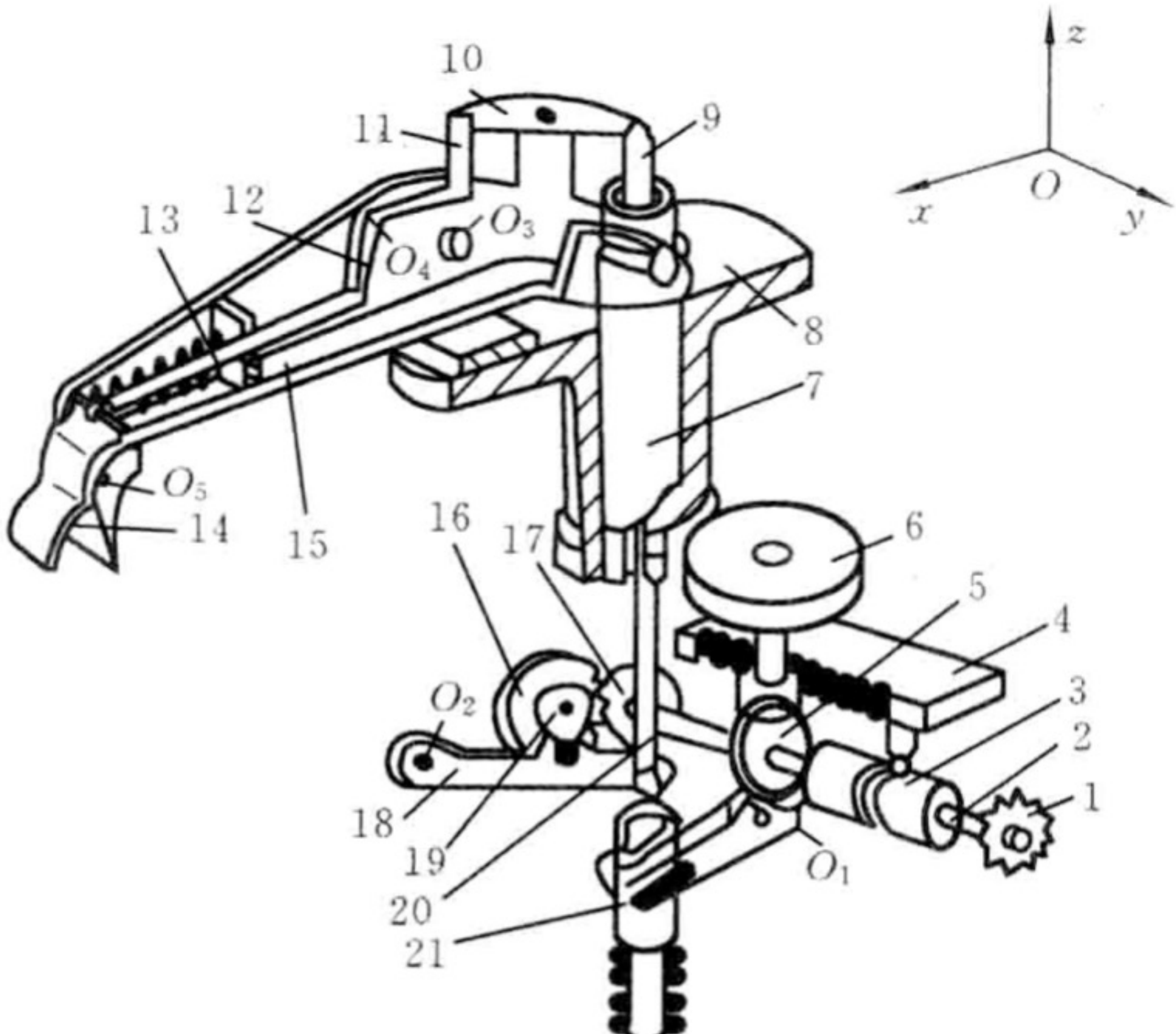
HW01
第01章 机械设计总论
作业参考答案

南方科技大学

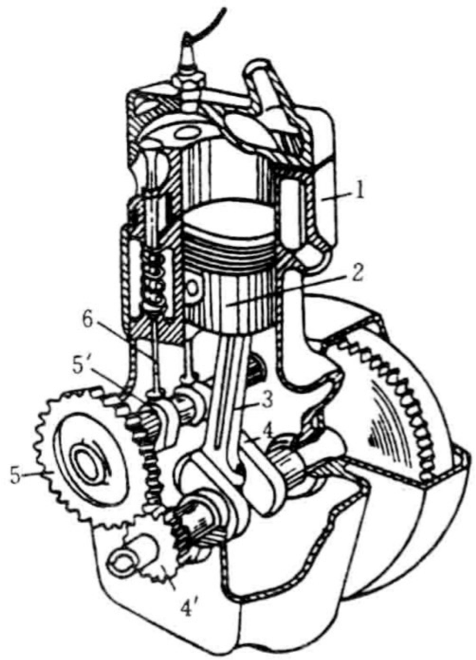
HW 01.1

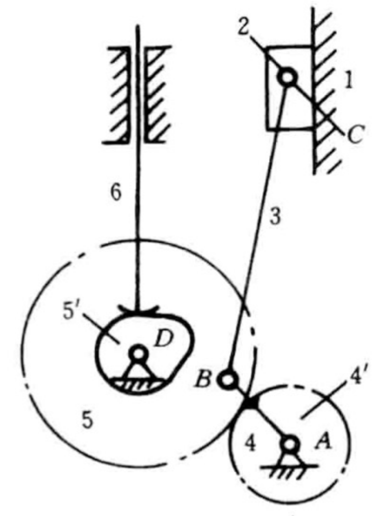
言之有理即可



HW 01.2

1. **曲柄滑块机构**（1，2，3和4）活塞、连杆、曲轴和汽缸体组成，可将活塞的往复运动变为曲柄的连续转动。
2. **凸轮机构**（1，5’和6） 凸轮、顶杆和汽缸体组成，将凸轮轴的连续转动变为顶杆有规律的间歇移动。
3. **齿轮机构**（1，4 ’和5） 曲轴和凸轮轴上的齿轮与汽缸体组成，使两轴保持一定的速比。



