Motor selection final session

Exercise – Winder/Unwinder

One of the industrial applications is to use a continuous rotation servomotor to follow a specific speed profile and wind or unwind certain materials on a webroll.

In this case, the axis configuration considers to include a DC brushed servomotor, a gear reducer, a cylinder load and a webroll to wind or unwind aluminium of 2720 kg/m^3 and a thickness of 1 mm. The profile is connected downstream the last mechanical component. The full axis can be seen in Figure 1.

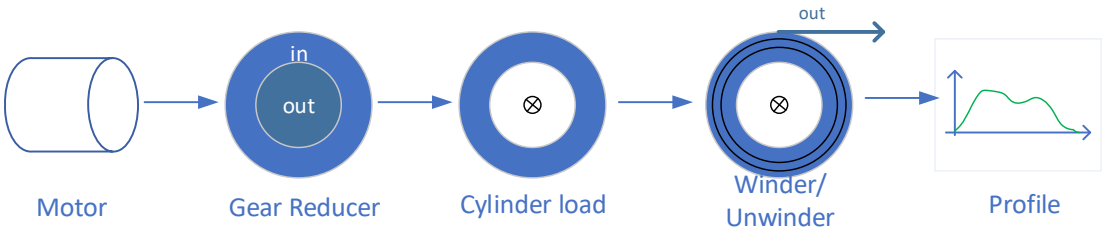

Figure 1 Axis configuration for winder unwinder exercise

The following information gathers the specifications of all the participating elements, even considering the profile.

The servomotor

Use model R88M-KH1K520(F/C)-E from Omron G5 High inertia family. Figure 2 to Figure 4 show the main specification for the specific servomotor and other ones from the same family.

Assume a thermal constant of 40 s. Also consider: ke= 0.54 V·s/rad, R= 0.88 Ω and L= 9.2 mH and number of poles 10.

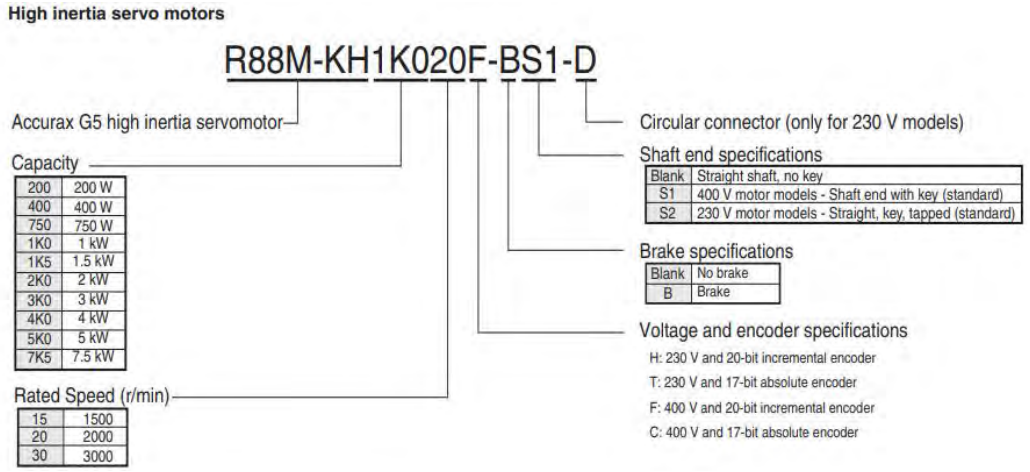

Figure 2 Servomotor designation for Omron G5 High inertia family

Torque-speed characteristics

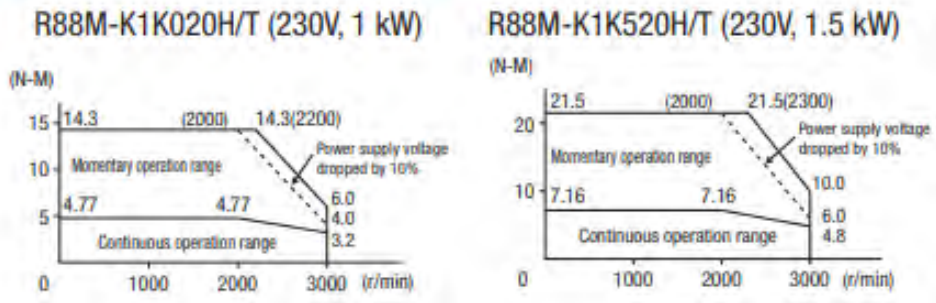

Figure 3 Servomotor torque-speed characteristics for Omron G5 High inertia family

