THE APPLICATION
OF TECHNOLOGY

KEHUI

SYNCHRONOUS RELUCTANCE MOTOR

Kehui International

Kehui International, Hertford, 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 ranges of reluctance motors.

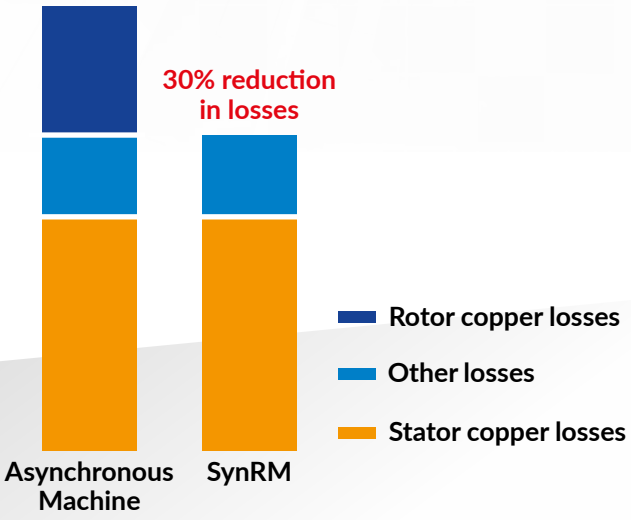
Advantages of Synchronous Reluctance Motors

Electric motors consume almost a half of all the electrical energy produced in the world. With the drive towards reducing carbon emissions, any improvement in motor efficiency can lead to significant reductions in electricity usage and fuels needed to generate it. The Synchronous Reluctance Motor (SynRM) can offer considerable improvements in efficiency compared to conventional induction machines, providing substantial economic and environmental advantages.

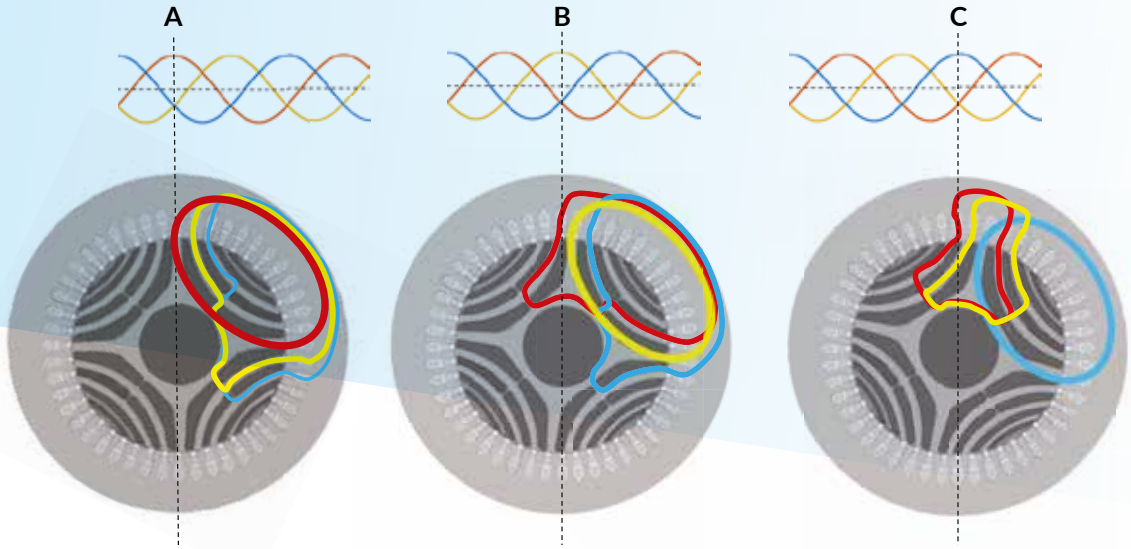
- Its efficiency meets the new IE5 standard, reducing energy usage, with the ensuing environmental and cost benefits.
- Low rotor and bearing temperatures allowing longer service and less downtime.
- Accurate speed regulation and torque control

- Combining mature induction motor stator design with an innovative rotor, the SynRM is a new approach to high efficiency, speed-adjustable motors. Its performance is comparable to permanent magnet motors, without the environmental and financial cost of rare earth metals and with no risk of degaussing.
- Efficient operation is achieved, even at non-rated speeds and variable loads. The SynRM motor can save 10%-20% of energy when compared to an induction machine under the same conditions.
- The winding-free rotor is highly reliable, with losses up to 40% lower than comparable induction motors. Convenient maintenance, reduces downtime by up to 70% and lower rotor temperature extends the life of the bearings.

