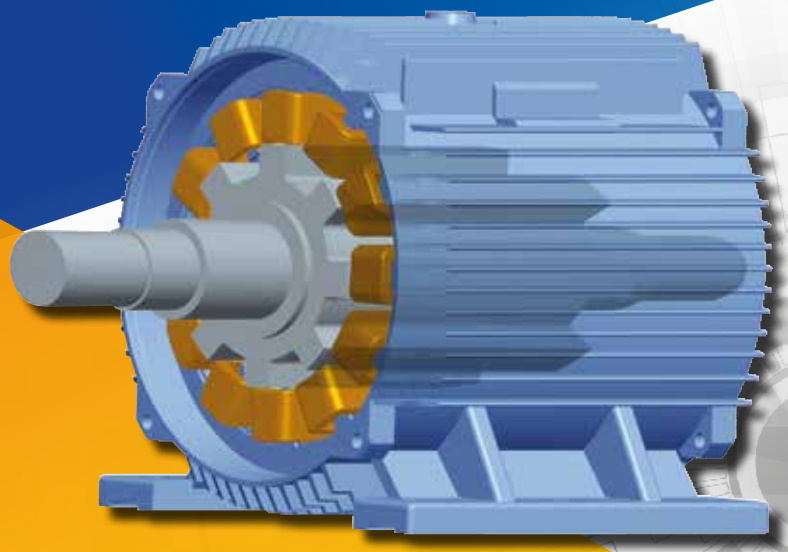
THE APPLICATION
OF TECHNOLOGY

KEHUI



SWITCHED RELUCTANCE MOTORS

Kehui International

Kehui International, Ware, UK

Kehui factory, Zibo, China

The word Kehui, literally means the Application of Technology in the Chinese language. This phrase perfectly defines the company's commitment to technological innovation, which it achieves whilst striving for the highest levels of quality.

The company was founded in 1991, utilising the best of Asian and European expertise to develop its range of cable and transmission line fault locators, as well as equipment for the automation of electrical distribution systems and its range of switched reluctance motors.

Switched Reluctance Motors

The technology behind the switched reluctance motor (SRM) has been in existence since the mid-nineteenth century. These early examples never reached their potential because they were difficult to control, noisy and unreliable. However, with recent developments in electronic switching, using insulated-gate bipolar transistor (IGBT) technology, the SRM have become an excellent solution for a wide variety of different applications. The latest designs of SRM allow users to take advantage of the higher efficiency, low starting currents and robust construction that characterises this type of motor.

Since 2000, Kehui has been working on the development of SRD motor systems and has regularly introduced new generations of drives, culminating in the KSM20 controller series, with a maximum power of 900kW. Coupled with the HS1 SR motor designed for high impact and high vibration applications, the Kehui switched reluctance motor systems are true world leaders with production of approximately 20,000 motor sets per year.

The company's capabilities are emphasised by its investment in a state-of-the-art SRD test facility to ensure that its commitment to quality is maintained.

The SR Revolution

The Switched Reluctance Drive (SRD), a combination of the motor and its electronic control system, creates a low cost, reliable, highly efficient, and flexible electric drive system. Its ability to use potential energy stored in one coil to energise the next, takes this technology to a whole new level of efficiency and performance. An SRM does not have magnetic “slip”, so there is virtually no heating of the armature (which is a weakness of standard induction motors). The losses that do occur are in the magnetic coils connected to the stator, where heat is more readily dissipated. As SRDs do not have bi-directional, three-phase, high frequency switching, they do not have the eddy and bearing current issues commonly associated with squirrel cage (induction) motors.

The technologies that make up SRDs are well established and use commonly available parts and materials; the difference is how they are combined and applied. Because of this, SRDs are not accompanied by a “leap in technology” risk that affects many new solutions. Specifying, purchasing, installing, commissioning,maintaining and operating Kehui SRDs is little different to a conventional Variable Frequency drive (VFD) system. However, there will be a substantial reduction in costs for all of these activities

Why SRD instead of a standard induction motor and VFD?

For an application that requires a relatively low torque start, which will then run at near full speed and a fairly constant torque for many hours at a time, a VFD system may make sense. However, for high torque starts (200-300%), operation at 10-150% speed and torque, wide operational load environments, or any number of scenarios that fall outside of the VFD comfort zone, SRD is the easy and obvious solution.

