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TECHNICAL NEWS

Issue 4

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

SOFT START FOR GENERATOR LOADS

A major advantage of electronic soft starters is the ability to reduce the motor starting current to the minimum level required to start a connected load. Nowhere is this capability of more benefit than when starting motors with a supply such as generator sets.

In existing installations, where the generator capacity is almost fully utilised, a soft starter may allow the connection of another motor without the need to increase the generator size.

For new installations, minimising the motor starting current with a soft starter may allow the use of smaller generator sets.

While the older electro-mechanical forms of reduced voltage starting do offer advantages over direct on line starting, electronic soft starting usually provides better results and has some unique advantages for generator sets.

This newsletter provides an overview of the important considerations when starting motors on limited supplies, an analysis of electro-mechanical starting options as well as outlining the advantages of soft start technology for generator set applications.

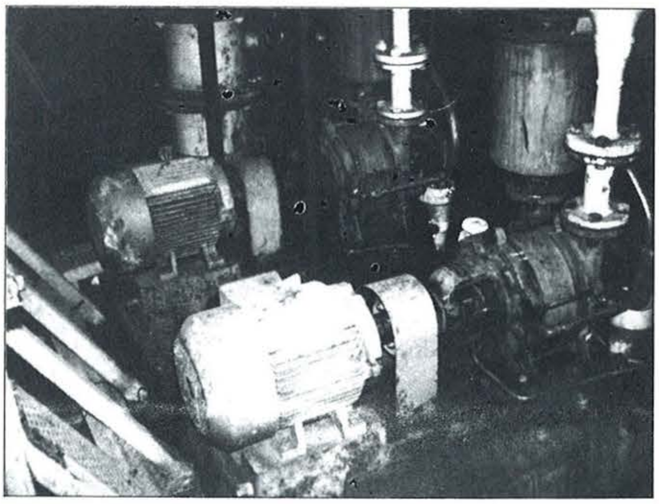
The magnitude of a motor's starting current is dependent upon its rotary design.

How motor starting effects ...

Direct on line starting characteristics

During starting, an AC induction motor draws a high current during acceleration before dropping back to its run current.

The magnitude of a motor's starting current is dependent upon its rotary design. Typically, a motor's locked rotor current will be around six times full load current



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Soft start for generator sets

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(FLC), but levels above nine times FLC are not uncommon.

The effect of this high start current is twofold. Firstly, it will cause a voltage drop on the supply, the amount of which is dependent upon the supply impedance. Secondly, it will also place a kW loading on the supply, which means physical work for the engine at the generation plant.

The same set of events and effects will occur on a generator set supply, however, there is a significant difference between these two supplies. For a hydro-power station, or similar, the energy required to start a motor is an insignificant load, whereas for a generator set the energy required to start a motor can be significant.

The fact that the motor starting current is often a major part of a generator set's loading. introduces special issues which must be considered if an efficient and cost effective installation is to be achieved.

Maximum loading

Where AC induction motors are a major part of a generator's loading, the energy required to start the motor will be a major factor in determining the generators size.

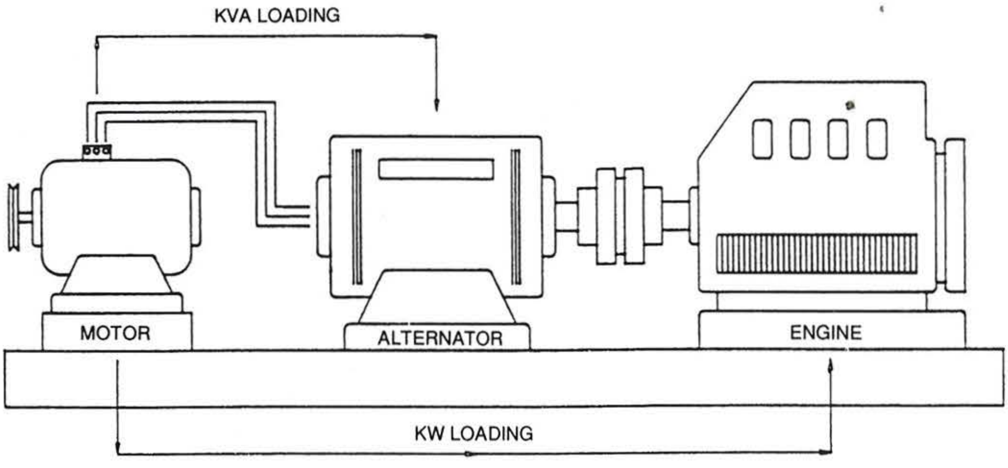
For a generator set to supply an electrical current of constant voltage, excitation of the alternator must be varied to match the carrying load conditions.

