Development of Low Inertia & Large Capacity AC Servo Motor: "SANMOTION"Q

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1. Introduction

In recent years, the method of driving a injection molding machine has been rapidly shifting from oil pressure drive to electric drive using a servo motor. Driving a large injection molding machine or a high-speed injection mechanism for thin molding demands high torque, high speed, and high response. To meet this demand, the motor must achieve large capacity, low inertia, high-speed and high torque in its performance. For a high-speed injection mechanism, in particular, high torque in the high-speed region is needed to accelerate to high-speed rotation at a stretch. The required specifications can be achieved by designing the torque generation of the motor to have low inertia and high-speed rotation.

When the number of motor poles is increased, although it is an advantage for miniaturization, the reactance drop becomes substantial, because the frequency at high-speed rotation rises and insufficient high-speed torque is generated. Low inertia simply requires reducing the rotor diameter, but the length of the motor expands to obtain high torque because the permanent magnet volume decreases, and so it is not practical given restrictions with the manufacturing equipment and the need to secure axis rigidity. A design that balances rotor diameter, product thickness, and the number of poles is necessary to achieve low inertia and high-speed, high torque.

SANYO DENKI has developed three new models, which form the Q4 series of SANMOTION Q. Two of the models have rated output 11kW and 15kW for the flange sq. size 180mm, and the other has a rated output of 20kW for 220mm.

This paper explains the main characteristics of the products, and reports on the technical results.

2. Features

2.1 Torque Characteristic

Table 1 shows a comparison of the main dimensions of the conventional 20kW product and the new Q4 motor. The amplifier to be used is the PQ M series 600A amplifiers. The maximum sq. acceleration has been increased by a factor of 2.5 by changing the rotor low inertia.

Fig. 1 shows the comparison of the torque rotating speed characteristics. We were able to improve the instantaneous maximum torque by approximately 9% while securing a torque area almost equal to that of the conventional model and achieving low inertia with the rotor. Moreover, the lineup can be expanded to a maximum rotating speed of 3000min^{-1}, depending on the combination of the servo amplifiers. It is also possible to meet respond to demand for greater speed.

Table 1 Main Dimensional Comparison

	Conventional Motor	New Motor
Model	P60B2220KBX*	Q4AA2220KBX*
Max. Rotating Speed	2000min^{-1}	2000min^{-1}
Continuous Torque	127N·m	127N·m
Max. Continuous Current	98Arms	100Arms
Instantaneous Max. Torque	280N·m	305N·m
Instantaneous Max. Current	181Arms	262Arms
Rotor Inertia	248×10^{-4}kgm^2	105×10^{-4}kgm^2
Max. Acceleration	11300rad/s^2	29000rad/s^2
Flange Sq. Size	220mm	220mm
Length	490mm	625mm
Cooling	External Fan	External Fan

