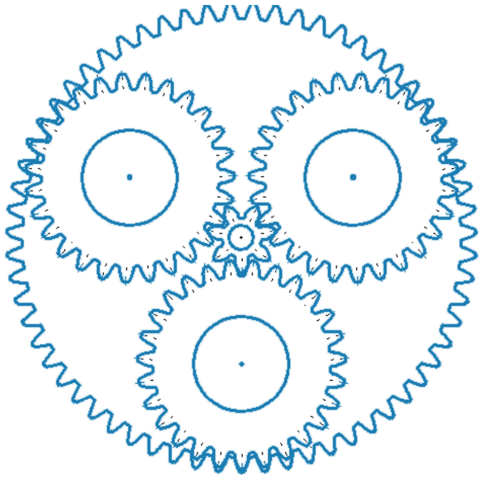
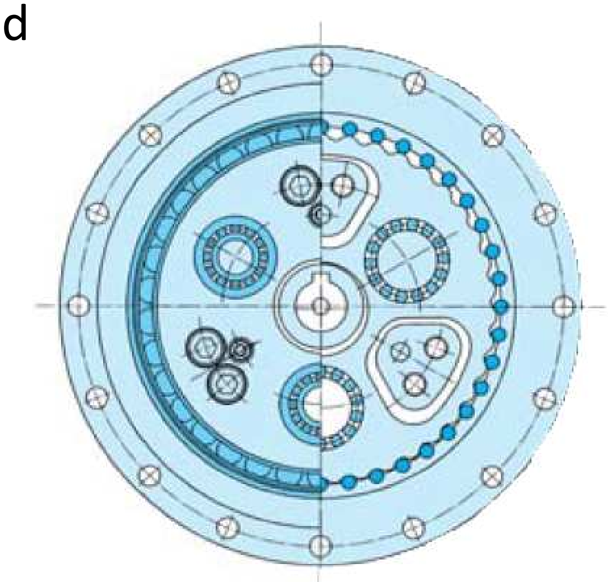
Planetary VS Cycloid

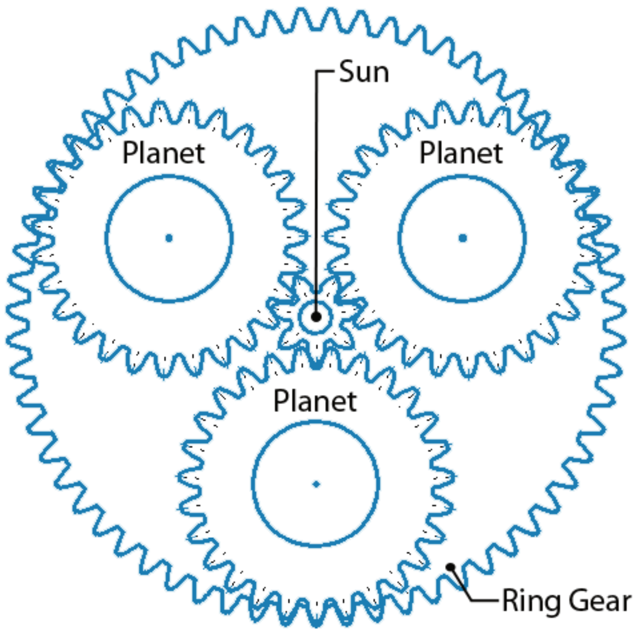




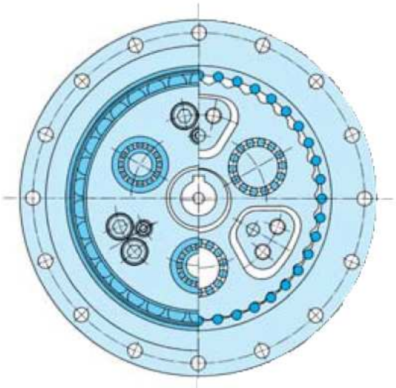
A planetary gearbox is comprised of three members: a sun gear, multiple satellite or planet gears (hence the gearbox's name), and an internal ring gear.

A cycloidal gearbox (or cycloidal reducer) is comprised of four components: the input shaft, a cycloidal cam (single or compound), cam followers, and an output shaft.