- Excellent servo-control performance: Accurate speed regulation from 5 to 3600 rpm can be realised.
- High power density: The SynRM is typically one frame size smaller than an equivalent induction motor. Conversely, a SynRM with the same frame size can achieve more than twice the power output of an induction motor of the same size.
- Retrofit: SynRM use standard IEC frame sizes and so, in most cases no mechanical modification is required. This facilitates the replacement and modification of the drives in existing installations.

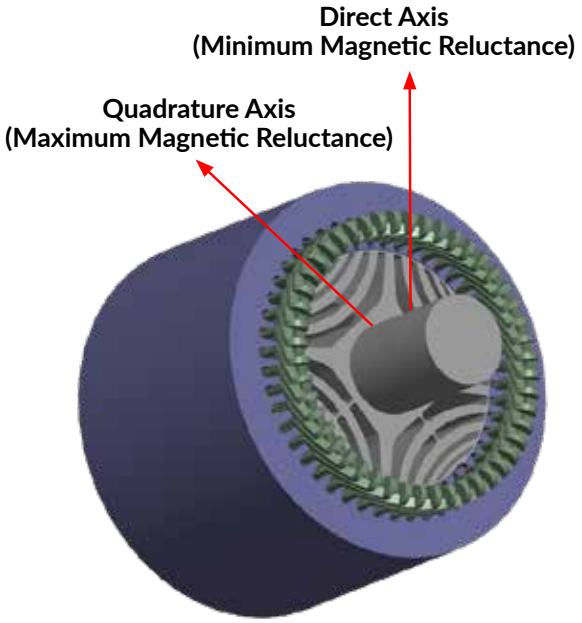


Operating Principle



The stator of the synchronous reluctance motor is similar to an induction motor; however, its rotor is made only of laminated silicon steel sheets, with no windings. It is designed with hollow air gaps as magnetic field barriers. The direction of these barriers is called the quadrature (q) axis, while the direction of the path with the continuous silicon steel sheet is called the direct (d) axis.

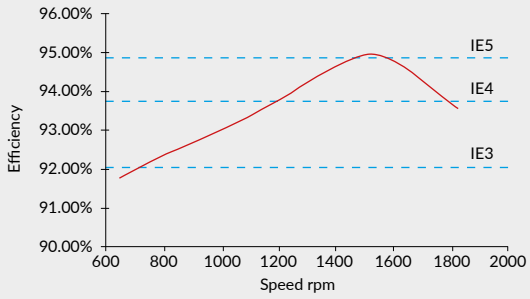
The stator of the SynRM contains windings which are energised from a three-phase supply, controlled by the controller, which results in a rotating magnetic field. The diagram shows the flow of flux from three pairs of windings, the others are omitted for clarity. When the voltage of the first phase is at a maximum, the rotor aligns itself so the reluctance is at a minimum (A), the reluctance paths for the other phases are much greater. As the second phase voltage reaches a maximum (B), the first phase voltage has reduced and the rotor re-aligns with the second phase, as this now presents the path of least reluctance. This is then repeated with the third phase (C) and so on. As the field rotates, the rotor follows it synchronously.



Features

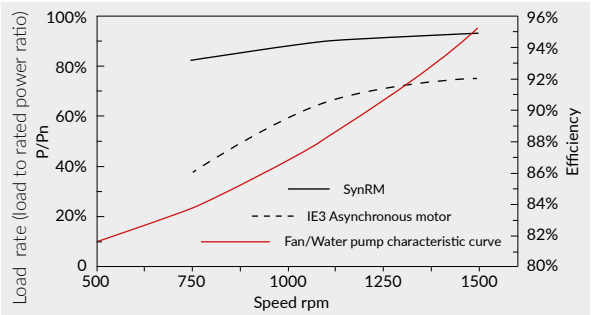
A SynRM is a speed-regulating motor in which the rotor operates synchronously with an applied sinusoidal magnetic field. It needs to be powered by a dedicated KSYC series controller, which is a high-performance, quantitative servo control system, used to adjust the motor's speed and torque. It provides:

- high-speed control precision, with a wide range of speed adjustment and long-term operation at low speeds.
- high-torque control precision, realising servo-control performance, with four-quadrant operation and regenerative braking.
- communication interfaces including CAN bus, RS232 and RS485. It has a multi-channel switch and analogue input and output interfaces, which facilitate remote monitoring and interfacing with an external device such as a PLC or a computer.



22kW SynRM
Speed vs. efficiency curve with constant torque

Why should the motor speed be adjusted?