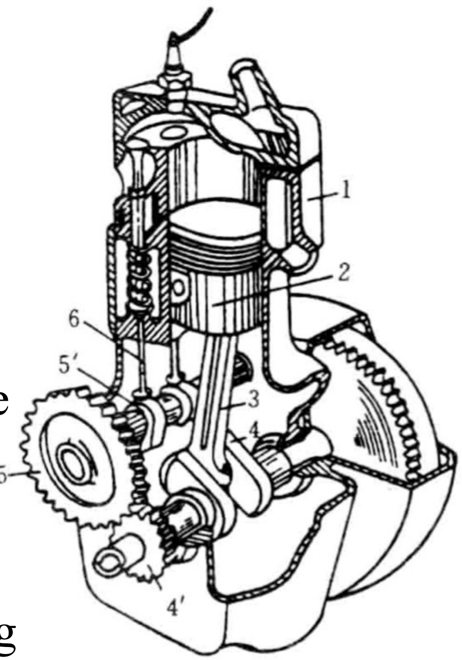


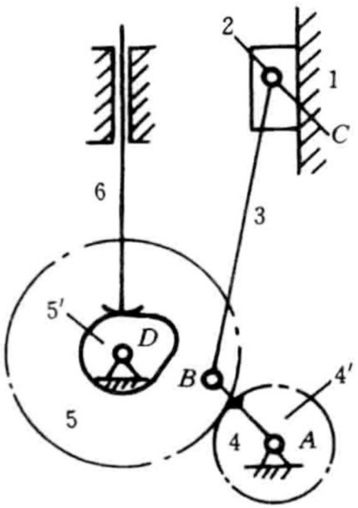
HW 01.2

1. **Slider crank mechanism**（1， 2， 3， 4）Consisting of a piston, links, crankshaft, and cylinder block, and can transform the reciprocating motion of the piston into continuous rotation of the crankshaft.

