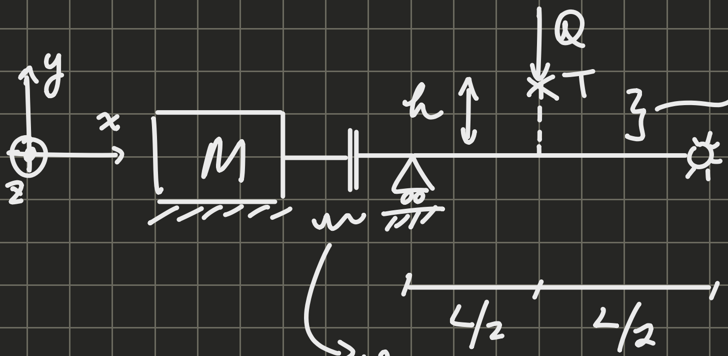
Excercises - Shafts and Axels

↳ There are more excercises then we can do so we can practice on our own.

Excercise 1:

↳ Circular Shaft



Dashed line ⇒ there is something else.

↳ In the realcase they will ask us to design this too.

↳ Usually placed to help with missallignment of the shafts, so we add this elastic joint.

Since the shaft has ~~now~~ not been designed it is now an axis.

Specifications:

$L = 150$ mm

$h = 40$ mm

$Q = 1$ kN $T = 2$ kN

Steel → Non-shim

Motor → is asynchronous 3 phase motor

Joint allows to only transmit torque.

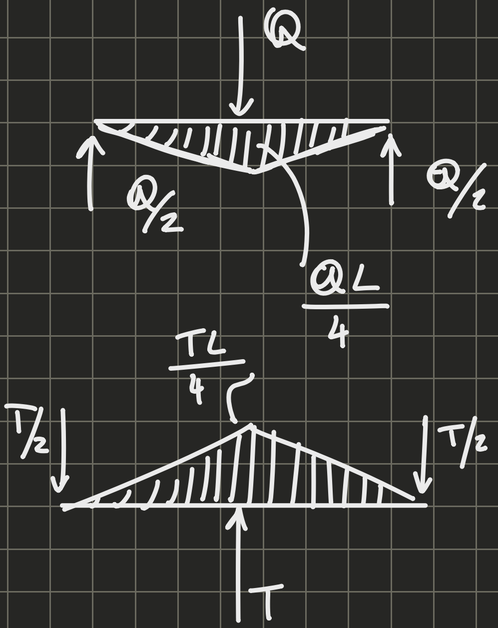
Since we are told to use the specific steel we need its data, we either do our own tests or use standard which have the data.

$R_{s\,min}$ → is the minimum guaranteed yield stress, they give us the worst value and not the average, so when we buy the properties will probably be better.

Pre-sizing

We have both torque and bending

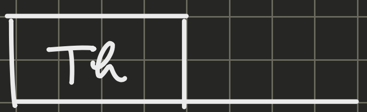
We have to determine M_f and M_t



Shear is present but we ignore, bending is present.

T also generates the torque, Th

And the motor has to generate an equal and opposite.



$M_t = Th = 80\,Nm$

$M_{f,max,x,y} = Q/2 \cdot L/2 = 37,5\ Nm$

$M_{f,max\ x,z} = T/2 \cdot L/2 = 75\ Nm$

$M_{f,max,tot} =$ Pythagoras $= 83,9\ Nm$

$$\sigma_{MAX} = \frac{32 M_{f,eq}}{\pi d^3} \leq \frac{R_m}{6}$$

$$M_{f,eq} = \sqrt{M_{f,max,tot}^2 + (\alpha \cdot M_{t,cost})^2} = 92{,}9 \text{ Nm}$$