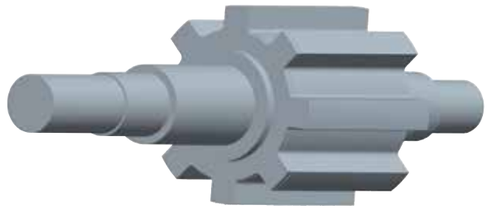
Benefits of SRD

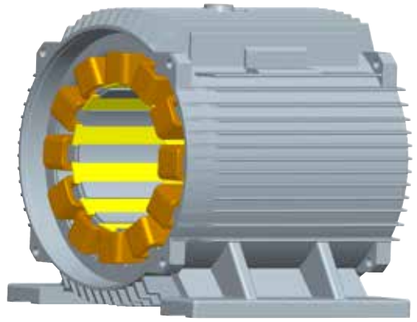
- Low starting current
- High starting torque
- Robustness
- Simplicity and reliability
- High Power
- Frequent rotational direction changes
- No need for magnets or rare earth metals
- High overload capacity
- Efficiency
- Frequent stopping and starting (up to 1000 times per hour)
- Excellent dynamic response

Features and benefits

Why is the SRM system so robust?

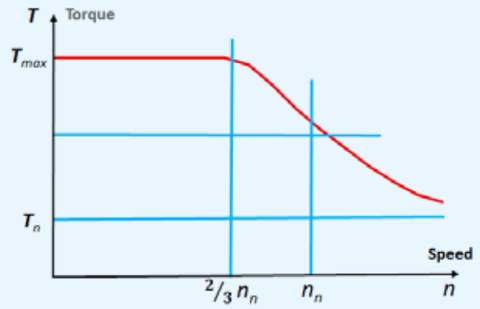
The rotor of SRM is made of laminated silicon steel sheets with no windings or permanent magnetic material. This makes it extremely strong, such that it can withstand frequent shocks received in applications such as press machines.





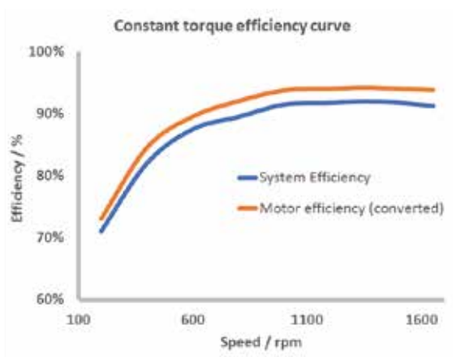
Frequent Stopping and Starting with High Starting Torque and Low Current

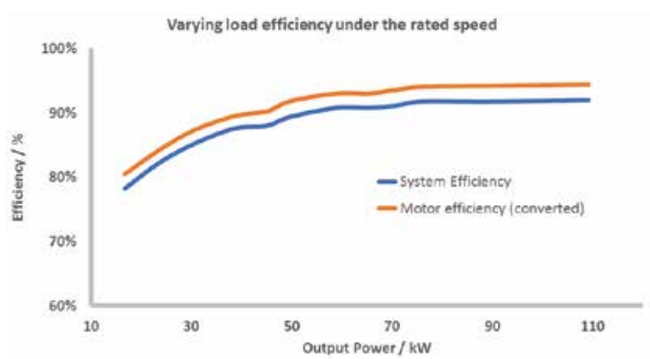
The starting torque of the motor is greater than 3 times the rated torque. Yet when the starting torque reaches 150% of the rated torque, the starting current is only 30% of the rated current. This is applicable for multiple starts and reversals up to 1000 times per hour.



Efficiency

The SRM drive system can reach up to (IE4) “Super Premium Efficiency” limits (in accordance with IEC/EN 60034-30-1:2014). This efficiency is especially evident at low speeds and light loads and is maintained across a wide speed range.

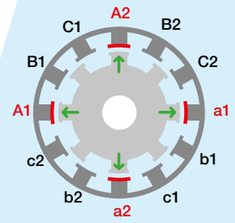


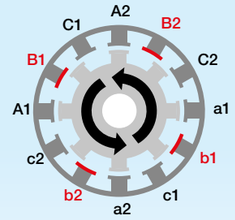


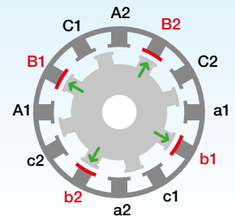
How does it work?