With respect to the alternator, the full voltage start current of a motor will be typically six to nine times higher than its running current. This places a high kVA loading on the alternator during motor starting. The alternator must be capable of meeting this temporary overload.

The total kW loading on the engine (prime mover) during full voltage starting is the sum of the "shaft kW" plus the IR loss in the motor and alternator. Typically the IR losses would be 50 - 100 per cent of the motor kW rating, and will remain constant throughout the start. The engine must be sized so as to have sufficient capacity to maintain speed during the starting overload.

Reducing the voltage applied to the motor during starting will reduce both the kVA loading on the alternator and the kW loading on the engine, provided that the means of reducing the voltage does not significantly add to the losses.

In summary, reducing the start current with an appropriate reduced voltage starter may allow selection of a smaller generator set in new installations, or allow



ELECTRIC MOTORS PLACE A KVA DEMAND ON ALTERNATORS, AND A KW LOADING ON THE ENGINE. TO HOLD SUPPLY VOLTAGE AND FREQUENCY STEADY, THE GENERATOR SYSTEM MUST BE ABLE TO RESPOND ACCURATELY TO CHANGES IN BOTH KVA & KW LOADING.

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connection of larger motors to existing generators without voltage or frequency disturbances.

Load shifts

To maintain constant voltage and frequency a generator set must be able to accurately track the load. The instantaneous load shifts associated with motor starting places a great demand on the ability of both the engine and alternator to respond.

For a generator set to supply an electrical current at a stable frequency the engine must rotate at a constant speed. To achieve this a governing system is employed to vary input of liquid fuel to the engine. This governing system has a finite response time, while most motor starting systems subject the system to instantaneous changes.
The "stepped" nature of most motor starting systems can result in severe frequency variations during motor starting.

For a generator set to supply an electrical current of constant voltage, excitation of the alternator must be varied to match the carrying load conditions.

This is achieved with the use of some form of Automatic Voltage Regulator (A.V.R.). However, here again there is a reaction time, and applications of load such as occurs with motor starting can be at a rate faster than this response time. Accordingly, there will be a voltage deflection equal to that which would result if no A.V.R. were present.

In addition, such action will invariably cause an overshoot in output voltage when the A.V.R. reacts to the voltage drop.

Optimum motor starting characteristics

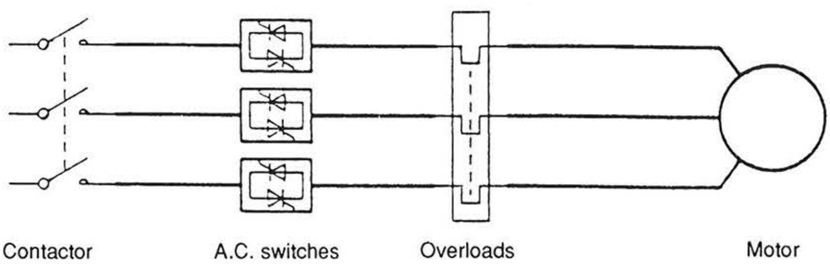
In summary, the ideal reduced voltage motor starting system for generator sets is one which:

(a) Allows the start current to be reduced to the minimum level required by the motor to start the connected load, without introducing losses of its own.

This reduces the kVA demand on the alternator and the kW loading on the engine.

(b) Controls the application of start current so as to gradually apply load to the generator at a rate which allows the generator time to respond.

This enables the generator set to respond accurately during motor starting, thereby reducing voltage and frequency disturbances.



SOFT STARTER POWER CIRCUIT

Electronic soft starters

a) Configuration

Electronic soft starters utilise solid state AC switches to provide infinite control over the voltage applied to a motor during starting.

b) Effect on start current

Soft starters provide better control of the start current than any of the other forms of reduced voltage starters. The effectiveness of soft starters with regard to limiting start current stems from three main areas.

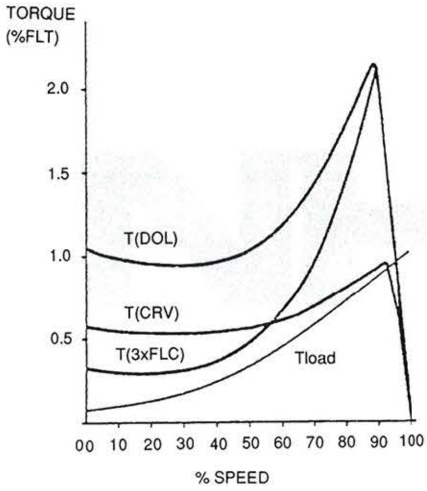
(i) Flexibility of adjustment

Soft starters allow selection of any desired start voltage/ current setting. This means the start parameters can be easily tailored to suit individual motor and load characteristics.

