS

3.1 EQUIPMENT ROOM SPACE SAVINGS

In the case of new projects there will be a defined cost for providing floor space for electrical and instrumentation control equipment. Wherever this space can be reduced will mean a reduced overall project cost.

In the case of this project there was free space available in the existing switch room but this had to be used wisely to avoid exceeding available space and incurring expensive switch room extension costs. Space had to be provided for equipment for the new plant including MCC, VSDs, 24 volt DC power supply and DCS cabinet.

3.1.1 DCS

The DCS control cubicle utilising Foundation Fieldbus and Profibus in lieu of standard control I/O was quite small for the size of the control system. It was a single sided unit of size 900 x 650 mm. Standard architecture DCS cubicle would have been up to 6 times the size taking into account marshalling as well as I/O requirements.

3.1.2 MCC

The basic Simocode motor control units have the following I/O capability on board as well as Profibus communications to the DCS:

4 digital inputs
4 digital outputs
Thermistor input
Motor amps monitoring

The Simocode I/O thus allowed the following "standard" control scheme hardware to be dispensed with inside the MCC:

i) Terminals for DCS signalling for “drive available”, “field auto selected”, “drive running status”, “drive overloaded status”, “drive start”, “motor amps”
ii) Current transformers and current transducers
iii) Thermistor relays (not used on drives 5.5kW or smaller)
iv) Thermal overload relay (offset by the use of the Simocode but note that the Simocode generates only 5 watts of heat regardless of the amps from the motor hence can allow greater stacking density in Form 1 panels)
v) Interposing “start” relay

The above saving in termination space coupled with the use of the Sprecher and Schuh “Advanced Motor Control System” Form 1 style of motor control to control drives smaller than 5.5kW, enabled 32 drives to be squeezed into 2.33 tiers of the MCC. A feature of the Form 1 controls was that the individual drive circuit breakers were able to be directly operated by operations and maintenance personnel for isolation purposes and thus the requirement for LED “drive isolated” indicators and associated fuses was dispensed with thus saving more space.

All the drives were fitted into a double-sided MCC that was only 4.8 metres long. Furthermore, at the end of the project there was spare space for a further 28 drives 5.5kW or less and 2 drives 22kW or less. Using "standard" design with Form 4 cubicles for each drive the MCC would have been 6 metres long with spare future capacity for only 16 drives 5.5kW or less. Thus the MCC length was 25% shorter and had more spare capacity than it would otherwise have been. The reward for keeping the MCC footprint so small will be reaped when a second plant is built or other uses are found for the remaining floor space.

In this particular project a large proportion of the drives were 5.5kW or less and thus the above floor space saving was achieved. In another plant where most of the drives are larger than 5.5kW with individual motor starter cubicles per drive, then the floor saving may be insignificant.

3.2 IMPROVED MOTOR PROTECTION

"Standard" motor control hardware required only basic motor protection for drives less than 30kW. This included overload protection using bimetallic strip over current and thermistor relays.

Using the Simocode effectively provided full electronic motor protection to all drives, not just 30kW or larger. The protection included:-

Current overload with variable class starting time
Thermistor protection (no change)
Instantaneous over current
Earth fault
Motor stalled
Current asymmetry
Contactor fail to close
Contactor fail to open

The additional drive tripped information will also be useful to maintenance for rapid troubleshooting.

3.3 INFORMATION FOR OPERATORS

The new technology provides a wealth of information to the operator on the state of each drive. Note that this is required in part because the Simocode does not have any plain english display interface built into it. To determine the fault or other status requires either sending all relevant information to be displayed on the DCS, as was the case on this project, OR to interrogate via Profibus or RS232 using a laptop with proprietary software. Clearly bringing up the information on the DCS is the preferred choice where this can be readily achieved.

3.3.1 AMPS

"Standard" configuration required motor amps for drives 7.5kW or larger but amps monitoring for smaller drives is determined by the load characteristic i.e. was on overload during a normal plant disturbance a likelihood?

The Simocode provides motor amps for all drives regardless of drive size. This will prove useful for troubleshooting and control of the plant.

3.3.2 DRIVE STATUS AND CONTROL

Using the Simocode allows full details to be sent to the DCS. This information is quite extensive but has minimal cost to implement since once a template has been set up for a drive then the DCS configuration can be readily copied and pasted.

Information includes individual identification of all the causes of a motor trip as noted in section 3.2 above, Profibus communications status to the drive, health of the Simocode and its status.