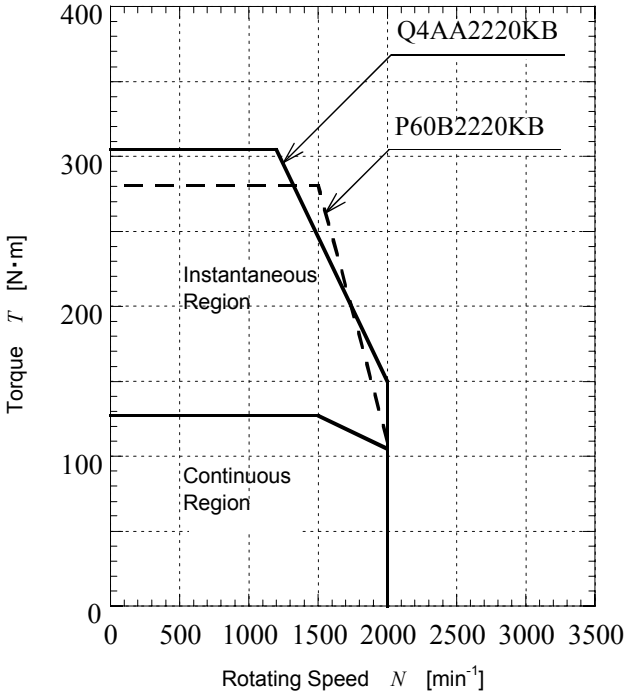

Fig. 1 Characteristics of Torque Rotation Speed

2.2 Acceleration Performance

Fig. 2 shows a comparison of rotor inertia in each series ※(1), and Fig. 3 shows a comparison of the maximum sq. acceleration. The performance in the large capacity and the low inertia area, which was not covered by the conventional series, was improved. It is believed to be possible to help injection molding machines, spring molding machines and press machines, the capacity of which is increasing in recent years, achieve higher speeds and pressure by improving the torque as well as the maximum acceleration further.

As an example of acceleration performance, Fig. 4 shows a comparison of the acceleration characteristics when the load inertia is assumed to be 0.03kg/m2 (about three times the Q4AA2220K motor inertia). The acceleration time can be shortened by approx. 40%.