Planetary gearboxes

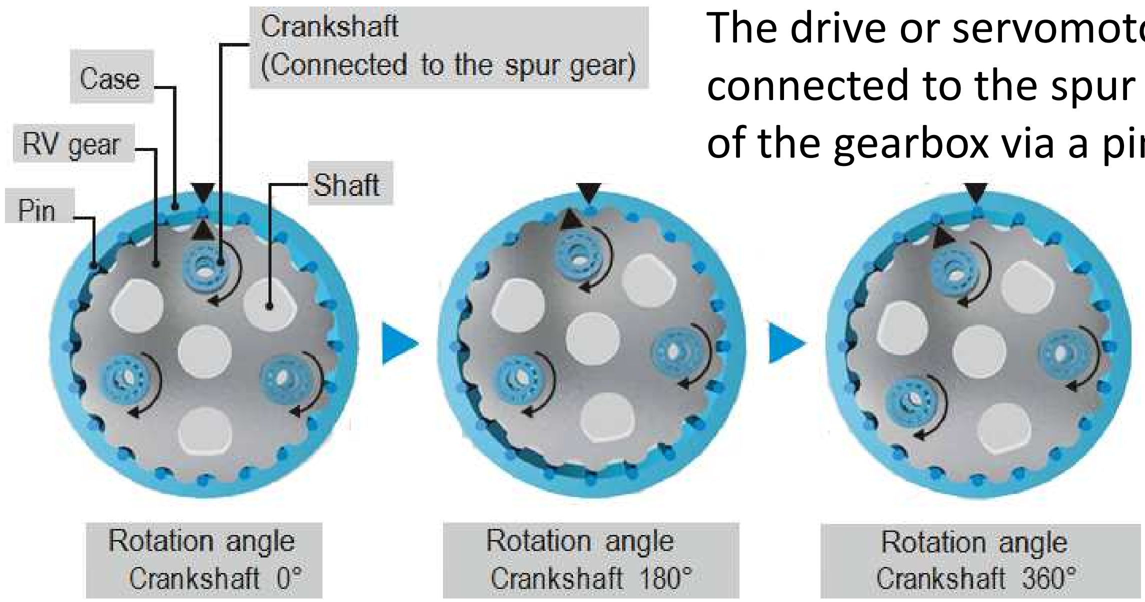


A planetary gearbox is comprised of three members: a SUN gear, multiple satellite or PLANET gears, and an internal ring gear. The input shaft attaches to the sun gear, which transmits rotational motion to the planet gears, which in turn rotate the internal RING gear, which is part of the gearbox housing. Planet gears rotate on rigid shafts attached to a plate called a planet carrier; this rotation of the planet carrier is what causes the output shaft to rotate. As with all mechanical speed reduction, this gives the output shaft a lower rotational speed and higher torque than the input shaft. Planetary gearboxes may also be single- or double-reduction, with reduction ratios ranging from 3:1 to over 100:1. Additional stages can be added for even higher reduction, or to change output shaft orientation (i.e. via bevel gearing, miter gearing, etc.).



Cycloidal gearboxes

A cycloidal gearbox (or cycloidal reducer) is comprised of four components: the input shaft, a cycloidal cam (single or compound), cam followers, and an output shaft. The input shaft attaches to a drive member that induces an eccentric rotation of the cycloidal cam; in compound reducers, the first cycloidal cam engages a second cycloidal cam (double reduction), which may then engage a third cycloidal cam (triple reduction). The cam followers act as gear teeth, and will exceed the number of cam lobes. Cycloidal gearboxes offer ratios from as low as 10:1 to over 300:1 without stacking stages in the manner of a planetary gearbox, and thus cycloidal gearboxes may have a more compact footprint. A typical cycloidal gear is seen here:



The drive or servomotor is connected to the spur gear stage of the gearbox via a pinion.

The first reduction gears are connected to crankshafts which drive the cams using needle bearings. These cams rotate inside the case which is lined with pins.