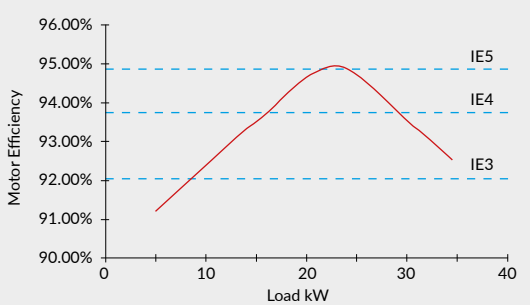


Comparison of SynRM and induction motor performance for application to fans and water pumps

The load applied to the motor is never completely constant and, usually, the motor does not need to run at its full speed or power. By adjusting the speed and torque to match the operation of the motor to the load, between 25% to 30% of the electric energy can be saved. By adjusting the speed of the motor in real time, the controller removes the need for valves, gears or brakes to control the speed, thus saving energy.

Efficiency under light load

A significant advantage of SynRM drive systems is their high efficiency during light-load operation. In water pump and fan applications, the SynRM drive system is 2% more efficient than an IE3 induction motor using a variable frequency drive at rated load and is 6-7% higher at light loads.

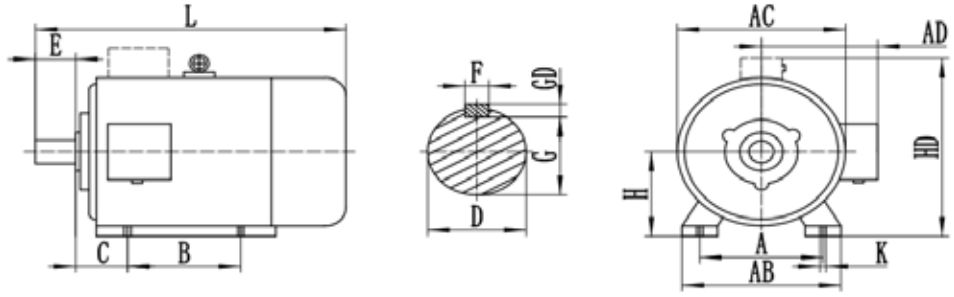


22kW 4-Pole SynRM; Load vs. Efficiency Curve

Product Selection

SynRM Type	Rated Power (kW)	Rated Torque (Nm)	Rated Current (A)	Rated Efficiency (%)	Speed Range (rpm)	Maximum Overload Torque	Weight (kg)	Rotational Inertia (kg m^2)	Insulation Grade
750 rpm									
KSYM1-160M1-8	4	51	9.5	85.45	5-1000	1.5	120	0.082	H
KSYM1-160M2-8	5.5	70	12.4	86.78	5-1000	1.5	138	0.093	H
KSYM1-160L-8	7.5	96	15.7	87.89	5-1000	1.5	180	0.122	H
KSYM1-180L-8	11	140	24.4	91.15	5-1000	1.5	202	0.142	H
KSYM1-200L-8	15	191	36.0	90.01	5-1000	1.5	276	0.250	H
KSYM1-225S-8	18.5	236	43.0	90.57	5-1000	1.5	330	0.375	H
KSYM1-225M-8	22	280	50.5	91.02	5-1000	1.5	363	0.501	H
KSYM1-250M-8	30	382	72.0	91.7	5-1000	1.5	435	0.687	H
KSYM1-280S-8	37	471	82.0	92.15	5-1000	1.5	540	1.212	H
KSYM1-280M-8	45	573	101.0	92.48	5-1000	1.5	650	1.429	H
KSYM1-315S-8	55	700	105.0	92.82	5-1000	1.5	1012	1.640	H
KSYM1-315M-8	75	955	145.0	93.39	5-1000	1.5	1076	1.874	H
KSYM1-315L1-8	90	1146	180.0	93.61	5-1000	1.5	1138	2.134	H
KSYM1-315L2-8	110	1401	208.0	93.86	5-1000	1.5	1220	2.350	H
1000 rpm									
KSYM1-160M-6	7.5	72	17.0	90.12	5-1500	1.5	160	0.070	H
KSYM1-160L-6	11	105	24.9	91.25	5-1500	1.5	177	0.086	H
KSYM1-180L-6	15	143	33.1	91.92	5-1500	1.5	242	0.242	H
KSYM1-200L1-6	18.5	177	41.5	92.48	5-1500	1.5	304	0.287	H
KSYM1-200L2-6	22	210	47.5	92.82	5-1500	1.5	328	0.310	H
KSYM1-225M-6	30	286	68.4	93.39	5-1500	1.5	391	0.499	H
KSYM1-250M-6	37	353	81.8	93.73	5-1500	1.5	428	0.575	H
KSYM1-280S-6	45	430	100.0	94.07	5-1500	1.5	639	1.012	H
KSYM1-280M-6	55	525	121.5	94.41	5-1500	1.5	690	1.029	H
KSYM1-315S-6	75	716	162.2	94.75	5-1500	1.5	873	1.640	H
KSYM1-315M-6	90	859	202.0	94.97	5-1500	1.5	925	1.874	H
KSYM1-315L1-6	110	1050	244.5	95.00	5-1500	1.5	965	2.080	H
KSYM1-315L2-6	132	1261	280.2	95.10	5-1500	1.5	1116	2.450	H
1500 rpm									
KSYM1-132S-4	5.5	35	12.0	90.8	5-2000	1.5	68	0.022	H
KSYM1-132M-4	7.5	48	16.0	91.58	5-2000	1.5	81	0.026	H