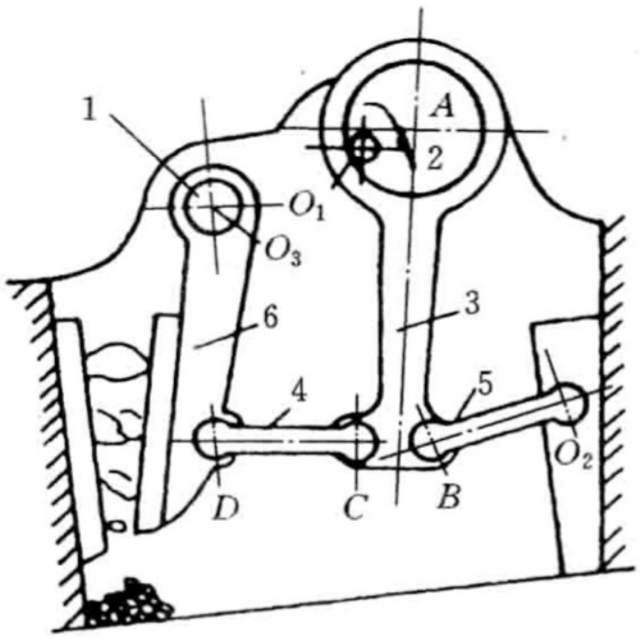
2. **Cam mechanism**（1， 5’, 6）The cam, tappet, and cylinder block are composed to transform the continuous rotation of the camshaft into regular intermittent movement of the tappet

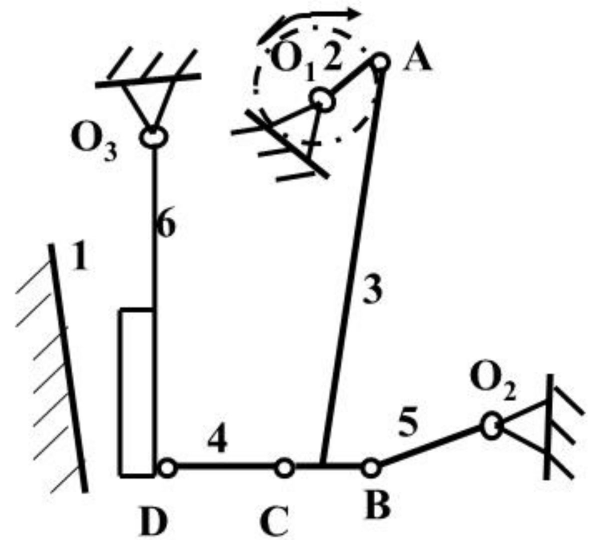
3. **Gear mechanism**（1， 5, 4’） Consisting of the cylinder block and gears on the crankshaft and camshaft, maintaining a certain speed ratio between the two shafts.