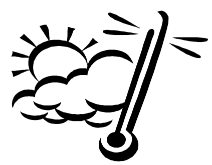
Planetary VS Cycloid

- Planetary Gears may run at higher speeds.
- Cycloidal Gears are very good for extremely heavy loads.
- Planetary Gears will work with very low Ratio's.
- Cycloidal Gears work at higher ratio's allowing them to be driven with less power.
- Planetary Gears are good if positioning accuracy and lost motion are not a concern.
- Cycloidal Gears are best in applications for high positioning accuracy and a minimum lost motion is required.
- Planetary Gears are ok if regular "monthly maintenance" is acceptable for the application.
- Cycloidal Gears are best if little maintenance and long gear life are required.

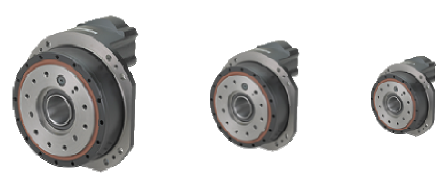
<u>Things to consider when choosing a Gearbox.</u>

After many years developing Cycloidal Gears our engineers have created some basic questions to help you in the beginning steps of selecting a gearbox for your application.

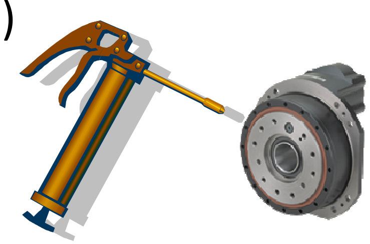
What environmental conditions will gear box need to endure? (Operating temperature, dust, moisture exposure, ect.)



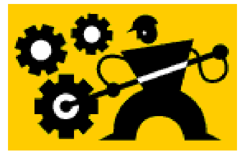
What physical size envelope does your gear box need? (any shape or space requirements)



Maintenance and lubrication access? (After the application is assembled how will you maintain the gear box?)

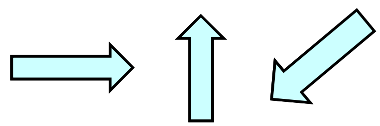


How much torque do you require to do the work required by the application? (Weight it needs to move.)

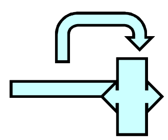


What if any, speed requirement does the application require? (How fast you need the gear box to go.)

Angle of the gearbox mounting? (Horizontally ,vertically or angled.)



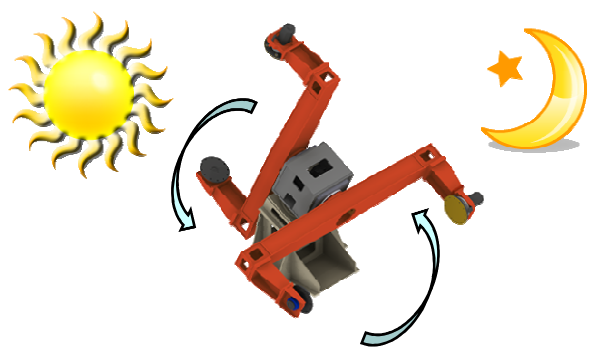
Moment rigidity? (Weight deflection of the gear box shaft due to the fixture and work load.)



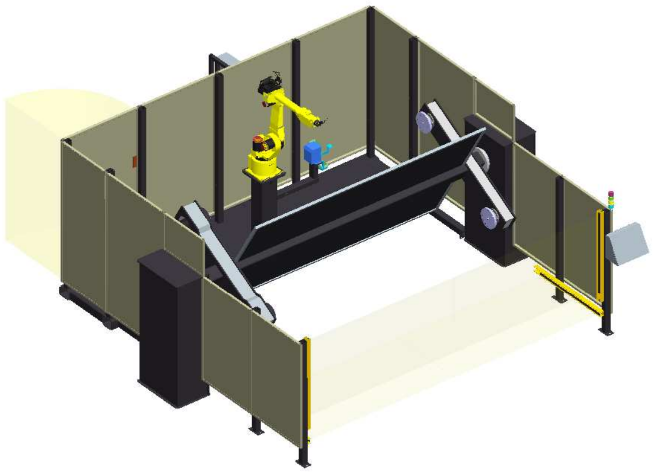
Torsional rigidity? (Shaft deflection, stopping and starting the application load.)