KSYM1-160M-4	11	70	23.3	92.37	5-2000	1.5	126	0.042	H
KSYM1-160L-4	15	96	31.3	93.05	5-2000	1.5	147	0.051	H
KSYM1-180M-4	18.5	118	42.0	93.39	5-2000	1.5	187	0.080	H
KSYM1-180L-4	22	140	49.7	93.73	5-2000	1.5	204	0.183	H
KSYM1-200L-4	30	191	71.5	94.18	5-2000	1.5	274	0.287	H
KSYM1-225S-4	37	236	89.3	94.52	5-2000	1.5	332	0.425	H
KSYM1-225M-4	45	287	105.9	94.75	5-2000	1.5	359	0.575	H
KSYM1-250M-4	55	350	127.0	95.09	5-2000	1.5	479	0.632	H
KSYM1-280S-4	75	477	177.2	95.43	5-2000	1.5	582	1.000	H
KSYM1-280M-4	90	573	211.0	95.54	5-2000	1.5	642	1.211	H
KSYM1-315S-4	110	700	235.0	95.62	5-2000	1.5	994	1.643	H
KSYM1-315M-4	132	840	289.9	95.74	5-2000	1.5	1097	1.870	H
KSYM1-315L1-4	160	1019	350.2	95.89	5-2000	1.5	1118	2.041	H
KSYM1-315L2-4	200	1273	428.9	95.91	5-2000	1.5	1169	2.452	H
3000 rpm									
KSYM1-132S1-2	5.5	17	12.5	89.68	5-3600	1.5	41	0.015	H
KSYM1-132S2-2	7.5	24	17.0	90.57	5-3600	1.5	50	0.018	H
KSYM1-160M1-2	11	35	25.8	91.58	5-3600	1.5	130	0.058	H
KSYM1-160M2-2	15	48	34.6	92.37	5-3600	1.5	142	0.063	H
KSYM1-160L-2	18.5	59	44.0	92.82	5-3600	1.5	149	0.066	H
KSYM1-180M-2	22	70	51.0	93.16	5-3600	1.5	160	0.071	H
KSYM1-200L1-2	30	95	68.9	93.73	5-3600	1.5	260	0.203	H
KSYM1-200L2-2	37	118	35.1	94.07	5-3600	1.5	271	0.225	H
KSYM1-225M-2	45	143	102.0	94.29	5-3600	1.5	285	0.242	H
KSYM1-250M-2	55	175	125.5	94.63	5-3600	1.5	425	0.610	H
KSYM1-280S-2	75	239	158.8	94.97	5-3600	1.5	550	0.975	H
KSYM1-280M-2	90	286	198.0	95.2	5-3600	1.5	592	1.120	H

Installation Dimensions



Model Number	Poles*	Dimensions (mm)												
		H	A	B	C	D	E	F x GD	G	K	AB	AC	AD	HD	L
132S	2.4	132	216	140	59	38	80	10'8	33	12	280	275	210	315	545
132M	4			178											585
160M	2.4.6.8	160	254	210	108	42	110	12 x 8	37	15	320	330	255	420	675
160L				254											720
180M		180	279	241	121	48		14 x 9	42.5		355	380	280	455	730
180L				279											770
200L		200	318	305	133	55		16 x 10	49		395	420	305	505	840
225S	4.8	225	356	286	149	60	140	18 x 11	53	19	435	470	335	560	875
225M	2			311		55	110	16 x 10	49						890
	4.6.8					60	140	18 x 11	53						900
250M	2	250	406	349	168					24	490	510	370	615	1000
	4.6.8					65			58						
280S	4.6.8	280	457	368	190	75		20 x 12	67.5		550	580	410	680	1040
280M				419											1090
315S	4.6.8	315	508	406	216	80	170	22 x 14	71	28	635	645	530	845	1270
315M				457											1385
315L				508											

* The pole number indicates the speed of the motor: 2 pole is 3000rpm; 4 pole is 1500rpm; 6 pole is 1000rpm and 8 pole is 750rpm.

Ordering requirements

When ordering, the following information should be specified:

- Model type
- Rated power
- Rated speed

If there are special requirements (such as the operating environment, working voltage, controller installation method, motor installation method, protection level, etc.), this needs to be known in advance of manufacture.

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