Rotor and Gearbox Selection (Helical Bevel Gear Unit)

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Table of Contents.

1. Introduction of Gearbox in Drive Systems

A gearbox, also known as a transmission, is a critical component in the drive system of machinery, providing the essential function of adjusting the speed and torque from a power source to the machinery's operating elements. The primary role of a gearbox is to convert the rotational speed and torque from the input shaft, typically driven by an engine or motor, to a desired output speed and torque suitable for the machine's operational needs. This is achieved through a series of gears with varying diameters and tooth counts that engage and transmit power. By altering the gear ratio, gearboxes can either increase torque and reduce speed or increase speed and reduce torque, providing versatility and efficiency in machine operations.

Gearboxes come in various types, each tailored to specific applications and performance requirements. Common types include spur gearboxes, helical gearboxes, bevel gearboxes, and planetary gearboxes. Spur gearboxes, characterized by their straight-cut gears, are known for simplicity and efficiency but can be noisy at high speeds. Helical gearboxes, with their angled teeth, offer smoother and quieter operation along with higher load capacity. Bevel gearboxes are used to change the direction of the drive, often found in differential drives. Planetary gearboxes, with their compact design and high torque transmission, are prevalent in high-precision applications such as robotics and aerospace.

The design and selection of a gearbox depend on several factors, including the required speed and torque, the type of load, efficiency, and the physical space constraints. Proper lubrication and maintenance are crucial for the longevity and performance of gearboxes, as they operate under significant mechanical stress. Advanced materials and manufacturing techniques, such as hardened steel and precision machining, enhance the durability and performance of gearboxes. Innovations like variable speed drives and integrated electronic controls are increasingly incorporated into gearbox design, offering enhanced control, monitoring, and energy efficiency, making them indispensable in modern machinery and industrial applications.

Figure 1. Gear Drive Components

2. Information Sources of Working Machine

2.1 Installation Data

Basic Data

- Type of the Industrial Fan (ventilator) = V1 - Internal Impeller/Supported Beam
- Working Power (P) = 1.5 kW
- Operating speed of the shaft (n_{shaft}) = 945 rpm
- Operating speed of the motor (n_{motor}) = 1500 rpm
- Thrust (axial) load on the rotor (F_A) = 250 N
- Thrust (radial) load on the rotor (F_B) = 800 N
- Mass of the rotor (m) = 40 Kg

Geometrical Data

- Distance of the bearings from the rotor (a) = 250 mm
- Shaft diameter under the rotor (d) = 42 mm

Data of the belt drive

- Direction of the belt pulling force (H) = 10^{o}

2.2 Estimation of Rotational Moment of Inertia

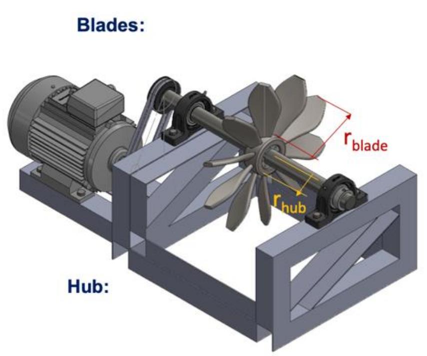


Figure 2. Determination of Moment of Inertia

Reduce the machine $J_2 = J_{working\_machine}$ rotational moment of inertia to the first input shaft:

$$J_{hub} = \frac{1}{3}mr^2 \quad ; \quad J_{impeller} = \sum_{k=1}^{n} J_{blade}$$

$$J_{working\_machine} = J_{impeller} + J_{hub}$$

Since we visualize the prototype's model on CAD (Autodesk Inventor), so we can easily find the value of $J_{working\_machine}$ by looking at properties of the model on the software. $J_{working\_machine}$ = 5555069.247 Kg mm^2 = 5.555 Kg m^2

Further step reduced rotational moment of inertia from the ratio of $J_{working\_machine}$ and $i_{squared}$.

$$\boldsymbol{i = \frac{n_1}{n_2} = \frac{945}{20} = 47.25 \quad ; \quad J_1 = \frac{J_{working\_machince}}{i^2} = \frac{5.555}{47.25^2} = 2.5\ x\ 10^{-3} = 0.0025}$$