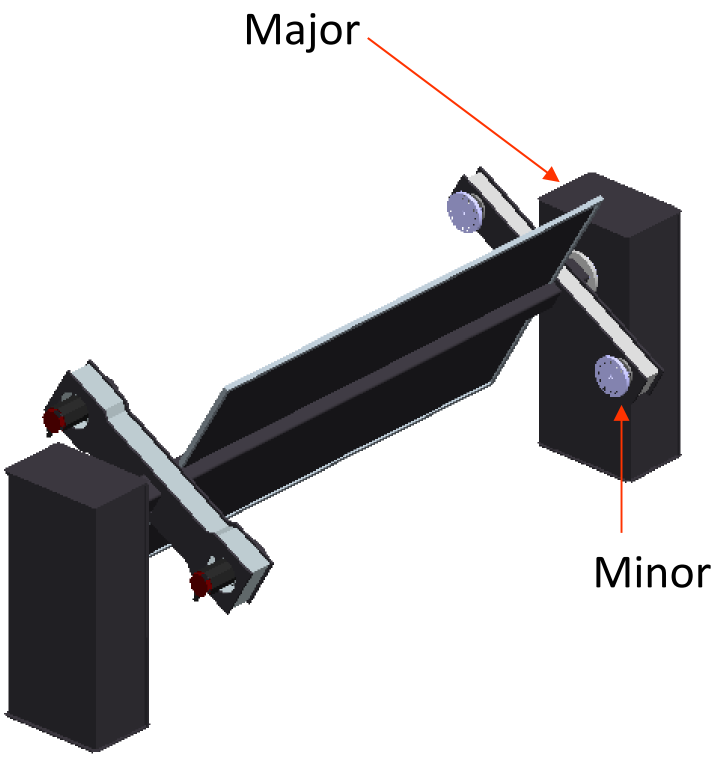
Momentary Maximum allowable torque? (Worst case E-stop condition with a load.)

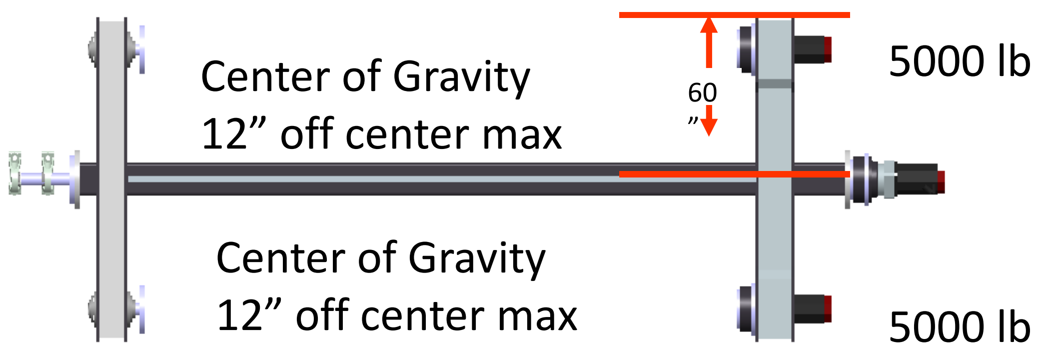
What kind of duty cycle will the Gear box have? (Hours of operation and number of days per week.)