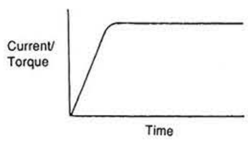
This ease of selection is possible because of the electronic nature of the control which allows start performance to be altered, on site, by the simple adjustment of a DIP switch or similar. This contrasts with electromechanical starters where the starter must be physically modified if the start voltage is to be changed.

(ii) Constant current feature

Some advanced soft starters include a constant current feature which allows the user to select a desired maximum start current setting. During starting the soft starter dynamically adjusts the voltage to maintain the desired start current. Thus, the start current can be set to the absolute minimum for the given application.

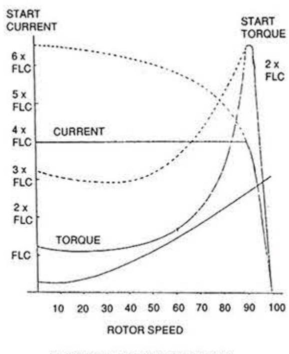


TYPICAL MOTOR SPEED/TORQUE CURVES MATCHED TO A FANS SPEED TORQUE CURVE



The application of current, and consequently torque, is not instantaneous. Both ramp up over time thereby eliminating transients.

TYPICAL CONSTANT CURRENT SOFT STARTER'S CURRENT PROFILE



CURRENT LIMITED SOFT STARTER

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(iii) Motor start torque during reduced voltage starting

Soft starters and electromechanical starters differ in that the constant voltage offered by an electromechanical starter reduces the motor starting torque by a constant factor during the entire starting. In contrast, soft starters which can maintain a constant current allow motor torque to increase during start.

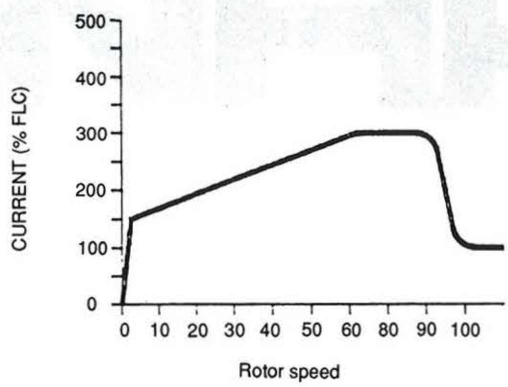
This occurs because, as the motor accelerates the ratio between the reduced start current and the motor's natural start current curve lessens. The natural consequence of this is that the reduction in the motor start torque is also lessened as the motor accelerates.

The significance of this is evident when the speed/torque curve of a typical load is matched with the speed/torque curve of a motor starting under reduced voltage conditions.

As the graphs on page 4 show the increasing torque characteristic of the motor started with soft starters which allows the motor to produce sufficient torque to fully accelerate the motor at a start current lower than that required by the electromechanical starter.

For generator sets this means that the generator's automatic voltage regulation system, and the engine's governing system, are given more time to respond during motor starting. This enables better regulation of both voltage and frequency during motor starting.

In addition to gradual changes of voltage, rather than instantaneous steps, some advanced soft starters incorporate a current ramp start mode.



TYPICAL CURRENT RAMP SOFT START CURRENT PROFILE

Like the constant current start mode, the current ramp start more dynamically adjusts voltage to maintain a preset start current. The difference is that the current ramp start mode allows a gradually increasing current profile to be specified.

The current ramp start mode can be of particular benefit in generator set applications where it can be used to further slow changes in loading.

c) Effect on application of load

Use of solid state power switching devices allows soft starters to ramp between voltages. This is in contrast to electro-mechanical starters which must switch or "step" between voltages.

The smooth ramping of voltage performed by soft starters eliminates instantaneous changes in the loading placed on the supply.

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Summary

Correctly engineered, electromechanical starters can be used to reduce the motor starting current, thereby reducing the loading on generator sets. However, these starters seldom result in the best possible current reduction, and still subject the generator set to instantaneous variations in load.

In contrast, electronic soft starters allow easy on site adjustment of the starting performance so that the minimum possible start current level can be achieved. Further, soft starters are able to slow the application of load to the generator set. This combination of reduced and gradual loading assists the generator set in maintaining constant voltage and frequency during motor starting.

For generator set users and manufacturers effectiveness of soft starting can provide benefits in three areas.

1. Improved voltage and frequency stability during motor starting.

2. An improved chance of being able to connect new motors to generator sets already operating at almost full capacity.

3. The possibility of reduced generator set sizing for new installations where motors are a significant part of the loading.

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