NHP

TECHNICAL NEWS

Issue 13

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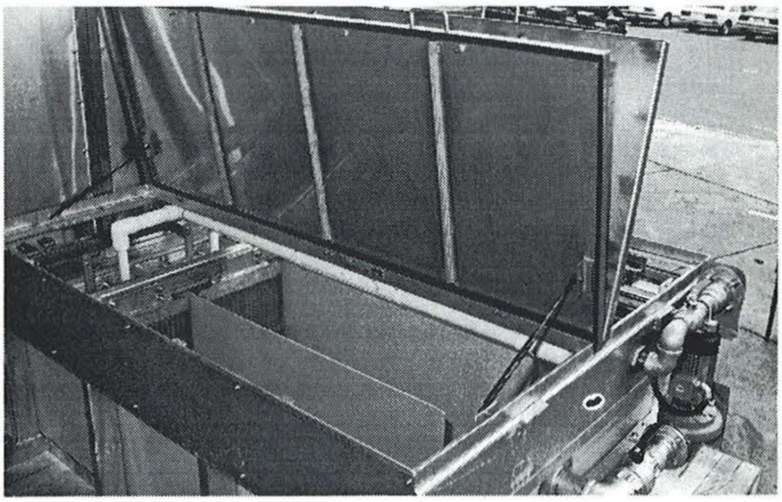
Quarterly Technical Newsletter of Australia's leading supplier of low-voltage motor control and switchgear.

LIQUID RESISTANCE STARTER DEVELOPMENTS

The AC cage induction motor is the mainstay of electrical drive systems. The motor has only one moving part and if designed and used correctly can give very long periods of trouble free service. The limitations of this type of motor show up during starting or where variable speed operation is required. To overcome the limitations additional equipment external to the motor is required to control the power applied to the motor or the characteristics of the motor itself. The slip-ring motor is the major example of an induction motor which can offer external control of the motor characteristics to provide excellent torque and speed control. While the cost of the motor and control equipment are substantially higher than a simple induction motor the control available is invaluable in some applications.

The slip-ring motor

The induction motor can be shown to have a maximum torque output which is independent of rotor resistance. It is only the speed at which peak torque occurs that is dependant on the rotor resistance. The slip-ring motor allows the rotor resistance to be controlled by adding external resistance to the rotor circuit.



Electrolyte tank of high range liquid resistance starter

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The slip-ring motor
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The concept has been around for a very long time and the added resistance has either been in the form of metal resistors or the liquid type. As can be seen from **Fig. 1** the actual speed at any value of rotor resistance will depend on the applied load – if this varies so will the speed. This problem has limited the use of the slip-ring motor in applications requiring close speed control.

The slip-ring motor at standstill, operates like a transformer. The rotor acts as the secondary and the open circuit voltage of the rotor depends on the turns ratio between the stator and rotor. The current that flows depends on the external resistance added to the rotor circuit. As the motor accelerates the rotor voltage and frequency drop in proportion to speed. Full torque output can be achieved without the current exceeding the normal full load rating. This process does however produce a lot of heat in the external resistance. If the resistance value is selected to give full load torque at locked rotor the initial power loss is equal to the kW rating of the motor.

The liquid resistance starter

The main advantage of the liquid resistance starter is that the resistance can be varied continuously over a wide range.

While it is normal to provide a shorting-contactor to bypass the liquid resistor at the end of the start cycle this contactor is operating under very light duty as it only is required to carry the rotor current. In the case of metal resistors it is common to have multiple contactors switching in and out during the start process. The breaking of rotor current stresses the contactor and careful selection is required to ensure long life.

The most common means of applying a liquid resistance starter is to allow the starter to operate in open-loop mode. The electrodes are moved at a speed determined by the gearbox ratio of the electrode drive system. This is quite adequate in applications where improved starting torque and lower-line currents are the main criteria. In more demanding applications a closed loop control system is required.

In a recent application for a large conveyor system a special liquid resistance starter was developed to allow close control of the conveyor drive motors.

Demanding applications

The conveyor drive required the following features:

a) ability to provide low initial torque to allow take up of belt tension.

b) to be able to then quickly increase torque to 1P.U.

c) to keep acceleration within defined limits while not exceeding 1P.U. torque.

d) no significant torque peak on closing the shorting-contactor.

e) to provide creep-speed operation capabilities.

f) reliable service over a very long period of time.