HW 01.3

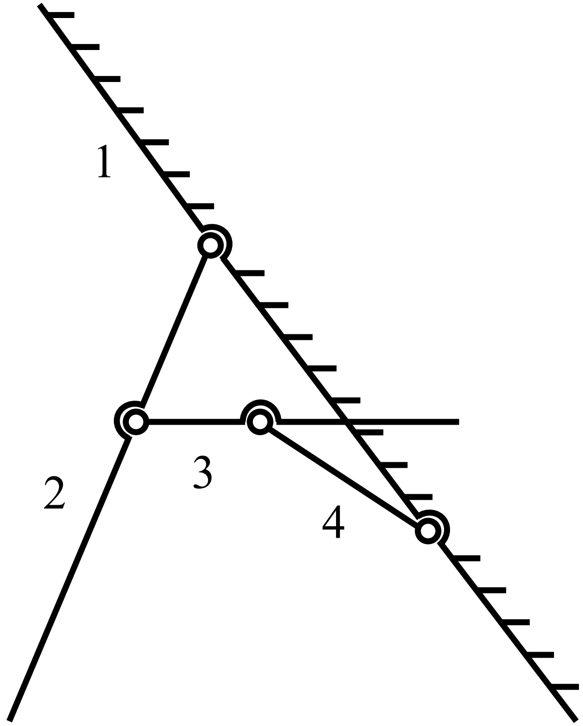




$n = 5 \qquad P_L = 7 \qquad P_H = 0$

$$F = 3n - (2P_L + P_H) = 3\times5 - (2\times7 + 0) = 1$$

HW 01.3



$n = 3 \qquad P_L = 4 \qquad P_H = 0$

$$F = 3n - (2P_L + P_H) = 3\times3 - (2\times4 + 0) = 1$$

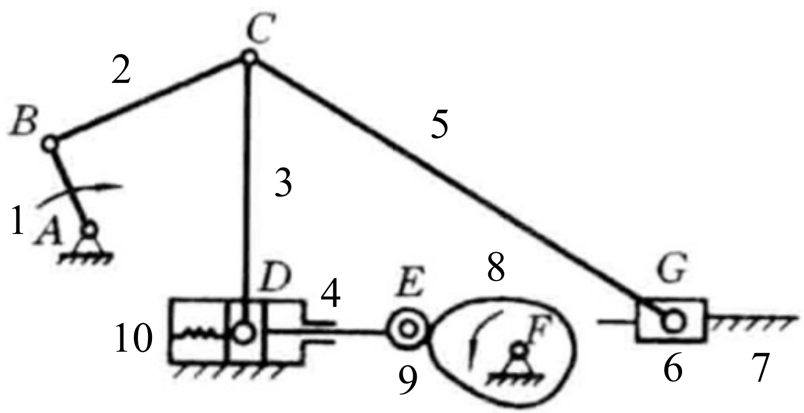
HW 01.4

$F = 3n - (2P_L + P_H)$

C处为复合铰链 (composite hinges)

滚子9有局部自由度 (local DoF)

4，9组成导路平行的移动副，存在虚约束(virtual constraint)



$n = 7$

$P_L = 9$

$P_H = 1$

$F = 3\times7 - (2\times9 + 1) = 2$

HW 01.4

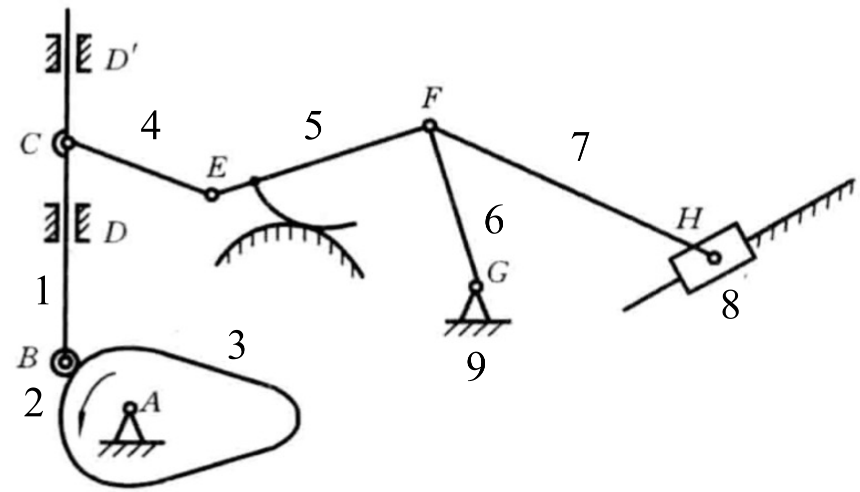
$F = 3n - (2P_L + P_H)$

F为复合铰链 (composite hinge)

滚子2有局部自由度 (local DoF)

1，9在D和D’处有导路平行的移动副，

存在虚约束 (virtual constraints)



$n = 7$

$P_L = 9$

$P_H = 2$

$F = 3×7 - (2×9 + 2) = 1$

HW 01.5

（1）已知最大应力$\sigma_{max} = 200\text{MPa}$，最小应力$\sigma_{min} = -50\text{MPa}$，则应力幅

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2} = \frac{200 - (-50)}{2} = 125\text{MPa},$$

平均应力

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2} = \frac{200 + (-50)}{2} = 75\text{MPa},$$