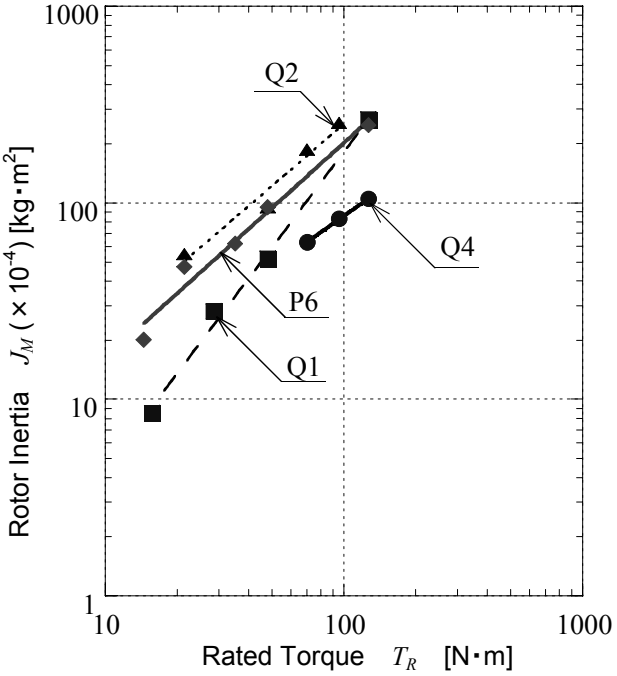

Fig. 2 Rotor Inertia Comparison

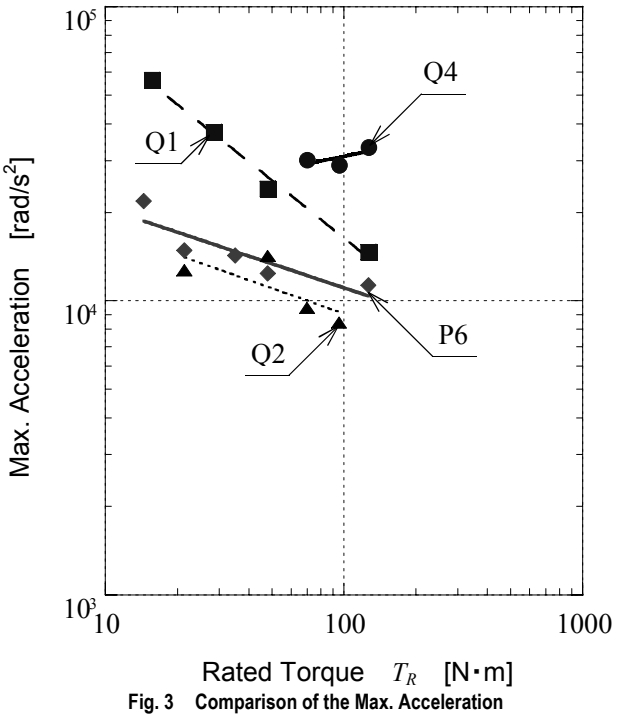

Fig. 3 Comparison of the Max. Acceleration

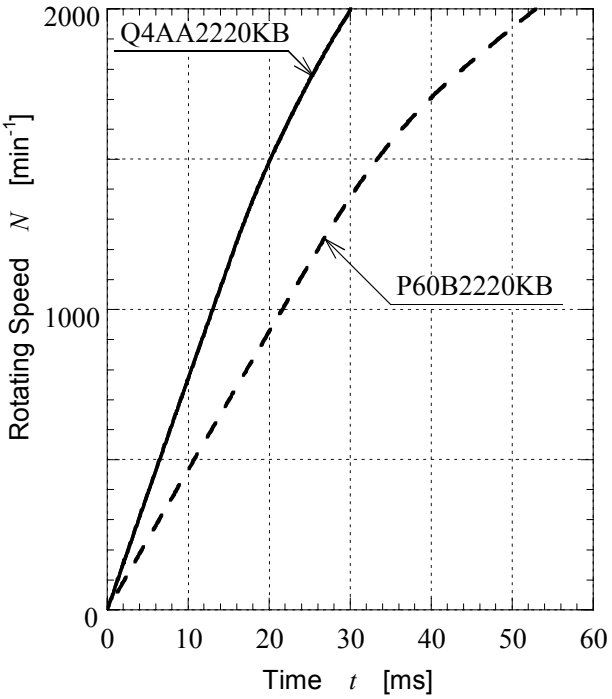

Fig. 4 Comparison of Acceleration Characteristics (Motor Temp.: Cool)

3. Line-Up (Q4 Series)

Table 2 shows the main parameters of the Q4 series lineup, Fig. 5 shows the product and Fig. 6-8 shows the characteristics of the torque rotating speed.

The power supply voltage is of the AC200V type and there is a choice of three models (with rated output of 11kW, 15kW, and 20kW). In addition, the maximum rotation speed can reach up to 3000min^{-1}, depending on the combination of servo amplifiers.

This was achieved by changing the winding of the motor to have the best combination of the continuous line and clashed line of Fig. 6-8 and servo amplifiers with different capacities.

The Q4 series products are able to the provide large capacity, low inertia, and high-speed high torque motor required for large injection molding machines. They can also deliver the high-speed injection mechanism for thin molding.

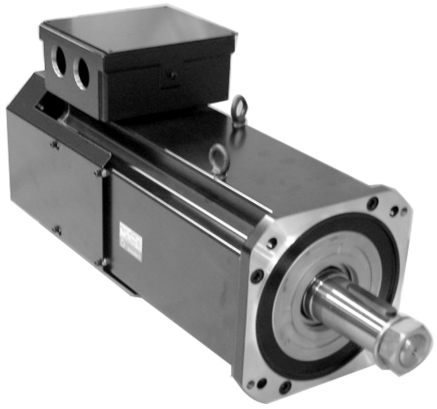

Fig. 5 SANMOTION Q(Q4AA2220K)

Table 2 Product Specification

Item	Unit	11kW Model		15kW Model		20kW Model	
		Q4AA1811KB	Q4AA1811KH	Q4AA1815KB	Q4AA1815KH	Q4AA2220KB	Q4AA2220KH
Rated Output	kW	11		15		20	
Rated Rotating Speed	min^{-1}	1500					
Maximum Rotating Speed	min^{-1}	2000	3000	2000	3000	2000	3000
Rated Torque	N·m	70		95.5		127	
Instantaneous Max. Torque	N·m	190	190	220	255	305	350
Instantaneous Max. Current	Arms	155	190	155	198	262	330
Rotor Inertia	$\times 10^{-4}$ kg·m^2	63		85		105	
Max. Acceleration	rad/s^2	30200	30200	25900	30000	29100	33300
Motor Size	mm	□180×533		□180×623		□220×625	
Weight	kg	60		75		104	

