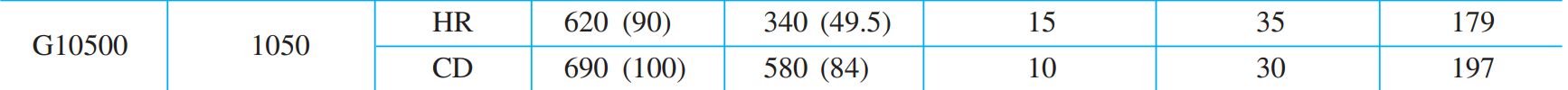
**Shaft Design L**

**Force Analysis:**

Choose the inexpensive steel, 1050CD steel, parameter is from Shigley’s book Table A-20:





Start with point C, where the bending moment is high and there is a stress concentration of the shoulder.

Forces at C:

Therefore,

Based on the inner radius of the gear (12 mm), let’s design the diameter d to be 12 mm.

Next, check for failure:

Choose diameter ratio for the shoulder: D/d = 1.5, thereby

Select standard value D = 18 mm.

Check if estimates were acceptable:

Choose fillet ratio for well-rounded shoulder, based on Shigley’s book [Table 7-1].

So the fillet radius is .

Choose the stress concentration factors from Shigley’s book

From the Shigley’s book equation 6-32:

Then the modifying factors:

**Surface factor** from the Shigley’s book Table 6-2, from cold draw.

From equation 6-18:

**Size factor** from the Shigley’s book equation 6-19, due to the ,

**Load factor** from the Shigley’s book equation 6-25, and since there is not fluctuating axial loading, and the loading factor for torsion is already taken into account when using Mises Stress.

**Temperature Factor** the endurance limit is available or being estimated based on the ultimate strength at the operating temperature.

**Reliability Factor**

Estimating the Endurance Limit from equation 6-10,

Finally, the endurance limit: From equation 6-17:

Use von Mises stresses from equation 7-4 and equation 7-5:

Then calculate the safety, using the Goodman Criterion from equation 6-41

And the yielding safety factor from equation 7-7:

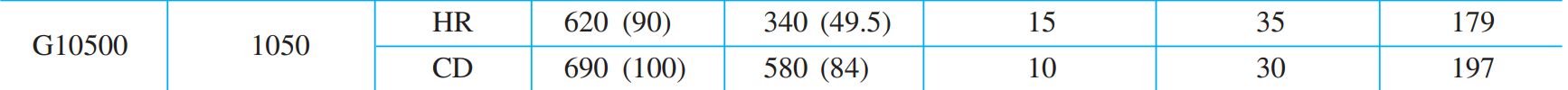
**Shaft Design R**

Free body diagram:

**Force Analysis:**

Choose the inexpensive steel, 1050CD steel, parameter is from Shigley’s book Table A-20:





Start with point D, where the bending moment is high and there is the keyway

Forces at D:

Therefore,

Based on the inner radius of the gear (12 mm), let’s design the diameter d to be 12 mm.

Assume the radius at the bottom of the keyway will be the standard , thereby

Choose the stress concentration factors from Shigley’s book

From the Shigley’s book equation 6-32:

Then the modifying factors:

**Surface factor** from the Shigley’s book Table 6-2, from cold draw.

From equation 6-18:

**Size factor** from the Shigley’s book equation 6-19, due to the ,

**Load factor** from the Shigley’s book equation 6-25, and since there is not fluctuating axial loading, and the loading factor for torsion is already taken into account when using Mises Stress.

**Temperature Factor** the endurance limit is available or being estimated based on the ultimate strength at the operating temperature.

**Reliability Factor**

Estimating the Endurance Limit from equation 6-10,

Finally, the endurance limit: From equation 6-17:

Use von Mises stresses from equation 7-4 and equation 7-5:

Then calculate the safety, using the Goodman Criterion from equation 6-41

And the yielding safety factor:

**At point E**, there is a ring we will look up data for a specific retaining ring to obtain and more accurately.

With a quick online search of a retaining ring specification appropriate groove specifications for a retaining ring for a shaft diameter of 11.5mm are obtained as follows: width, a=1mm; depth, 0.25mm; and corner radius at the bottom of grove, r=0.13mm

Just to the up of point E.