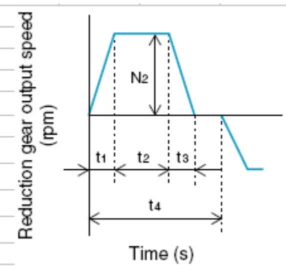
Description
Ferris Wheel
Positioner

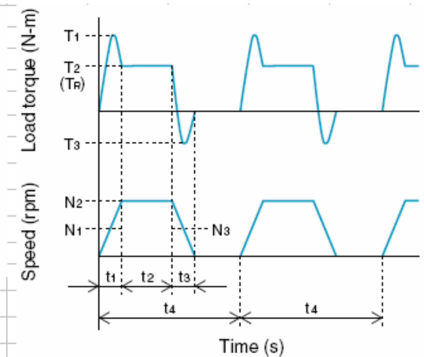






Work Piece Mass (kg)	2314.00
Rotating Assy Mass (kg)	6629.50
Rotating Assy Mass (N)	64969.10
CG distance from axis of rotation (M)	0.070000
Moment of Inertia (kg*M²)	5444.00
Acceleration Time (s)	2.0
Constant Speed Operation Time (s)	4.0
Deceleration Time (s)	2.0
One Operation Cycle Time (s)	60.0
Constant Speed (rpm)	5.0
Average Speed for Startup (rpm)	2.5
Average Speed for Stop (rpm)	2.5
Constant Speed Torque (Nm)	4547.84
Load Moment of Inertia (kg*M²)	5444.00
Inertia Torque During Acceleration (Nm)	1425.239
Inertia Torque DuringDeceleration (Nm)	-1425.24
Maximum Torque For Startup (Nm)	5973.08
Constant Speed Torque (Nm)	4547.84
Maximum Torque For Stop (Nm)	3122.60
Average Output Speed (rpm)	3.75
Max Output Torque (Nm)	5973.08
GearBox Reduction Ratio	555 :1
GearBox Efficiency	72%
Max Input Torque (Nm)	14.95





$$T_A = \left\{ \frac{I_R \times (N_2 - 0)}{t_1} \right\} \times \frac{2\pi}{60}$$

$$T_D = \left\{ \frac{I_R \times (0 - N_2)}{t_3} \right\} \times \frac{2\pi}{60}$$

$$T_1 = \left| T_A + T_R \right|$$

$$T_2 = \left| T_R \right|$$

$$T_3 = \left| T_D + T_R \right|$$

$$N_m = \frac{t_1 \bullet N_1 + t_2 \bullet N_2 + t_3 \bullet N_3}{t_1 + t_2 + t_3}$$

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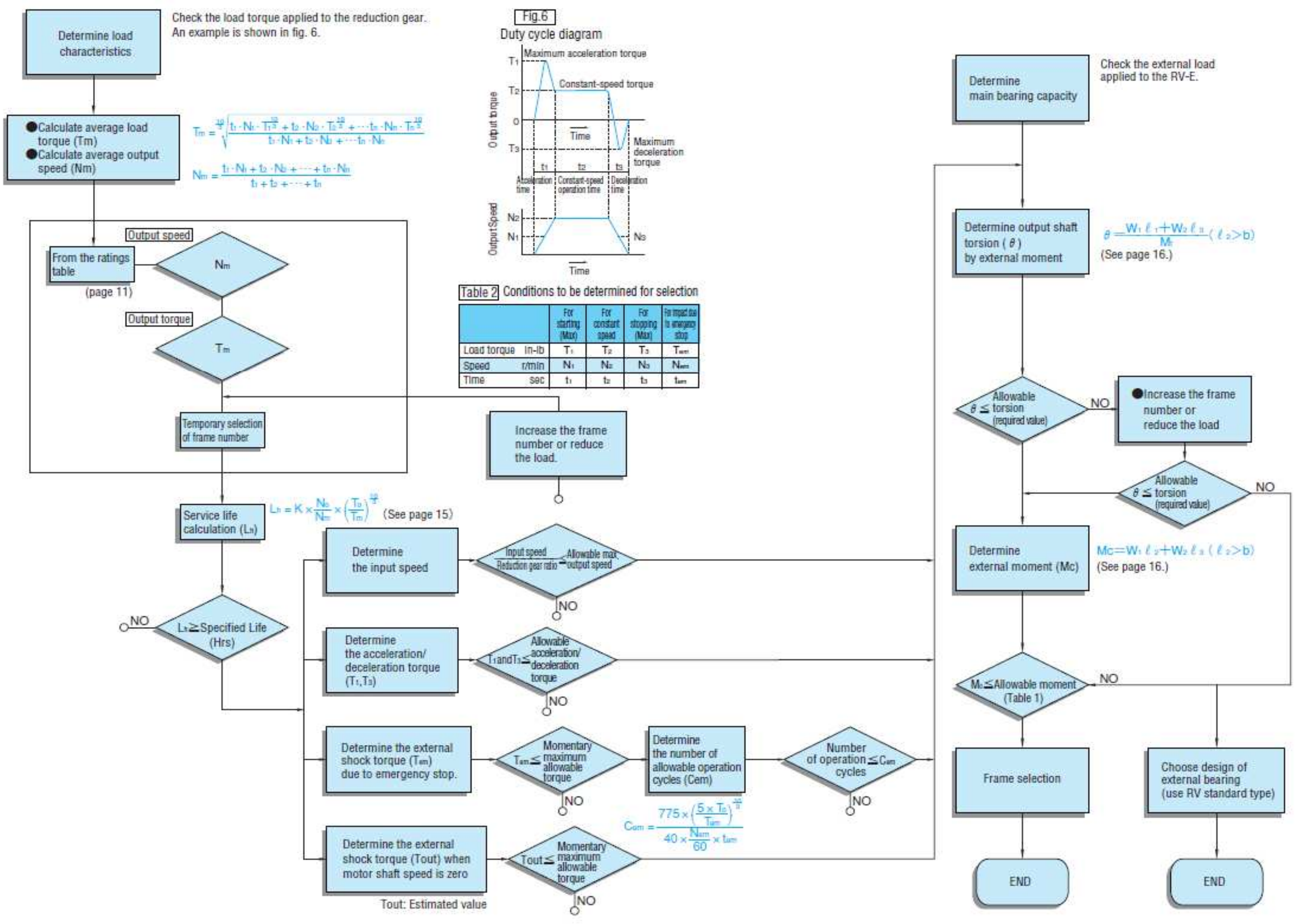