循环特征

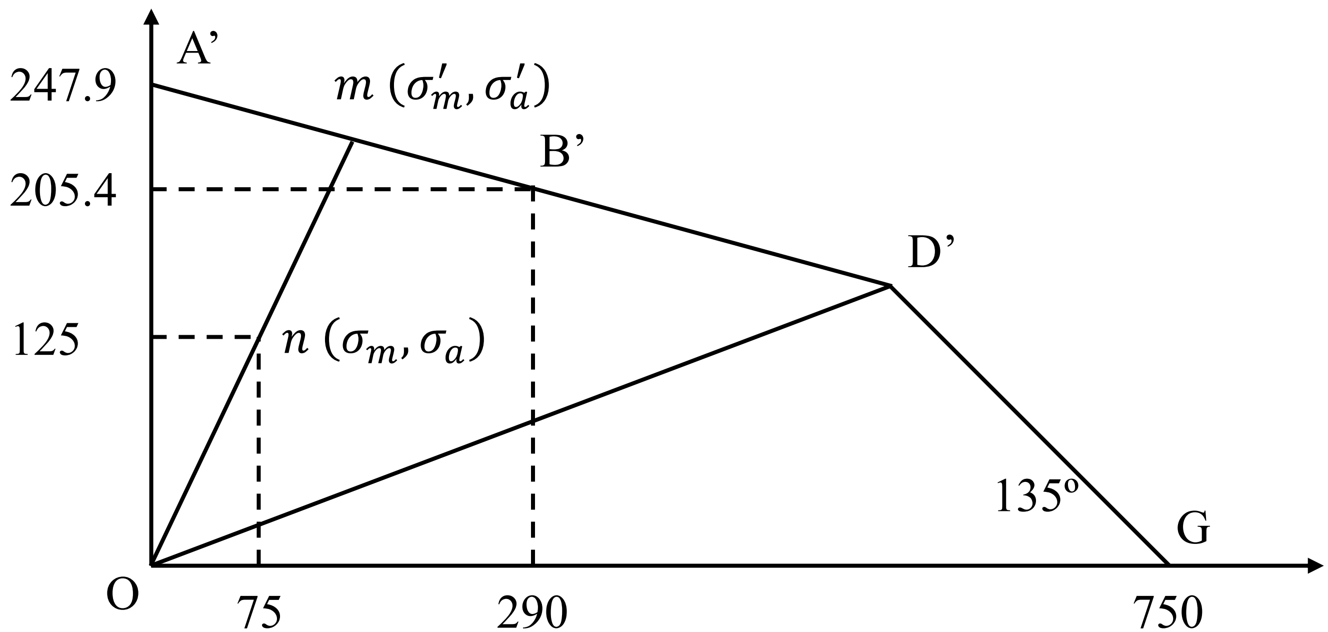
$$r = \frac{\sigma_{min}}{\sigma_{max}} = \frac{-50}{200} = -0.25$$

已知应力集中系数$k_\sigma = 1.2$，尺寸系数$\varepsilon_\sigma = 0.85$，表明状态系数$\beta = 1$，则综合影响系数

$$(K_\sigma)_D = \frac{k_\sigma}{\varepsilon_\sigma \beta} = \frac{1.2}{0.85 \times 1} = 1.4118$$

由此可绘制极限应力图。

HW 01.5



此外，还可通过计算得知工作应力点位置。已知$\sigma_0 = 580\text{MPa}$，$\sigma_{-1} = 350\text{MPa}$，则等效系数

$$\psi_\sigma = \frac{2\sigma_{-1} - \sigma_0}{\sigma_0} = \frac{2\times 350 - 580}{580} = 0.2069$$

HW 01.5

又知$\sigma_s = 750\text{MPa}$，则有

$$\frac{[(K_\sigma)_D + \psi_\sigma]\sigma_s - 2\sigma_{-1}}{[(K_\sigma)_D - \psi_\sigma]\sigma_s} = \frac{[1.4118 + 0.2069]\times 750 - 2\times 350}{[1.4118 - 0.2069]\times 750} = 0.5688 > r,$$

故工作应力点在OA’D’区域内。

（2）由（1）中图可知极限应力

$$\sigma_r = \frac{\sigma_{-1}(\sigma_a + \sigma_m)}{(K_\sigma)_D\sigma_a + \psi_\sigma\sigma_m} = \frac{350\times(125 + 75)}{1.4118\times 125 + 0.2069\times 75} = 364.6\text{MPa}$$

（3）根据式（2-1），已知极限应力$\sigma_r = 364.6\text{MPa}$，许用安全系数$[S] = 1.5$，则许用应力

$$[\sigma] = \frac{\sigma_r}{[S]} = \frac{364.6}{1.5} = 243.1\text{MPa},$$

又知最大应力$\sigma_{max} = 200\text{MPa}$，则

$$\sigma_{max} < [\sigma],$$

故此零件安全。

HW 01.5

根据式（2-11），已知$(K_\sigma)_D = 1.4118$，$\psi_\sigma = 0.2069$，$\sigma_{-1} = 350\text{MPa}$，$\sigma_a = 125\text{MPa}$，$\sigma_m = 75\text{MPa}$，则计算安全系数

$$S_\sigma = \frac{\sigma_{-1}}{(K_\sigma)_D\sigma_a + \psi_\sigma\sigma_m} = \frac{350}{1.4118\times125 + 0.2069\times75} = 1.82$$