The switched reluctance drive (SRD) system consists of an SRM and its associated control system.

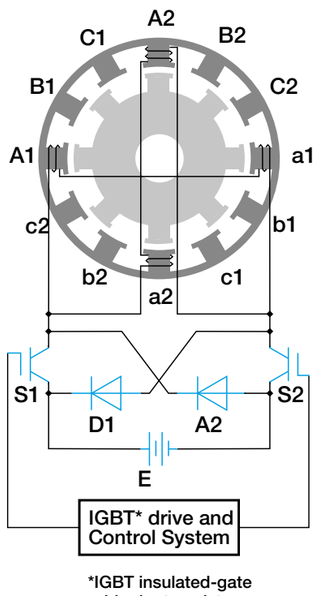
The electrical power is delivered to the SRM windings positioned around the stator, which create a magnetic field. The magnetic reluctance of the rotor results in its poles aligning with an energised stator winding. By using an electronic switching circuit to sequentially energise the windings around the stator, the rotor is attracted to the magnetic field on each stator pole in turn and hence, rotates until it is aligned. If the relative positions of the stator and the rotor in the diagram are taken as the starting position energising the B phase winding will result in the rotor rotating anti-clockwise against the excitation sequence. The direction of rotation of the motor is independent of the direction of the current in the phase winding and the current of the stator winding of the switched reluctance machine is uni-directional.







12/8-pole (12 stator poles and 8 rotor poles) SRM



*IGBT insulated-gate bipolar transistor

The KSC20 series controller controls the switching of the magnetising current consecutively from one stator winding to the next, causing the rotor to rotate. The switching is carried out electronically. The controller also facilitates changes to the motor’s speed, torque, brakingand direction.

Applications

Electric Screw Press Motors

The electric screw press is a major challenge for motor drive technology. It is required to manage heavy loads, frequent starts, rapid braking and impact resistance. The SRD motor has a high starting torque coupled with a low starting current and can be frequently reversed, while providing the required fast braking. The rotor has no coil or permanent magnet and is immune to the load's shock and vibration. Additionally, there is a direct drive which makes gear chains and clutches unnecessary, therefore increasing the efficiency of the system.

Machine Tools

SRD motors have excellent dynamic response,fast, closed-loop speed control and constant speed even at speed full load.The machine tool motor is used to digitally control the operation of the planer, which can be moved forward and backward, as well as jog forward, move back, lift and drop the bit and other functions.The high and low speed operating parameters are self-adaptive, such that there is no need to adjust the parameters when the speed of the table changes.

Oil Pumping Motors

Many oil fields are still using beam pumping units, otherwise known as Nodding Donkeys. With these, electricity costs can account for more than 25% of the cost of oil production, and the stroke adjustment is not optimal. Due to increasing cost and lower revenue, reducing energy consumption is a high priority, so an energy-efficient pumping unit can be very beneficial. The SRD can facilitate a long stroke pumping unit. The motor directly drives the oil rod moving it up and down by using its ability to readily reverse its direction, simplifying the transmission. The overall efficiency is greatly improved compared to the original pumping unit. This includes a maintenance-free motor, ideal for the harsh environment in many oil fields and which is simple to commission.

Textile Machinery Motors

The SRD motor features a low starting current and high torque, with a fast-dynamic response.It can deliver variable speed weaving and other enhanced weaving processes.The textile motor starting torque is up to 5 times its rated torque, with fast starting acceleration from standstill to rated speed in only 200ms.

Mining Machinery Motors

Switched reluctance motors are especially suitable for a variety of coal mining equipment, such as cutters, and coal ploughs. This type of motor provides a low starting current and a high torque (30% of rated current gives starting torque up to 150%). The simple winding-free rotor is ideal for high speeds and its mechanical strength is resistant to impacts, the stator has no overlapping windings, making short-circuits unlikely.

Electric Vehicle Motors

The low starting current, quick acceleration and extremely efficient direct drive associated with the switched reluctance motor make it ideal for electric vehicles as it minimises the load on the battery and extends the driving range from a single battery charge. Its ability to cope with frequent starting, stopping and reversal is also beneficial for transport applications.