Acceleration factor based on Bonfiglioli Catalogue:

$$\boldsymbol{K = \frac{J_c}{J_m} = \frac{J_1}{0.0028\ Kg\ m^2} = \frac{0.0025\ Kg\ m^2}{0.0028\ Kg\ m^2} = 0.8928\ ; \qquad 0.25\ < 0.8928 \le 3}$$

K ≤ 0,25	→	K1	Carico uniforme	*Uniform load*	Gleichmäßige Belastung	*Charge uniform*
0,25 < K ≤ 3	→	K2	Carico con urti moderati	*Moderate shock load*	Belastung mit mäßigen Stö-ßen	*Charge avec chocs n dérés*
3 < K ≤ 10	→	K3	Carico con forti urti	*Heavy shock load*	Belastung mit starken Stö-ßen	*Charge avec chocs i portants*

Figure 3. Table for acceleration factor (K)

The above K value is included in the range values of K2. So, our type of load for this project is moderate shock load.

2.3 Service Factor Determination

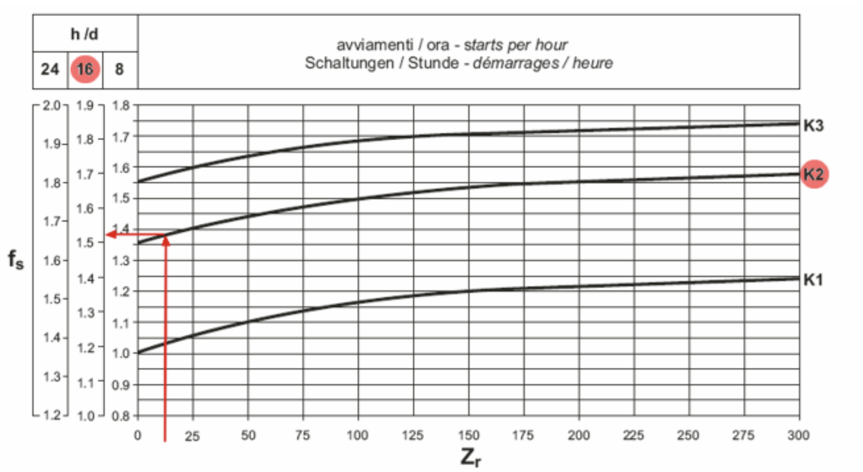


Figure 4. Service factor table based on Bonfiglioli Catalogue

Our input data for K_2:

- Z_r = I = 10
- h/d = 16
- f_s = 1.52 = 1.5 (rounded for service factor)

3. Gearbox and Drive System Design

3.1 Selection of Motor

For a 3-phase synchronous electric motor: A 4-pole motor with a speed of n_{motor} = 1500 rpm is selected. The chosen impeller type operates at a shaft speed of n_{shaft} = 945 rpm. From these values, we can determine the speed ratio (i) of the motor to the shaft.

No. of Poles (p)	Synchronous Speed at 50 Hz, in rpm	Synchronous Speed at 60 Hz, in rpm
2	3000	3600
4	1500	1800
6	1000	1200
8	750	900
10	600	720
12	500	600

Figure 5. Rotational speed for different number of poles

$$\text{Speed ratio (i)} = \frac{\text{n} - \text{motor}}{\text{n} - \text{shaft}} = \frac{1500\ \text{rpm}}{945\ \text{rpm}} = 1.58$$

Based on the catalog of the "Three-Phase Squirrel Cage Motor", we can conclude the nominal power series for the selected motor is 4.0 kW = 4000 W. Meanwhile, the necessary power:

$$\text{P} - \text{power} = \frac{\text{P} - \text{working}}{\text{Efficiency}} = \frac{1500\ \text{rpm}}{0.7} = 2143\ \text{W}$$

The condition must be acquired: $P_{nominal} >= P_{power}$ = 4000 W > 2143 W (fulfilled)

3.2 Operating Time

We can determine the load factor (C2) which is define by type normal starting torque. In this case, we assumed that the lifetime is 4500 hours in 8 years operation time.