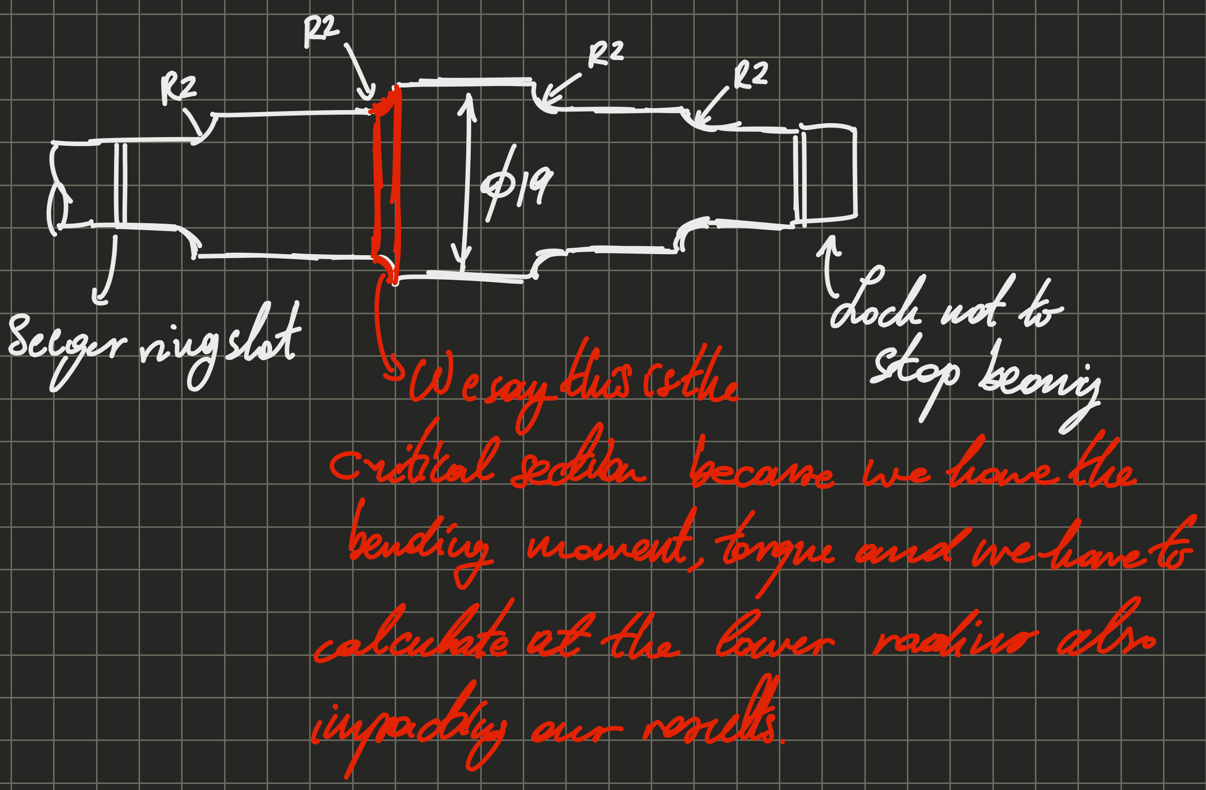
$\alpha^2 = 0{,}25 \Rightarrow$ because it's static

Using $R_m = 980$ MPa

$d \geq 17{,}98$ mm (≥ 16 mm, for which $R_m = 980$ MPa is valid)

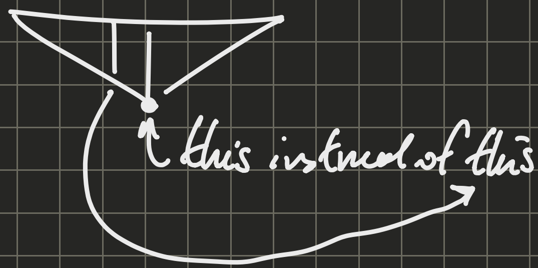
Using $R_m = 930$ Nm we get $d \geq 18{,}3$, we take 19 mm, because if we want to get from stock which does by millimeters and not random numbers.
We round up to be safer.

Pre-drawing, we need to be able to draw the shaft so that it can fit everything that we need



Doing the check

we use the smaller radius, and the M at the longer radius



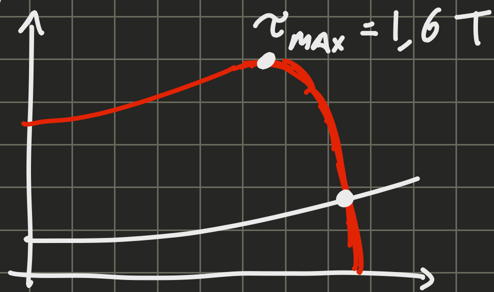
$d/L \rightarrow .13$, it's close to $.1$ but we just treat it as slender.

Press-fit $\Rightarrow$ we heat up gear / or cool down shaft, place and return to room temp.

Phase 3) Check

Static

3 phase electric motor:



The problem with is that we cannot use the regime condition since to get to it we have to go through τ_{max}, meaning that we have to check with that.

$\sigma_{vm}^{*} = \sqrt{405^2 + 3 \cdot 193^2} \rightarrow \eta = 1{,}4$ Good (for now, we will see if the rest are okay)

If it weren't good, we would have to affect immediate change. As we have said we have to change material and/or chang geometry.

Fatigue

$$\sigma_{FA} = \sigma_{FAf} = 0{,}5\, R_m = 465\, MPa$$

$$\sigma_{lim} = \sigma'_{FAf} = \frac{0{,}95 \cdot 0{,}7}{1{,}54} \cdot 465 = 200{,}5\, MPa$$

$$\tau_{lim} = \tau_{sn} = \frac{R_{sn}}{\sqrt{3}} = 424\, MPa$$

$H = 0{,}47$ $\rightarrow \eta_F = 0{,}76$ Not good, we cannot change material, we only change the shape (size), we set the d to 19 rather than 15 and the largest radius will now be 23.mm.

We now have to redo the calculations for both.

Deformation check

↳ we can use the covers to find the deflection and rotation.

↳ if we have a shaft with multiple diameters we use a weighted mean, using the length for which the exist as the weight.

We do a deflection and rotation check and we find that none pass the checks, so we have to add even more material to $d = 24$ and a maximum a 6 28 (we continue to neglect shear)

Final drawing that satisfies all the checks.

We look at the lowest safety factor and see if we are happy with that.