Standard servo motors 2000 r/min, 230 V/400 V

Ratings and specifications

Voltage			230 V		400 V							
Servo motor model R88M-K□	20-bit incremental encoder		1K020H-□	1K520H-□	40020F-□	60020F-□	1K020F-□	1K520F-□	2K020F-□	3K020F-□	4K020F-□	5K020F-□
	17-bit absolute encoder		1K020T-□	1K520T-□	40020C-□	60020C-□	1K020C-□	1K520C-□	2K020C-□	3K020C-□	4K020C-□	5K020C-□
Rated output	W		1000	1500	400	600	1000	1500	2000	3000	4000	5000
Rated torque	N·m		4.77	7.16	1.91	2.86	4.77	7.16	9.55	14.3	19.1	23.9
Instantaneous peak torque	N·m		14.3	21.5	5.73	8.59	14.3	21.5	28.7	43	57.3	71.6
Rated current	A (rms)		5.7	9.4	1.2	1.5	2.8	4.7	5.9	8.7	10.6	13
Instantaneous max. current	A (rms)		24	40	4.9	6.5	12	20	25	37	45	55
Rated speed	min^{-1}		2000									
Max. speed	min^{-1}		3000									
Torque constant	N·m/A		0.63	0.58	1.27	1.38	1.27	1.16	1.27	1.18	1.40	1.46
Rotor moment of inertia (JM)	$kg·m^2×10^{-4}$ (without brake)		4.60	6.70	1.61	2.03	4.60	6.70	8.72	12.9	37.6	48
	$kg·m^2×10^{-4}$ (with brake)		5.90	7.99	1.90	2.35	5.90	7.99	10	14.2	38.6	48.8
Max. load moment of inertia (JL)	Multiple of (JM)		10^{*1}									
Rated power rate	kW/s (without brake)		49.5	76.5	22.7	40.3	49.5	76.5	105	159	97.1	119
	kW/s (with brake)		38.6	64.2	19.2	34.8	38.6	64.2	91.2	144	94.5	117
Allowable radial load	N		490							784		
Allowable thrust load	N		196							343		
Approx. mass	kg (without brake)		5.2	6.7	3.1	3.5	5.2	6.7	8	11	15.5	18.6
	kg (with brake)		6.7	8.2	4.1	4.5	6.7	8.2	9.5	12.6	18.7	21.8
Brake specifications	Rated voltage		24VDC ±10%									
	Holding brake moment inertia	(J) $kg·m^2×10^{-4}$	1.35								4.7	
	Power consumption (20°C)	W	14	19	17		14	19		22	31	
	Current consumption (20°C)	A	0.59±10%	0.79±10%	0.70 ±10%		0.59±10%	0.79 ±10%		0.90±10%	1.3±10%	1.3 ±-10%
	Static friction torque	N.m (minimum)	4.9	13.7	2.5		4.9	13.7		16.2	24.5	
	Rise time for holding torque	ms (max.)	80	100	50		80	100		110	80	
	Release time	ms (max)	70	50	15		70	50			25	
Basic specifications	Time Rating		Continuous									
	Insulation class		Type F									
	Ambient operating/ storage temperature		0 to +40°C/–20 to 65°C									
	Ambient operating/ storage humidity		20% to 85% (non-condensing)									
	Vibration class		V-15									
	Insulation resistance		20 MΩ min. at 500 VDC between the power terminals and FG terminal									
	Enclosure		Totally-enclosed, self-cooling, IP67 (excluding shaft opening)									
	Vibration resistance		Vibration acceleration 49 m/s^2									
	Mounting		Flange-mounted									

*1. Applicable load inertia: The operable load inertia ratio (load inertia/rotor inertia) depends on the mechanical configuration and its rigidity. For a machine with high rigidity, operation is possible even with high load inertia. Select an appropriate motor and confirm that operation is possible.

Figure 4 Servomotor rates and specifications for Omron G5 High inertia family

The gear reducer

Use model PLF090 Series Standard & High Precision Planetary Gear Reducers from ZionKaifull Automation. In this case, choose a gear reducer that provides a reduction ratio of 4.

