2.3 Precaution of usage for Worm gear pair

① To obtain ideal engagement of Worm gear and Worm wheel's shafts, provide right angle (90°) correctly.
② Lubricant oil is indispensable to Worm gear and Worm wheel during operation due to high friction between flanks of Worm gear and Worm wheel.
③ Engagement of the same number of thread and hand of thread are indispensable to Worm gear and Worm wheel. (Engage Worm gear and Worm wheel with both having right hand and one thread)
④ The design of the axes between Worm gear and Worm wheel should be firm and provide bearing as close as possible to Worm gear pair.
⑤ Provide the bearing that will completely support the Worm gear pair as the axial thrust increases during operation. Refer to Fig. 6 for axial thrust direction.

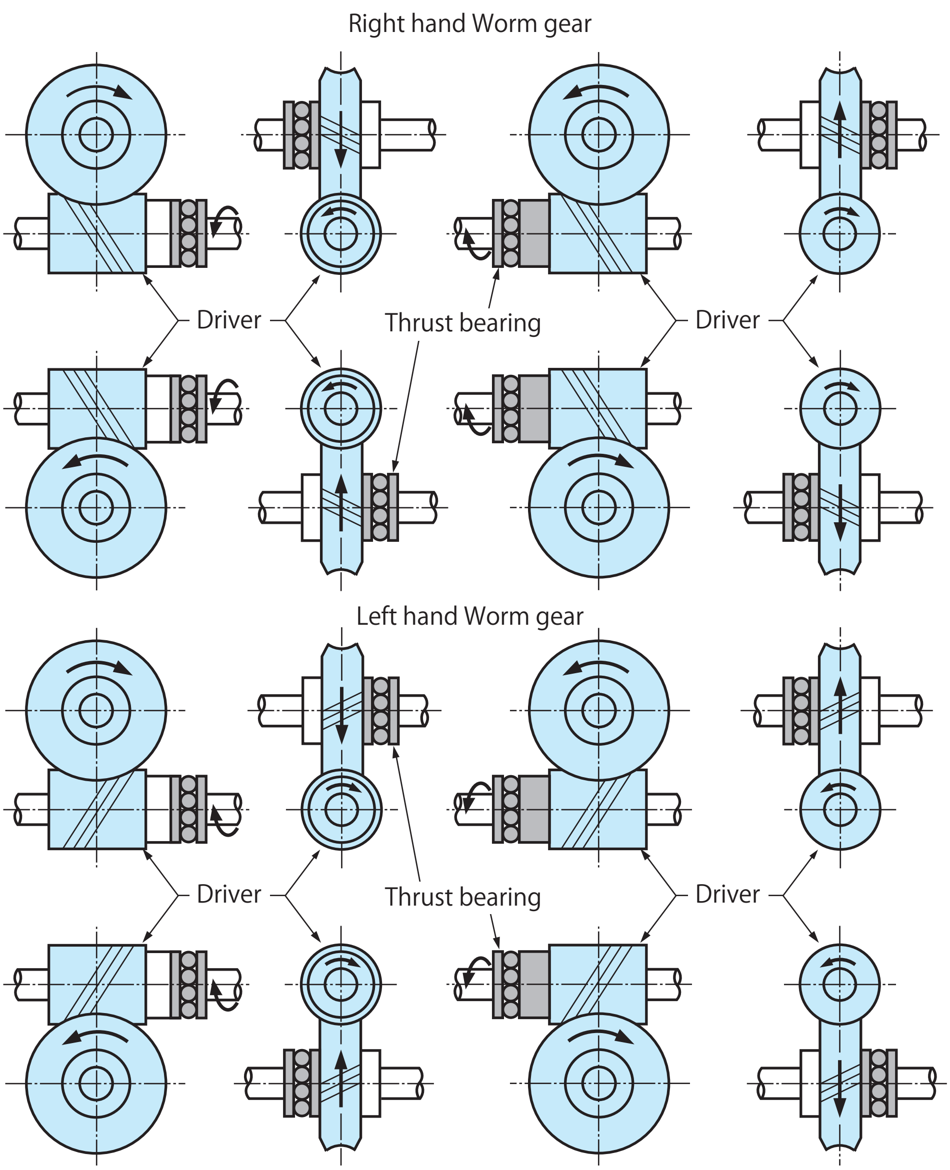

Fig. 6 Axial thrust load to Worm gear and location of bearings.

⑥ When assembling and warm up for Worm gear pair, design such that Tooth contact can be measured and assembly position can be adjusted.