The implementation of this feature was helped by the standard Delta V operator graphic which has a detail faceplate which can be called up from the standard faceplate at the push of a mouse button.

3.4 CONTACTOR FAILURE

By utilising one of the available outputs of the Simocode relay and adding the appropriate programming, protection against the contactor failing closed was achieved. This fault condition occurs when the Simocode has no active start command but sees current going to the motor. In this case the Simocode will operate the shunt trip coil of the motor starter breaker. Thus for occasions where a contactor may have welded closed, the supply to the motor will still be isolated. This feature could not be as cheaply implemented in the standard motor control scheme.

3.5 EARTH FAULT DISCRIMINATION

In AGR "standard" design, motor starters use a switch-fuse to provide isolation and short circuit protection. It is impossible to obtain effective grading for low level earth fault currents between the fuses on medium size drives and the earth fault protection of MCC main incoming air circuit breaker.

Through the use of circuit breakers for all motor starters, and toroid earth fault relays on drives 90kW or larger, it was possible to obtain full earth fault discrimination for all drives.

Note that there are some issues with the Simocode as noted in section 4 with regards earth fault tripping times.

3.6 EMERGENCY GENERATOR CONTROLLED DRIVES

In the event of a loss of power to the plant there is an emergency diesel generator, which is used to keep 3 critical drives running. On loss of power, the DCS and 24 volt power supplies will only hold up for about 15 minutes until the UPS batteries are fully discharged. On loss of power it is thus not possible to control the drives from the DCS through the Profibus link.

To deal with this, a Simocode operator panel was installed for the 3 drives. A spare input on the Simocode was used to identify that the generator was on line and the Simocode programmed to respond to start and stop commands from the local Simocode operator panel. Thus when on normal power, the Simocode would only accept commands from the DCS through the Profibus link and when the emergency generator was running the Simocode would only accept commands from the local Simocode operator panel.

3.7 MOTOR OVERLOADS

During commissioning there were 2 fans and a centrifuge which were high inertia loads. These drives would not start within 10 seconds. The standard bimetallic overload, if used on these drives, would have to have been upgraded to allow for the longer start up time. With the Simocode it was just a matter of programming a new operating curve for the higher class of start, eg. 15 seconds in lieu of 10 seconds. It is acknowledged that this may have been foreseen at the design stage, and this is why it is not listed as a defined saving, but it was a useful feature on the day when these small issues get through the system.

3.8 CONTACTOR ON OUTPUT OF VSD

The Danfoss variable speed drive chosen for this project had the following features:-

- Profibus communications capability
- Digital inputs that could be used to transfer information across the Profibus link
- Ability to allow the output of the VSD to be switched using a contactor
- Auxiliary 24 volt power supply for controls in lieu of deriving control power from main incoming 415 volts

In AGR "standard" controls for VSDs a contactor is wired to the input of the VSD since VSDs generally can't handle the output being switched. The disadvantage of this is that when there is a hard-wired trip, eg. due to field control station being switched off, then the VSD loses input power and this brings up other alarms such as loss of Profibus communications. Another disadvantage is that if the drive is isolated so that work can be carried out on the motor, time must be allowed for the capacitors in the VSD to discharge before work begins so that there is no risk of electric shock. Using 24 volts DC to power the VSD controls will only solve the first of the above two problems. Placing the isolating contactor on the output of the VSD solves both problems and this is what was done on this project.

4. NOTES FOR SPECIFICATION AND DESIGN

4.1 SIMOCODE PROGRAMMING AND DCS INTERFACE

The Simocode has much flexibility but requires some skill in applications that are not "run of the mill". It is recommended that a detailed functional specification be written against which the configuration can be tested. If configuration of the Simocode becomes problematic then there are a number of companies in WA with personnel who are skilled at programming it. These persons could either be engaged to do the whole configuration, as was the choice at AGR, or are available to provide assistance (at a cost) if required.

In the case of AGR the company providing the Simocode configuration expertise also built a test and training module with a Simocode, motor, motor controls identical to that used for the project and wiring and switches to simulate normal starting, stopping and running, over load, stalled motor, instantaneous over current, earth fault, thermistor trip, phase imbalance and contactor faults.

This test module proved highly beneficial in ensuring that the Simocode configuration matched the functional specification and saved much time at site commissioning since only minor configuration changes were required. The test module was also used to do factory acceptance testing of the DCS to ensure that all the signals and alarms went to the right place and operated correctly on the DCS faceplates.

An unexpected use for the Simocode test module was in highlighting problems with earth fault trip response times as noted in section 4.2 below.