Conveyor Systems

Conveyor systems have attributes which make them ideal for the application of SRD systems. This is especially true where the load on the conveyor has one or more of the following attributes; high capacity; regular starting and stopping; low speed operation. These requirements are often found on coal and mineral transport systems, or for use in airports.

System parameters

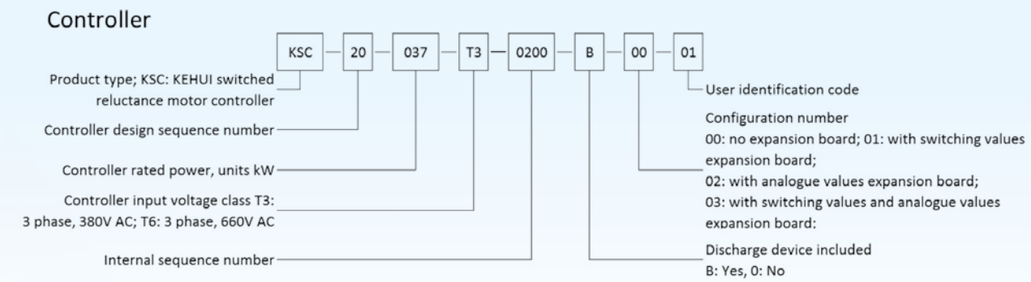
Controller technical parameters

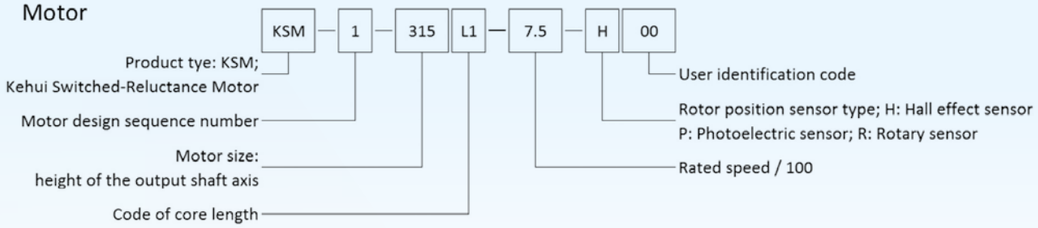
Parameters	Requirements and functions	
Power input	Input voltage	3-phase AC 380V, 415V, 660V, 1140V
	Voltage frequency	50Hz or 60Hz
Functions and parameters	Rated power	4 - 500kW
	Communication port	RS232, RS485, CAN (Controller Area Network)
	Input and output interface	6 digital inputs, 4 digital outputs, 4 analogue inputs, 2 analogue outputs. Expandable
	Overload capacity	200% rated torque for 60s; 120% rated torque for 1 hour
	Protective functions	Short circuit, over-current, overload, stalling, under-voltage, over-voltage, overheating and speeding
	Cycle time	300s, the average power within the cycle time should not exceed the rated power
	Installation	11 - 160kW wall mounting; 200 - 500kW floor mounted cabinet
Structure	Cooling method	11 - 250kW controller forced air, 280 - 500kW industrial air-conditioning
	Controller ingress protection	11 - 160kW IP20, 200 - 250kW IP51, 280 - 500kW IP54
	Controller standard	Enterprise standard: Q / 0303SKH 062-2012

Motor Technical Data

Rated voltage	514V DC, derived from full-wave rectified and filtered three-phase 380V AC
Insulation class	180(H), using 200 corona-resistant enamelled wires and DuPont solvent-free impregnating varnish with vacuum pressure impregnation (VPI)
Work system	S1: Continuous work system; S5: Intermittent cycle work including electric brake
Protection level	IP 54: dust, splash proof water
Cooling method	Optional fan-cooled or stand -alone fan air-cooled
Overload capacity	150% rated torque for <60s 200% rated torque for <30s 300% rated torque for <15s The average torque in any 300s period must not exceed the rated value
Temperaturecheck	The motor winding is embedded with a temperature relay or temperature sensor, which can be connected to the controller for thermal protection of the motor
Motor standard	Enterprise Standard: Q/0303SKH 064-2013

Product selection





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