- Lifetime: 45000 hours
- Assumption: 8 years operation time

$$h = \frac{45000}{365\ x\ 8} = 15.4\ [\frac{hours}{day}]$$

For 15.4 hours operating time in a day, the appropriate stops time is 7 times in a day. There are several factors that scheduled stops in industrial machine is important:

- Quality control
- Maintenance and lubrication
- Shift changes
- Tool changes
- Batch processing
- Calibration and adjustments
- Safety checks

Examples for Work Machines	Examples for Drive Machines					
	AC motors and three-phase induction machines with a normal starting torque (up to 1.8 times nominal torque), e. g. synchronous motors and single-phase motors with a starting-aid phase, three-phase squirrel cage motors with direct start, star-delta connection or slip ring starters; direct-current shunt-wound motors, combustion engines and turbines n > 600 rpm			AC motors and three-phase induction machines with high starting torque (over 1.8 times nominal torque), e. g. single-phase motors with high starting torque; direct-current series-wound motors with series connection and compound; combustion engines and turbines n < 600 rpm		
	Load factor c_2 for daily operating time (hours)			Load factor c_2 for daily operating time (hours)		
	up to 10	over 10 to 16	over 16	up to 10	over 10 to 16	over 16
Light drives Centrifugal pumps and compressors, belt conveyors (light weight materials), fans and pumps up to 7.5 kW.	1.1	1.1	1.2	1.1	1.2	1.3

Figure 6. Load factor C2 which is define by type normal starting torque

Since the selected supported beam type of rotor has operating speed 945 rpm; > 600 rpm (general parameter limit), so this AC motors and three phase induction machine is applicable with the average usage hours as written above. With the calculated value of h = 15.4 hours/day, and P = 1.5 kW; which is lower than 7.5 kW (light weight material). Based on the figure given, we can conclude that load factor (C2) = 1.1 and $P_{planning}$ = C2 x P = 1.1 x 1.5 = 1.65 kW.

3.3 Determination of Gearbox Units

A 10 — **1330 lb-in**

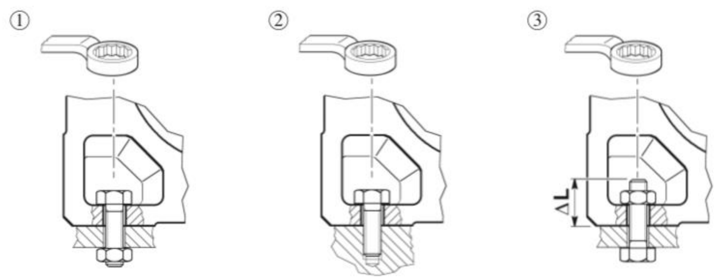
	i	n_1 = 1800 rpm					n_1 = 1200 rpm					
		n_2 rpm	T_{n2} lb·in	P_{n1} hp	R_{n1} lbs	R_{n2} lbs	n_2 rpm	T_{n2} lb·in	P_{n1} hp	R_{n1} lbs	R_{n2} lbs	
A 10 2_5.5	5.5	327	646	3.6	—	500	218	646	2.4	227	587	
A 10 2_6.3	6.3	286	708	3.4	—	520	190	708	2.3	197	611	
A 10 2_7.2	7.2	250	814	3.4	—	528	167	823	2.3	149	621	
A 10 2_8.5	8.5	212	814	2.9	—	567	141	841	2.0	171	666	
A 10 2_9.6	9.6	188	1047	3.3	—	539	125	1133	2.4	—	633	
A 10 2_10.6	10.6	170	1227	3.5	166	526	113	1330	2.5	192	618	
A 10 2_12.3	12.3	146	1129	2.8	—	585	98	1276	2.1	—	688	
A 10 2_13.9	13.9	129	1227	2.7	221	602	86	1330	1.9	256	707	
A 10 2_16.4	16.4	110	1239	2.3	233	650	73	1330	1.6	270	764	
A 10 2_18.6	18.6	97	1301	2.1	241	687	65	1330	1.4	280	807	308
A 10 2_21.4	21.4	84	1330	1.9	245	732	56	1330	1.3	284	859	309
A 10 2_23.8	23.8	76	1330	1.7	250	768	50	1330	1.1	289	902	
A 10 2_25.5	25.5	71	1330	1.6	250	793	47	1330	1.1	289	931	
A 10 2_28.6	28.6	63	1330	1.4	256	833	42	1330	0.94	292	979	
A 10 2_32.2	32.2	56	1330	1.3	260	876	37	1330	0.83	292	1029	
A 10 2_35.1	35.1	51	1330	1.1	260	908	34	1330	0.77	292	1067	
A 10 2_40.9	40.9	44	1330	0.99	266	969	29	1330	0.66	292	1139	
A 10 2_45.4	45.4	40	1330	0.89	266	1012	26.4	1330	0.59	292	1189	
A 10 2_51.3	51.3	35	1330	0.79	264	1065	23.4	1330	0.52	292	1236	
A 10 2_58.6	58.6	31	1330	0.69	266	1118	20.5	1330	0.46	292	1236	
A 10 2_65.9	65.9	27.3	1330	0.61	266	1118	18.2	1330	0.41	292	1236	
A 10 2_76.4	76.4	23.6	1330	0.53	266	1118	15.7	1330	0.35	292	1236	
A 10 2_91.6	91.6	19.7	1151	0.38	266	1160	13.1	1151	0.25	292	1236	