At the completion of the project the module was used for training.

AGR found the module to be extremely useful and worth the additional costs to develop and build.

4.2 SIMOCODE EARTH FAULT DETECTION

The literature for the Simocode suggested that it would detect earth faults and issue a trip command within approximately 0.3 seconds. On this basis a spare output of the Simocode was used to shunt trip the motor starter circuit breaker on earth fault detection. For earth fault tripping occurring within 0.3 seconds there would have been discrimination with the main incoming air circuit breaker (ACB) which had a maximum earth fault trip time of 0.4 seconds.

As it turned out, during factory testing of the Simocode test module, the actual earth fault tripping time was more like 0.6 seconds. This meant some changes to the earth fault setting of the main ACB. If this longer tripping delay was not detected at factory testing then the plant would have been exposed to a possible trip of the main ACB due to a motor earth fault.

4.3 DCS PROFIBUS INTERFACE

Commissioning of the Profibus interface to the DCS was not straight forward. Having a specification which detailed the requirements helped achieve the final result. There were some problems with the transfer of information which had to be worked through and in the case of the VSD required the manufacturer’s representative to assist. This process was made easier through use of the Simocode test module and also hire of a VSD test module complete with motor so that live data could be swapped and the system fully function tested.

4.4 PROFIBUS CABLE

4.4.1 HARDWARE

The standard Profibus cable is single pair solid core cable. The motor starter cubicles for the larger drives are withdrawable type and solid cored cable will eventually break internally if flexed too many times. To overcome this problem stranded cable was used for the withdrawable drive cubicles. Note that the flexible cable is 2 to 3 times the price of standard solid core cable.

Some Profibus terminating plugs are designed to automatically grip the core as it is fed into the connector termination and others use the insulation displacement technique. AGR has a preference for screw type of connections on communications cables. This was overcome by sourcing a manufacturer of RS485 "D" plugs with screwed connections.

4.4.2 INSTALLATION

It is self evident that the quality of the signal on the Profibus cable and the quality of the terminations was critical to the operation of a large section of the plant. A single Profibus communications fault could knock out nearly half the drives. There was also the fact that 11 VSDs were being controlled through the Profibus cabling and thus the possibility of high frequency interference. Furthermore the Profibus signalling is polarity sensitive. Thus care is needed to ensure minimum start up problems. To minimise the possibility of Profibus communication faults the following steps were taken:-

- i) The Profibus cabling runs within the MCC and drive cubicles were run with as much segregation from motor cabling as possible
- ii) The Profibus cabling external to the MCC was run in either flexible steel conduit or rigid steel conduit and segregated from other power cabling
- iii) Profibus cable screens were earthed
- iv) Additional supervision of the electrical installation contractor took place to ensure that the cable screen on all VSD controlled drives was earthed at both the VSD and the motor.
- v) Active terminators were fitted at each end of each Profibus network.
- vi) The supplier of the Simocode units was given the responsibility to supply the Profibus cable, to do all terminations and to direct the electrical installation contractor on how the cable had to be installed. Thus there was a vested interest by that supplier to ensure that the cable installation and terminations were to a high quality.

During commissioning there was the odd bad connection which had to be tightened and the wiring crossovers on the DCS Profibus communication modules which had to be swapped over. There have not been any other poor communications or interference issues. The Profibus networks operate at 500 kilobaud and data update rates across the Profibus link are in the order of 20 milliseconds (this is different to the DCS screen update time since the servicing rate of the DCS is considerably slower).

4.5 DCS COSTS

With traditional I/O configuration the DCS vendor is able to make profit from the sale of propriety hardware modules. With the advent of bus communication it is not possible to do this as the cost of a bus interface module is relatively cheap. A significant component of the cost of modern DCS systems is for tag license charges. These tags are called DST’s in the Delta V system.

Part of the attraction of the new technology is to be able to transfer much more information to the operator at minimal cost. This attractiveness would be significantly offset if every item of data was considered to be 1 DST. The upside is that the Delta V DST count is in bytes and not bits. Thus 16 or more digital signals, depending on the equipment, can be transferred as a single DST. This helps keep the cost of licensing to a more reasonable level.

When doing cost estimates on a Delta V system it is recommended that the number of DST’s be determined and thus accounted for in the budget.