⑦ Worm gear pair performs self-locking when lead angle is below 4°. Please separately design the safety device to stop the gear from inversing.

⑧ Load applied to Worm gear pair (Refer to Fig. 7)

$F_1 d_1/2$ is moment for driver of Worm gear. F_2 is revolving force for Worm wheel by $F_1 d_1/2$. Formula is as follows,

$$F_1 = F_2 \tan(\gamma + \rho) = \frac{4.5H \times 10^6}{\pi d_1 n_1} \bullet 9.80665\ (\mathrm{N})$$

(a) F_2 is axial direction thrust for Worm gear.

$$F_2 = \frac{F_1}{\tan(\gamma + \rho)} = \frac{1.432H \times 10^6}{\tan(\gamma + \rho) \times d_1 n_1} \bullet 9.80665\ (\mathrm{N})$$

F_1 is axial direction thrust for Worm wheel.

$$F_1 = \frac{1.432H \times 10^6}{(d_1 n_1)} \bullet 9.80665\ (\mathrm{N})$$

Hereby

H : Net power applied to Worm gear (PS=horse power)

γ : Lead angle

$$\tan\rho = \frac{\mu}{\cos\alpha_n}$$

μ : Coefficient of friction on flank

α_n : Normal pressure angle

d_1 : Pitch diameter of Worm gear (mm)

n_1 : Revolution speed per minute for Worm gear

ρ : Apparent friction angle of flank

Note: If $H_2 PS$ is the power from Worm wheel and η_R is efficiency. Calculation is as follows.

$$H = \frac{H_2}{\eta_R}$$

(b) Calculation for load to displace the axis

$$F_s = \frac{F_1 \tan\alpha_n \cos\rho}{\sin(\gamma + \rho)}\ (\mathrm{N})$$

Alternatively $= F_n \sin\alpha_n$

(c) Normal load

$$F_n = \frac{F_1 \cos\rho}{\sin(\gamma + \rho)\cos\alpha_n}\ (\mathrm{N})$$

Reference literature: Dr. Waguri Akira "Gear Design and Manufacturer" 30th Machine Literary of Japan.

Basic formula of Worm gear pair

1. Sliding velocity υ_s(m/s)

$$\upsilon_s = \frac{\pi d_1 n_1}{60 \times 1000 \times \cos\gamma}$$

Hereby

d_1 : Pitch diameter of Worm gear (mm)

n_1 : Revolution per minute for Worm gear (min^{-1})

γ : Reference pitch cylinder lead angle (°)

2. Torque and Efficiency (When the driver is from Worm gear)

$$T_2 = \frac{F_t d_2}{2000} \bullet 9.80665\ (\mathrm{N \bullet m})$$

Hereby

T_2 : Nominal torque of Worm wheel (N・m)

F_t : Nominal circular force of Worm wheel (N)

d_2 : Pitch circumferential diameter of Worm wheel (mm)

$$T_1 = \frac{T_2}{u\eta_R} = \frac{F_t d_2}{2000 u \eta_R}$$

Hereby

T_1 : Nominal torque of Worm gear (N・m)

u : Gear ratio ($u = z_2/z_w$)

η_R : Transfer efficiency of Worm gear pair when driver is from Worm gear.

$$\eta_R = \frac{\tan\gamma\left(1 - \tan\gamma \dfrac{\mu}{\cos\alpha_n}\right)}{\tan\gamma + \dfrac{\mu}{\cos\alpha_n}}$$

Hereby

μ : Coefficient of friction

α_n : Normal reference pressure angle (°)

Note the efficiency of KG' s Worm gear pair is as follows.

Worm gear with single thread	45% - 55%
Worm gear with double thread	55% - 65%

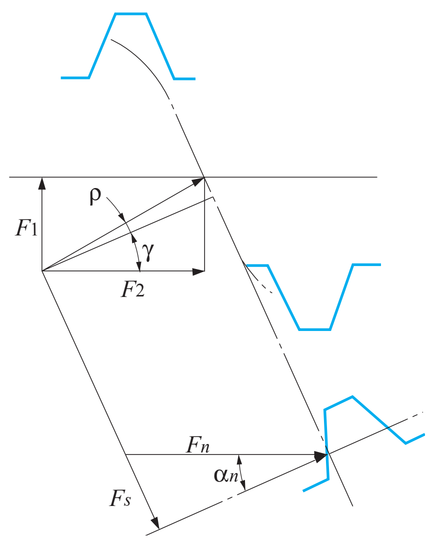

Fig. 7 Load applied to Worm gear pair.