Figure 7. Bonfiglioli gearbox catalogue

According to the previous calculation, our i value is 47.25 which is close to 45.4. Since our revolution speed of the motor is 1500 [rpm], we can pick a bigger value for the reference, n_{motor} = 1800 [rpm].

Therefore, our selected gearbox type is helical bevel gear, unit **A 10 2_45.4** with the following data:

- Maximal output speed: n_2 = 40 [rpm]
- Rated torque value: T_{n2} = 1330 [Ib.in]
- Extra power: P_{n1} = 0.89 [hp]
- Radial load on input shaft: R_{n1} = 266 [Ibs]
- Radial load on output shaft: R_{n2} = 1012 [Ibs]
- Gear frame size: 10
- Reductions: 2
- Gear ratio: 45.4



(A 10)

	Bolt type			
	①	②	③	ΔL [mm / in]
A 05	M8x22	M8x20	M8x ...	22 / 0.866
A 10	M8x25	M8x20	M8x ...	20 / 0.787
A 20	M8x25	M8x20	M8x ...	20 / 0.787
A 30	M10x30	M10x25	M10x ...	25 / 0.984
A 35	M10x30	M10x25	M10x ...	25 / 0.984
A 41	M12x35	M12x30	M12x ...	30 / 1.181
A 50	M14x45	M14x40	M14x ...	35 / 1.378
A 55	M14x40	M14x40	M14x ...	35 / 1.378
A 60	M16x50	M16x45	M16x ...	40 / 1.575
A 70	M20x60	M20x55	M20x ...	45 / 1.772
A 80	M24x70	M24x65	M24x ...	55 / 2.165
A 90	M24x90	M24x80	M24x ...	65 / 2.559

Figure 8. Three possible installation patterns for A gear units

3.4 Design Features and Selected Version

The main design characteristics for gear unit series A are:

- Modularity
- Space effective
- Universal mounting
- High efficiency
- Quite operation
- Gears in hardened and case-hardened steel
- Bare aluminium housing for sizes 05, 10, 20, unpainted
- High strength painted cast-iron housings for larger frame sizes.
- Input and output shafts from grade steel.

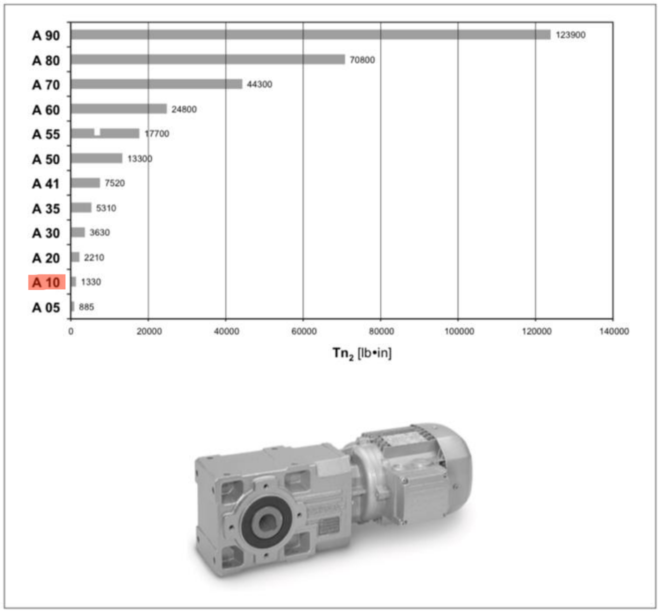


Figure 9. Table for rated torque value on each gear frame size

For the version of gearbox unit series A, we consider to select single extention output shaft (UR/NUR) gearbox which is applicable for A 05 …A 90. Here are some of the key benefits and properties:

- Compact design
- High efficiency
- Durability
- Versatility
- Precision
- Load capacity

Gearboxes like the A 10 UR/NUR are often made from high-grade materials such as alloy steels, cast iron, or other metals that provide excellent strength and resistance to wear and tear. Due to these advantages and properties, gearboxes like the A 10 UR/NUR with a single extension output shaft are used in a variety of applications, including but not limited to:

- Industrial machinery
- Automotive systems
- Conveyor systems
- Robotics
- Packaging equipment

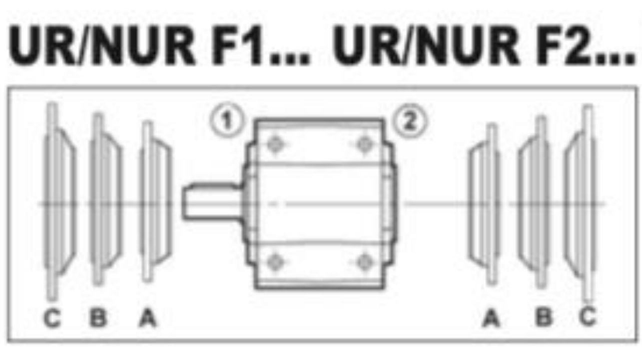
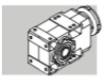


Figure 10. Basic version with bolted flange

3.5 Gear Motor Rating Charts

The extra power of the selected gearbox is 0.89 [hp] which is can be rounded to 1with maximal output speed n_2 is 40 [rpm]. Therefore, we can check the frame motor and its series number in the gear motor rating chart.



1 hp											
n_2 rpm	T_2 lb·in	S	i	R_{n2} lbs		IE2	IE3	IE2	IE3	NEMA	
11.9	4851	1.6	146.9	3092	A413_146.9	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	342...345
12.4	4644	2.9	140.6	4119	A503_140.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	352...355
12.8	4502	1.0	136.3	2498	A353_136.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	332...335
14.9	3861	1.2	116.9	2498	A353_116.9	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	332...335
15.1	3826	1.9	115.9	3092	A413_115.9	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	342...345
16.5	3485	1.2	105.5	2498	A353_105.5	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	332...335
18.2	3263	1.5	95.6	2498	A352_95.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	332...335
18.8	3064	2.1	92.8	3092	A413_92.8	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	342...345
20.1	2956	1.0	86.7	1792	A302_86.7	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	322...325
21.1	2816	1.9	82.5	2498	A352_82.5	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	332...335
22.0	2703	2.6	79.2	3092	A412_79.2	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	342...345
22.8	2610	1.2	76.5	1767	A302_76.5	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	322...325
23.5	2534	2.1	74.3	2498	A352_74.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	332...335
24.5	2433	2.9	71.3	3092	A412_71.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	342...345
26.4	2252	1.5	66.0	1722	A302_66.0	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	322...325
26.5	2246	2.4	65.8	2498	A352_65.8	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	332...335
27.6	2154	0.9	63.1	1061	A202_63.1	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
28.9	2059	2.6	60.4	2498	A352_60.4	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	332...335
29.4	2027	1.7	59.4	1687	A302_59.4	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	322...325
32	1852	2.9	54.3	2498	A352_54.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	332...335
33	1830	1.2	53.7	1073	A202_53.7	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
33	1797	2.0	52.7	1645	A302_52.7	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	322...325
36	1647	1.3	48.3	1058	A202_48.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
36	1647	2.2	48.3	1614	A302_48.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	322...325
40	1481	2.4	43.4	1577	A302_43.4	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	322...325
40	1474	1.5	43.2	1042	A202_43.2	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
43	1394	1.0	40.9	898	A102_40.9	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
44	1351	1.6	39.6	1028	A202_39.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
44	1339	2.7	39.3	1540	A302_39.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	322...325
48	1250	2.9	36.6	1516	A302_36.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	322...325
49	1209	1.8	35.4	1007	A202_35.4	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
50	1198	1.1	35.1	878	A102_35.1	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
54	1098	1.2	32.2	1032	A102_32.2	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
56	1068	2.1	31.3	984	A202_31.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
60	997	2.2	29.2	970	A202_29.2	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
61	975	0.9	28.6	471	A052_28.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
61	975	1.4	28.6	854	A102_28.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
66	903	2.4	26.5	951	A202_26.5	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
69	869	1.0	25.5	478	A052_25.5	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
69	869	1.5	25.5	996	A102_25.5	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
73	811	1.1	23.8	447	A052_23.8	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
73	811	1.6	23.8	827	A102_23.8	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
76	788	2.6	23.1	923	A202_23.1	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
82	729	1.2	21.4	449	A052_21.4	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
82	729	1.8	21.4	963	A102_21.4	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
82	724	2.8	21.2	904	A202_21.2	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	312...315
94	634	1.3	18.6	445	A052_18.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
94	634	2.1	18.6	789	A102_18.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
106	561	1.5	16.4	439	A052_16.4	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
106	561	2.2	16.4	912	A102_16.4	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
125	475	1.7	13.9	429	A052_13.9	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
125	475	2.6	13.9	740	A102_13.9	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
142	420	2.1	12.3	423	A052_12.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
142	420	2.7	12.3	717	A102_12.3	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	302...305
165	360	2.3	10.6	408	A052_10.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
181	328	2.6	9.6	404	A052_9.6	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297
205	291	2.8	8.5	394	A052_8.5	S2+ME2SB4	S2+MX2SB4	P80+BE80B4	P80+BX90SR4	N56C	296, 297