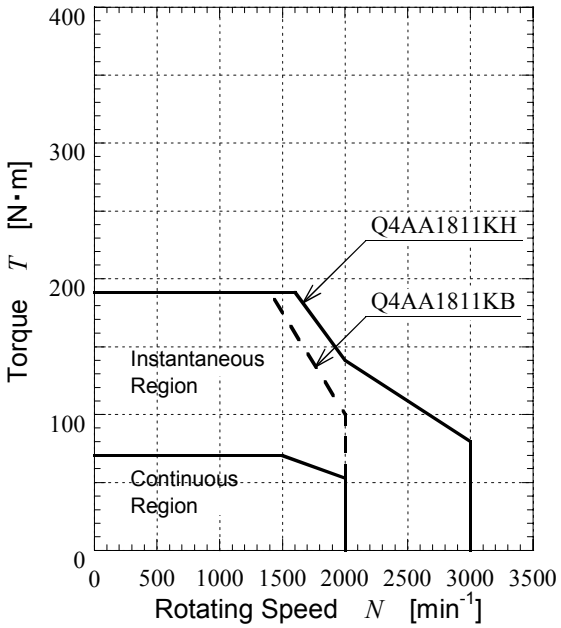

Fig. 6 Characteristics of Torque Rotating Speed of 11kW Machine

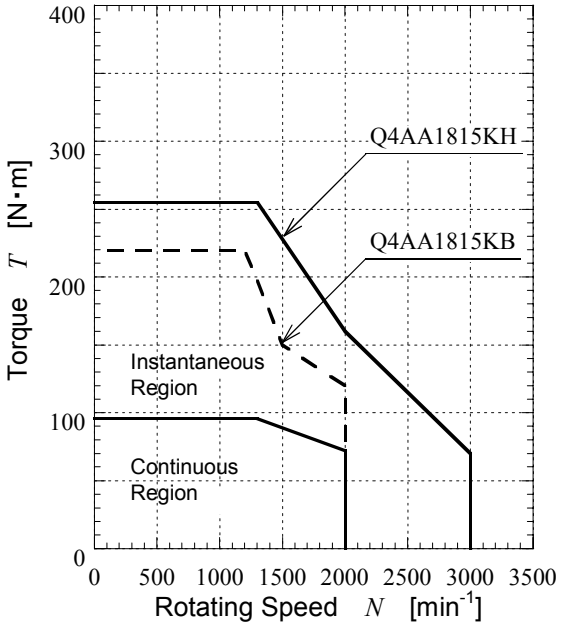

Fig. 7 Characteristic of Torque Rotating Speed of 15kW Machine

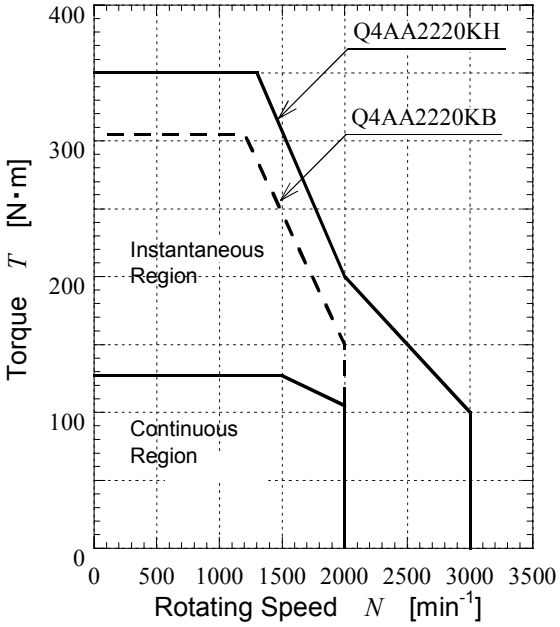

Fig. 8 Characteristics of Torque Rotating Speed of 20kW Machine

4. Conclusion

We have developed the Q4 series of low inertia large capacity AC servo motors. We will continue to contribute to recent market trends towards enlargement, higher speeds and higher responses, as seen with injection molding machines.

Reference

*(1) SANYO DENKI Technical Report No.14:"AC Servo Motor "Q" Series",pp.32-34 (2002-11)

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