$$T_m = \sqrt[\frac{10}{3}]{\frac{t_1 \cdot N_1 \cdot T_1^{\frac{10}{3}} + t_2 \cdot N_2 \cdot T_2^{\frac{10}{3}} + \cdots + t_n \cdot N_n \cdot T_n^{\frac{10}{3}}}{t_1 \cdot N_1 + t_2 \cdot N_2 + \cdots + t_n \cdot N_n}}$$

$$N_m = \frac{t_1 \cdot N_1 + t_2 \cdot N_2 + \cdots + t_n \cdot N_n}{t_1 + t_2 + \cdots + t_n}$$

$$L_h = K \times \frac{N_0}{N_m} \times \left(\frac{T_0}{T_m}\right)^{\frac{10}{3}}$$

$$\theta = \frac{W_1 \ell_1 + W_2 \ell_3}{M_1} \quad (\ell_2 > b)$$

$$C_{em} = \frac{775 \times \left(\frac{5 \times T_0}{T_{em}}\right)^{\frac{10}{3}}}{40 \times \frac{N_{em}}{60} \times t_{em}}$$

Table 2 Conditions to be determined for selection

		For starting (Max)	For constant speed	For stopping (Max)	For impact due to emergency stop
Load torque	In-lb	T_1	T_2	T_3	T_{em}
Speed	r/min	N_1	N_2	N_3	N_{em}
Time	sec	t_1	t_2	t_3	t_{em}

Selection example

Selection conditions

$T_1 = 22{,}125$ In-lb $T_2 = 4{,}425$ In-lb
$T_3 = 13{,}275$ In-lb $T_{em} = 61{,}950$ In-lb
$t_1 = 0.2$ sec. $t_2 = 0.5$ sec.
$t_3 = 0.2$ sec. $t_{em} = 0.05$ sec.
$N_1 = N_3 = 10$ r/min $N_2 = 20$ r/min
$N_{em} = 20$ r/min

Determine load characteristic

- Determine average load torque

$$T_m = \sqrt[\frac{10}{3}]{\frac{0.2 \times 10 \times 22{,}125^{\frac{10}{3}} + 0.5 \times 20 \times 4{,}425^{\frac{10}{3}} + 0.2 \times 10 \times 13{,}275^{\frac{10}{3}}}{0.2 \times 10 + 0.5 \times 20 + 0.2 \times 10}}$$
$= 13{,}053$ In-lb

- Determine average output speed

$$N_m = \frac{0.2 \times 10 + 0.5 \times 20 + 0.2 \times 10}{0.2 + 0.5 + 0.2} = 15.6 \text{ r/min}$$

Provisional selection of RV-160E-129.