Figure 11. Gear motor rating chart

3.6 Gear Motor Drive System Model Arrangement

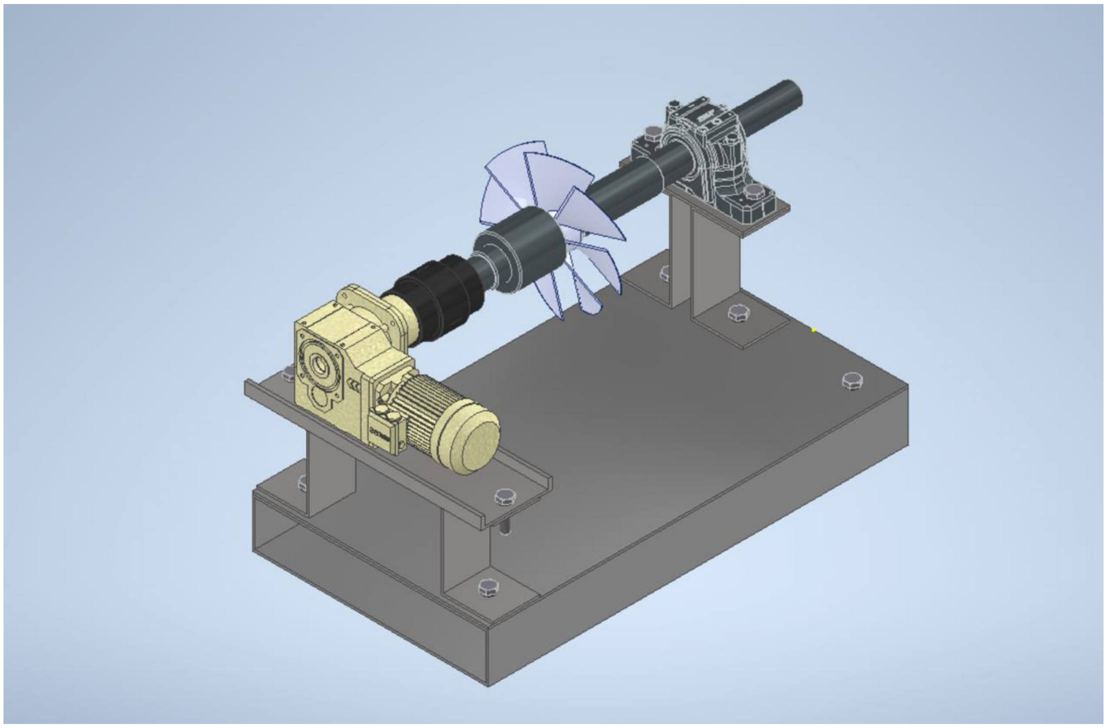


Figure 12. Inventor CAD model of the gear motor and shaft arrangement

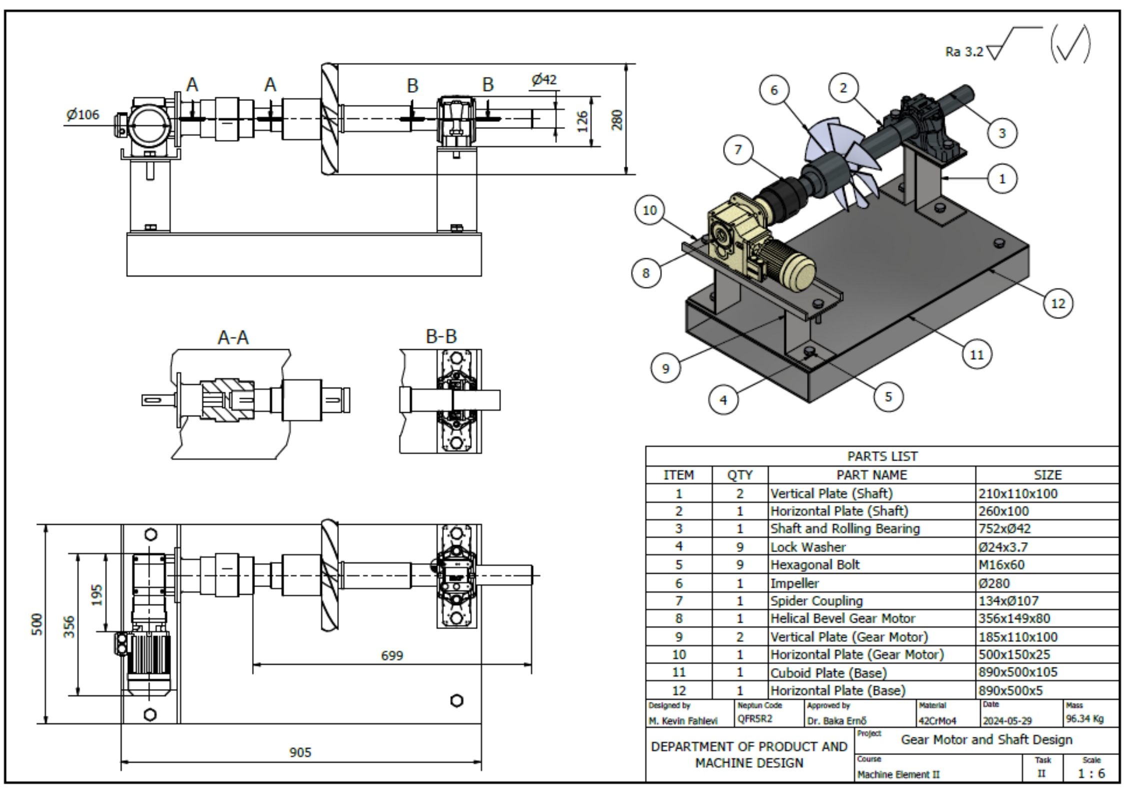


Figure 13. Inventor CAD drawing of the gear motor and shaft arrangement

References

1. Manual practical guidance about manual gearbox selection provided by: Dr. Baka Ernő Zsolt
2. Rotational speed based on number of pole
https://www.engineeringtoolbox.com/electrical-motor-frequency-speed-d_456.html
3. Gearboxes and speed reducers for electric motors
https://www.emotorsdirect.ca/knowledge-center/article/gearboxes-and-speed-reducers-for-electric-motors
4. Gearboxes type units from Bonfiglioli catalogue
https://agisys.hu/up/docs/bonfiglioli-cafs-hajtomu-katalogus-2020.pdf
5. Shaft catalog
https://www.mikipulley.co.jp/EN/Services/Tech_data/tech03.htm