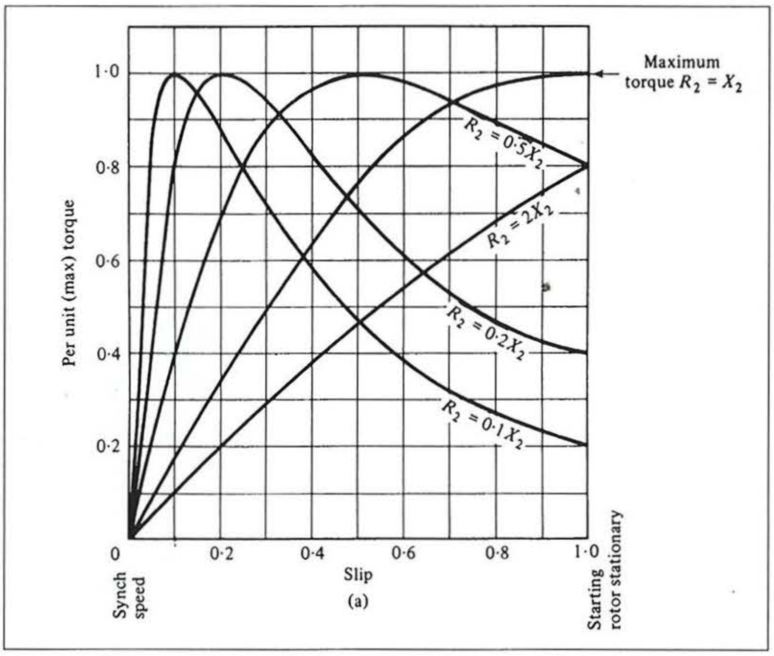
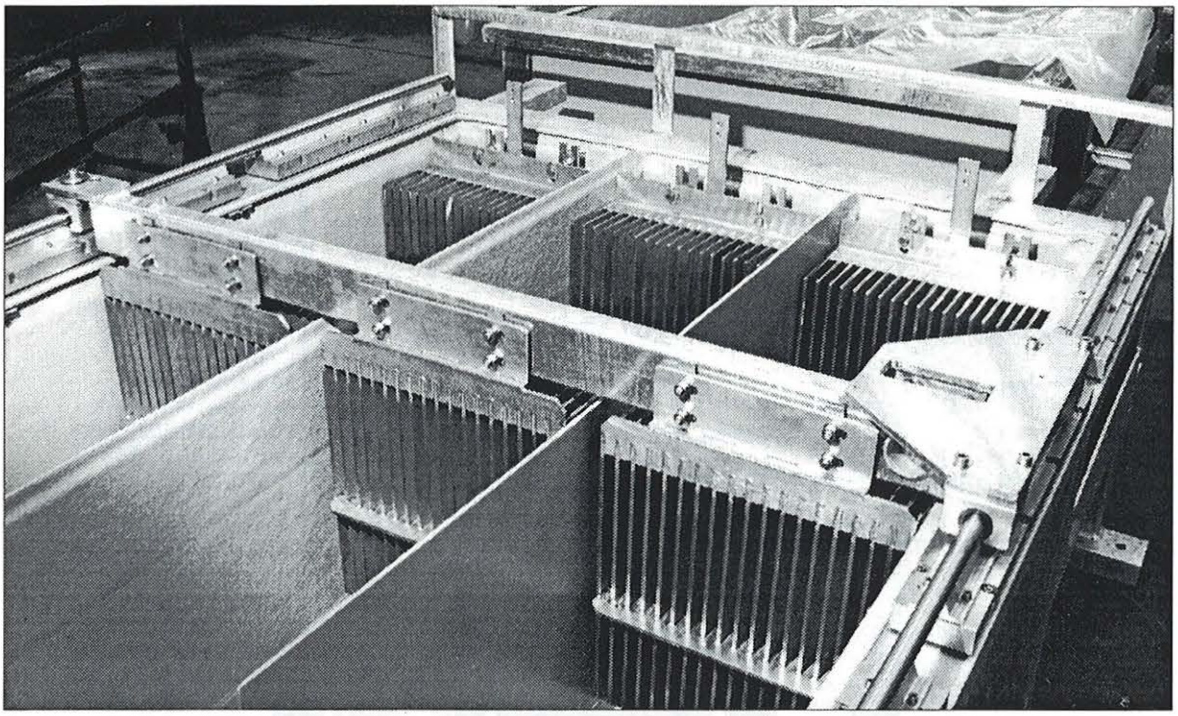


Fig. 1 ***The actual speed at any value of rotor resistance will depend on the applied load - if this varies so will the speed.***



Partially completed starter showing large grid type stainless steel electrodes.