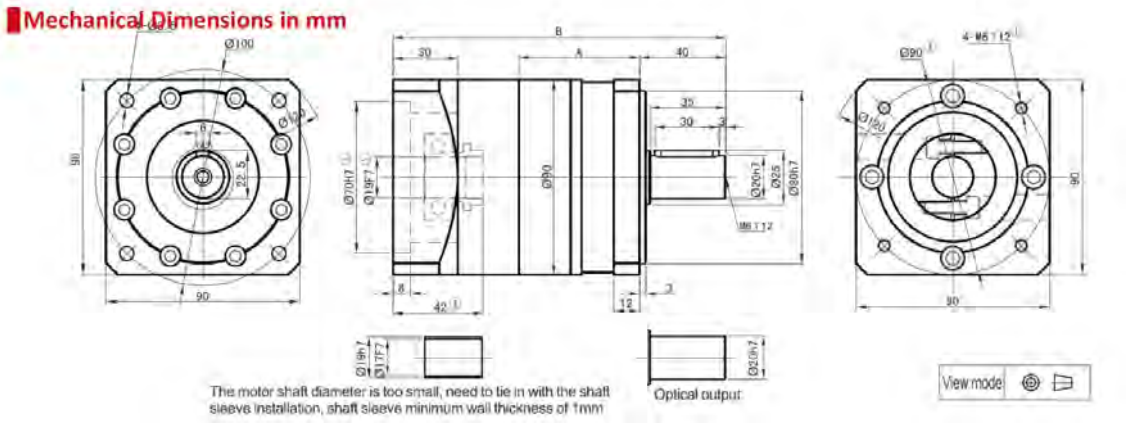

Figure 5 Gear reducer mechanical dimensions

Technical Specifications

Stage	Stage 1 (Contains the speed ratio 3 4 5 7 10)		Stage 2 (Contains the speed ratio 12 16 20 25 28 35 40 50 70 100)		Stage 3 (Contains the speed ratio 80 100 105 140 175 200 250 280 350 400 490 500 700 1000)	
	A	B	A	B	A	B
Length(mm)	56. 0	154. 5	80. 0	178. 5	104. 0	202. 5
Rated input speed(rpm)	3500		3500		3500	
Maximum input speed(rpm)	6000		6000		6000	
The maximum radial force(N)②	1020		1270		1420	
The maximum axial force(N)②	850		1100		1250	
No load torque(Nm)	About 0. 8		About 0. 4		About 0. 4	
Efficiency withfull load(%)	96		94		90	
Back lash(arcmin)	Precision: <3	Standard: <8	Precision: <5	Standard: <10	Precision: <8	Standard: <12
Noise(dB)	≤62		≤62		≤62	
Weight(Kg)	2. 8		3. 4		4. 0	
Average lifetime(h)	>20000					
Torsional rigidity(Nm/arcmin)	7. 5					
lubricant	Effective lubrication					
direction of rotation	The input and output to the same					
Protection level	IP65					
Installation	arbitrarily					

Ratio(i)	3①	4	5	7	10	12②	16	20	25	28	35	40	50	70
Rated output torque(Nm)	60. 0	86. 0	94. 5	64. 0	39. 5	96. 0	96. 0	96. 0	105. 5	96. 0	105. 5	96. 0	105. 5	71. 5
maximum output torque(Nm)	120. 0	172. 0	189. 0	128. 0	79. 0	192. 0	192. 0	192. 0	211. 0	192. 0	211. 0	192. 0	211. 0	143. 0
Moment of inertia(Kgcm²)	0. 4	0. 309	0. 291	0. 285	0. 283	0. 4	0. 309	0. 291	0. 291	0. 285	0. 285	0. 283	0. 283	0. 283

Figure 6 Gear reducer technical specifications

Cylinder load

For this component is complicated to find a datasheet that describes technically it. In this case, simply assume an inertia of 0.03 [kg·m^2].

Winder

The empty core is solid, has a diameter of 0.02 [m], a length of 0.2 [m] and is made from a steel of 7850 [kg/m^3]. The web roll is considered full assuming a diameter of 0.2 [m].

The profile

A symmetrical trapezoidal profile in speed is desired. The profile is defined by

1. Increment of position: 20 [m]
2. Time to position: 10 [s]
3. Dwell time: 0 [s]
4. External torque: 0 [N·m]

Results

Fill and draw according to next and select

Surname	*Study case*
[A-M]	Winder
[N-Z]	Unwinder

All in units of the international system. In case of absence of information assume null value for that missing data except for efficiencies that are assumed as 100%.

1. Draw the profile kinematics.
2. Draw the radius of the winded or unwinded material over time
3. Draw the inertia of the winder/unwinder component over time
4. Draw the kinematics (position, speed and acceleration) and dynamics (torque and power) that finally requires the servomotor.
5. Considering non-safety margin and a safety margin of 10%, fill the next table seen from the motor perspective

		Ratios [%]			
		Without safety margin		**With safety margin**	
		[%]	[ad]	[%]	[ad]
Motor max speed [rad/s]			--		--
Motor effective speed [rad/s]			--		--
Motor max torque [N·m]			--		--
Motor effective torque [N·m]			--		--
Motor inertia capability [ad]		--		--	

6. Provide a final judgment for the goodness of use of the servomotor proposed from results obtained in sections 1 to 5.