Forces at E:

Therefore,

And

Choose the stress concentration factors from Shigley’s book

From the Shigley’s book equation 6-32:

Then the modifying factors:

**Surface factor** from the Shigley’s book Table 6-2, from cold draw.

From equation 6-18:

**Size factor** from the Shigley’s book equation 6-19, due to the ,

**Load factor** from the Shigley’s book equation 6-25, and since there is not fluctuating axial loading, and the loading factor for torsion is already taken into account when using Mises Stress.

**Temperature Factor** the endurance limit is available or being estimated based on the ultimate strength at the operating temperature.

**Reliability Factor**

Estimating the Endurance Limit from equation 6-10,

Finally, the endurance limit: From equation 6-17:

Use von Mises stresses from equation 7-4 and equation 7-5:

Then calculate the safety, using the Goodman Criterion from equation 6-41

And the yielding safety factor:

And then check for point C, here the bending moment is high and there is a stress concentration of the shoulder.

Forces at C:

Therefore,

Based on the inner radius of the gear (12 mm), let’s design the diameter d to be 12 mm.

Next, check for failure:

Choose diameter ratio for the shoulder: D/d = 1.5, thereby

Select standard value D = 18 mm.

Check if estimates were acceptable:

Choose fillet ratio for well-rounded shoulder, based on Shigley’s book [Table 7-1].

So the fillet radius is .

Choose the stress concentration factors from Shigley’s book

From the Shigley’s book equation 6-32:

Then the modifying factors:

**Surface factor** from the Shigley’s book Table 6-2, from cold draw.

From equation 6-18:

**Size factor** from the Shigley’s book equation 6-19, due to the ,

**Load factor** from the Shigley’s book equation 6-25, and since there is not fluctuating axial loading, and the loading factor for torsion is already taken into account when using Mises Stress.

**Temperature Factor** the endurance limit is available or being estimated based on the ultimate strength at the operating temperature.

**Reliability Factor**

Estimating the Endurance Limit from equation 6-10,

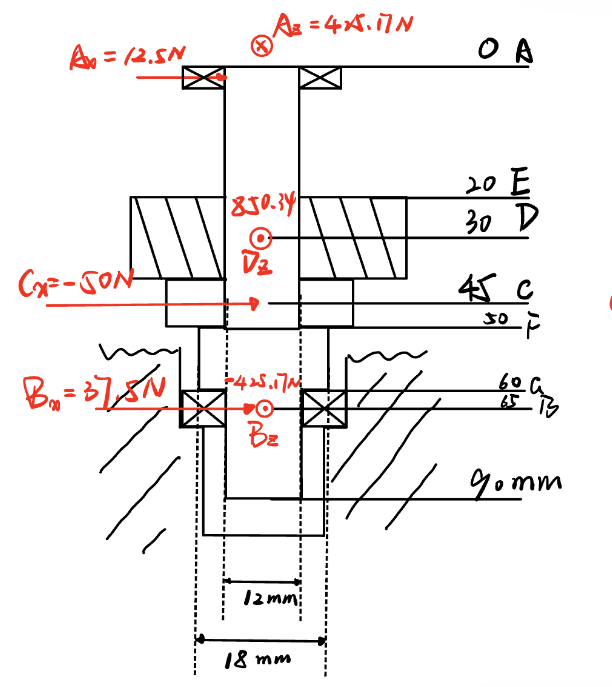
Finally, the endurance limit: From equation 6-17:

Use von Mises stresses from equation 7-4 and equation 7-5:

Then calculate the safety, using the Goodman Criterion from equation 6-41

And the yielding safety factor from equation 7-7:

Finally, let us check for deflection:

**

For simplification, let’s assume diameter from F to G is equal to OF, this is more conservative.

**In xy plane**, For boundary condition:

Integrate the moment functions:

And , and

So, there is four equations and four unknowns, use python to solve:

**In xz plane**, For boundary condition:

Therefore, use python to solve:

|  |  |  |  |
| --- | --- | --- | --- |
| Point of interest | XY Plane | XZ Plane | Total |
| Gear slope (D) | [rad] | [rad] | 0.00061131[rad] |
| Bearing slope (B) | [rad] | [rad] | 0.00152938[rad] |
| Gear slope (D) | 0.00033[mm] | 0.000169[mm] | 0.00037[mm] |
|  |  |  |  |
|  |  |  |  |