5. FACTORS FOR PROJECT SUCCESS

Some of the factors which contributed to the successful implementation of the new technology on this project are as follows:-

a) Detailed specifications prepared for the Simocode motor starter control requirements and the DCS interface

b) Use of experienced Delta V programmer for developing interface for VSD and Simocode

c) Use of experienced personnel for Simocode programming and to monitor/control the Profibus cable installation and Profibus terminations

d) Use of Simocode test box and VSD test box for factory testing of Simocode logic and DCS interface thus enabling comprehensive testing against the specification requirements before commissioning at site.

e) Good technical back up from the VSD and Simocode supplier

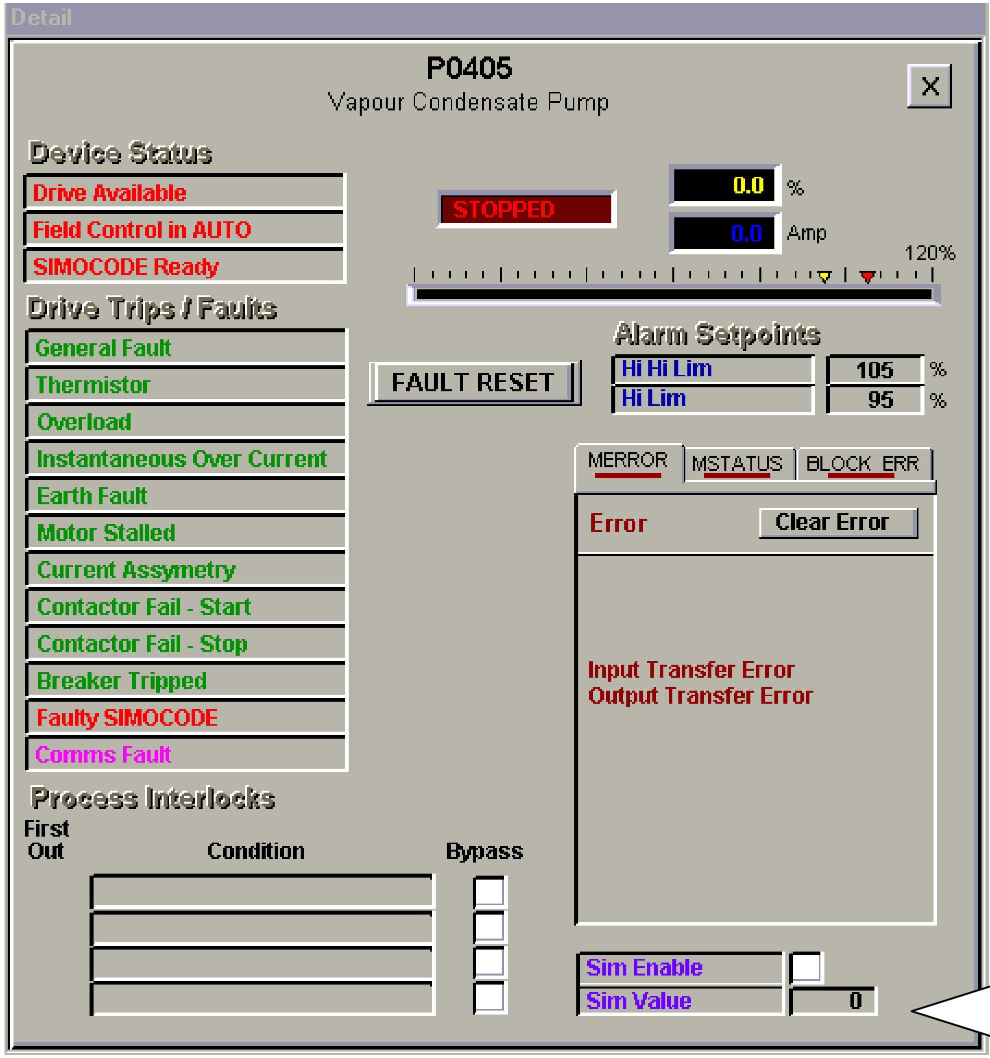
f) Close liason with MCC manufacturer in design of the Form 1 drive layout and installation of Profibus cables

6. CONCLUSIONS

Overall the use of the new technology in the form of Simocode motor starter protection units and Profibus communications for DOL and VSD motor control from the DCS has been highly successful. It is judged that immediate cost savings were not realised on this project compared with standard motor control. Some cost savings will be realised in the future - such as deferring extension of a motor control room or reduced engineering costs when the new technology is used on the next project. There are clear benefits other than cost such as improved information to the operator and better motor protection.

In conclusion the use of the new technology and other motor control initiatives as described herein are worthwhile and recommended for future projects.

DCS Detail Motor Faceplate



DCS Motor Faceplate