These requirements could not all be met with starters currently available. Such features meant that a very large resistance range (approx. 1000/1 see **Fig. 2**) was required. The resistance / electrode travel characteristic also needed to be close to linear to ensure optimum operation of the closed loop-control system and material selection had to be such that a very long service life would be guaranteed.

To produce the high resistance range, the electrodes were arranged to move horizontally 1500 mm and the electrodes themselves, were constructed from stainless steel plate and allowed to mesh in the last 80 mm of the 1500 mm of distance travelled. The frontal area of the electrodes were made almost the same as the cross section of the liquid tank to produce the linear characteristic.

The large volume of the electrolyte allows the starter to absorb the heat from five consecutive start stop operations but, once hot the rate of heat loss is too slow to allow further operation in a reasonable time. To overcome this and provide for creep-speed operation external heat exchangers were required. The size of the heat exchangers were determined by the power input during creep operation. This was 20% speed and 26% torque. At this operating point the voltage across the liquid resistance is 80% of the nominal rotor volts and current is 26%. Power loss or input to the starter is simply the product of V x I and in the application under consideration this equalled 180 kW.

Conclusion

Liquid resistance starters and slip-ring motors are indeed old technologies but in some applications can still provide the best technical solution. The addition of more advanced technologies help provide the control loop and the "tuning up" of the electrical characteristics of the conventional liquid resistance starter which when combined produces a very high performance system.

Conclusion
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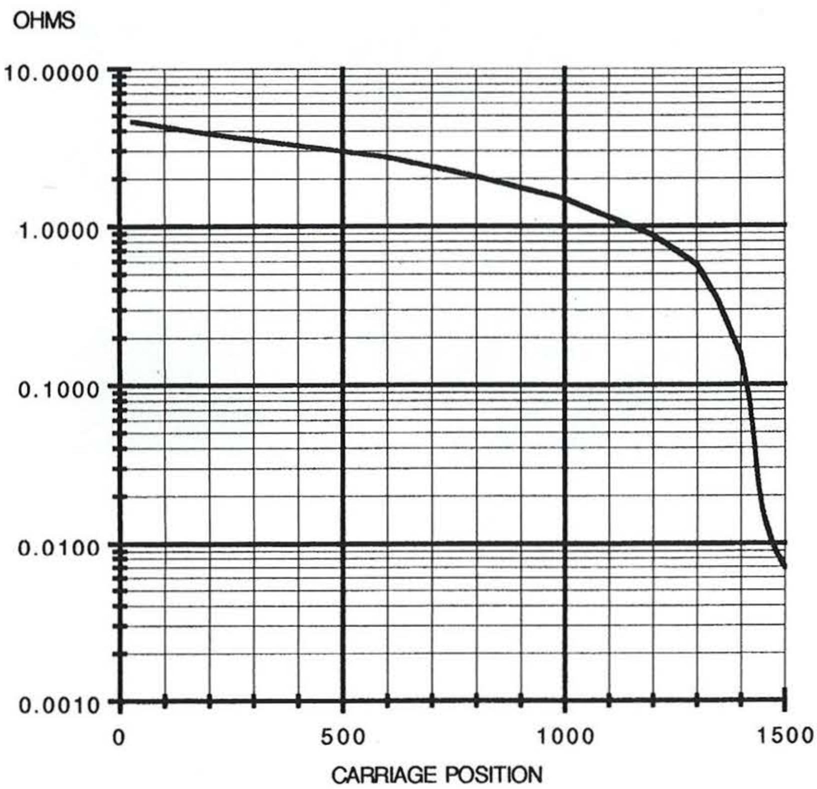

Fig. 2 ***Typical starter resistance curve (Stainless steel electrodes)***

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