- Calculation to determine whether reduction gear service life meets required specification value.

$$L = 6{,}000 \times \frac{15}{15.6} \times \left(\frac{13{,}887}{13{,}053}\right)^{\frac{10}{3}} = 7{,}092 \text{ Hr}$$

- Determine output speed

Maximum output speed 20r/min < 45r/min
(Maximum allowable output speed of RV-160E)

- Determine torque during starting and stopping

$T_1 = 22{,}125$ In-lb < 34,718 In-lb
(Allowable acc./dec. torque for RV-160E)
$T_3 = 13{,}275$ In-lb < 34,718 In-lb
(Allowable acc./dec. torque for RV-160E)

- Determine emergency stop and external shock torque

$T_{em} = 61{,}950$ In-lb < 69,436 In-lb
(Momentary max. allowable torque for RV-160E)

$$C_{em} = \frac{775 \times \left(\frac{5 \times 13{,}887}{61{,}950}\right)^{\frac{10}{3}}}{40 \times \frac{20}{60} \times 0.05} = 1{,}700 \text{ times}$$

Determine main bearing capacity

- External load conditions

$W_1 = 660$ lbs $\ell_1 = 19.7$ in.
$W_2 = 330$ ibs $\ell_3 = 7.9$ in.

Determine moment rigidity

- Determine whether output shaft deflection angle meets required specification value.

$$\theta = \frac{660 \times 19.7 + 330 \times 7.9}{26{,}019} = 0.6 \text{ (arc.min)}$$

- Determine external moment

$$\ell_2 = 19.7 + \frac{8.3}{2} = 23.85 \text{ in.}$$

$M_c = 660 \times 23.85 + 330 \times 7.9$
$= 18{,}348$ In-lb < 34,718 In-lb
(Allowable moment of RV-160E)

Since all required specification are satisfied, select RV-160E-129.

Strength and service life

Allowable torque during acceleration or deceleration

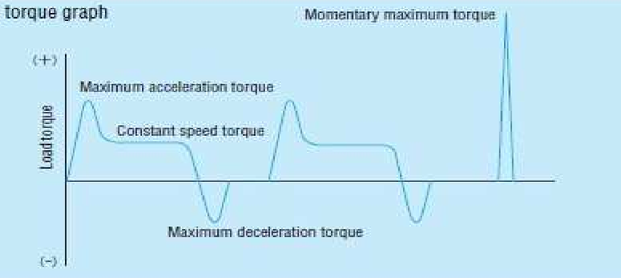
When the Machine starts (or stops) a larger torque than steady-state torque is applied to the reduction gear because of the internal loads. The values in the ratings table (see page 11) show the allowable value of the peak torque when the reduction gear starts or stops.
With the RV-6E, the allowable acceleration/deceleration torque is 200% of the rated torque; other models in the series have a acceleration/deceleration torque of 250% of the rated torque.

Momentary maximum allowable torque

A large torque during an emergency stop or external shock may be applied to the reduction gear. The maximum allowable torque is shown in the ratings table(see page 11).
Momentary maximum allowable torque is 500% of the rated torque.

Note) When shock torque is applied, be sure to use at below the limit cycles(refer to selection flowchart on page 13).

Fig.7 Load torque graph



Rated service life

The service life of the RV-E reduction gear is based on the life of the roller bearings of the crankshafts. The service life is set as shown in Table 3 for all models and ratios at rated torque and at rated output speed.

Table 3

L_h	Service life (Hrs)	
L_{10}	K	6,000

When in actual service installed in the equipment, calculate the service life using the following formula because the load condition depends on the types of reduction gear.

$$L_h = K \times \frac{N_0}{N_m} \times \left(\frac{T_0}{T_m}\right)^{\frac{10}{3}}$$

L_h : Service life to be obtained (Hr)
N_m : Average output speed (r/min) (calculation on page 13)
T_m : Average output torque (In-lb) (calculation on page 13)
N_0 : Rated output speed (r/min) (table 4)
T_0 : Rated output torque (In-lb) (table 4)

Table 4

Type	Rated torque(T_0) In-lb(Nm)	Rated output speed (N_0)r/min
RV-6E	514 (58)	30
RV-20E	1,479 (167)	15
RV-40E	3,649 (412)	
RV-80E	6,944 (784)	
RV-110E	9,547 (1,078)	
RV-160E	13,887 (1,568)	
RV-320E	27,774 (3,136)	
RV-450E	39,058 (4,410)	