又知许用安全系数$[S] = 1.5$，则

$$S_\sigma > [S],$$

故此零件安全。

HW 01.5

（1）The amplitude component:

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2} = \frac{200 - (-50)}{2} = 125\text{MPa},$$

and the midrange component:

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2} = \frac{200 + (-50)}{2} = 75\text{MPa},$$

The stress ratio:

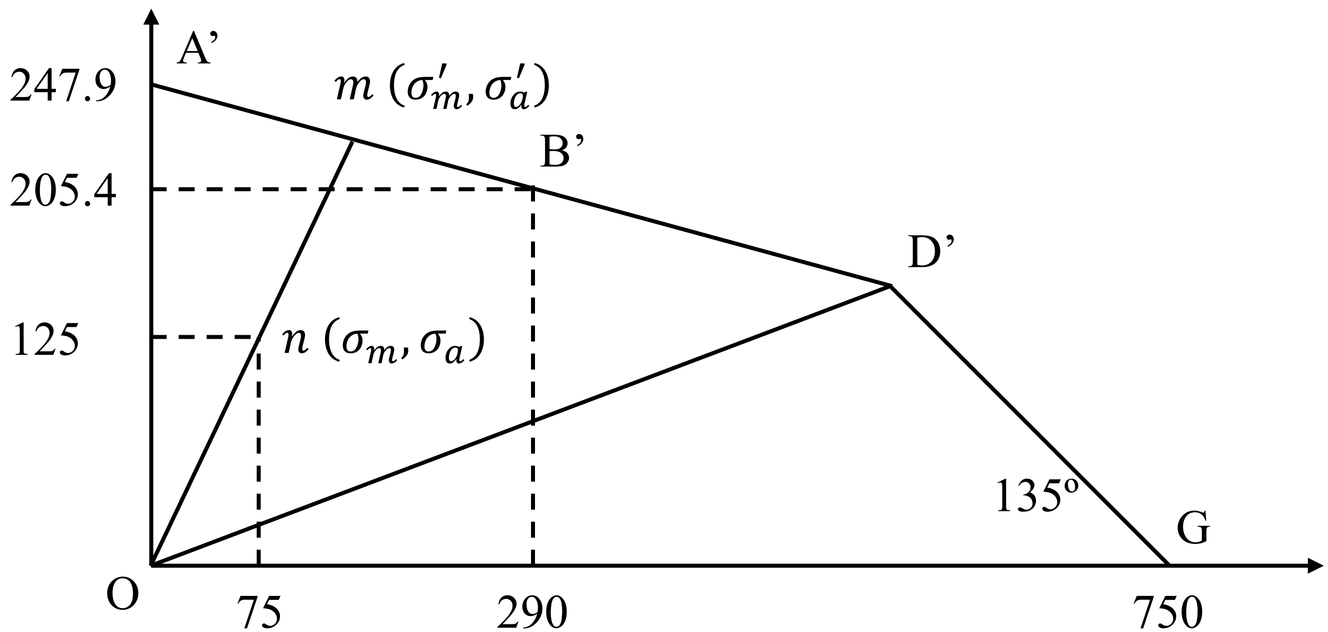
$$r = \frac{\sigma_{min}}{\sigma_{max}} = \frac{-50}{200} = -0.25$$

The fatigue stress-concentration factor: (应力集中系数)

$$(K_\sigma)_D = \frac{k_\sigma}{\varepsilon_\sigma \beta} = \frac{1.2}{0.85\times 1} = 1.4118$$

Then the fatigue diagram can be drawn.

HW 01.5



Then analyze the position of the working stress state point. Since $\sigma_0 = 580\text{MPa}$, $\sigma_{-1} = 350\text{MPa}$, then

$$\psi_\sigma = \frac{2\sigma_{-1} - \sigma_0}{\sigma_0} = \frac{2\times 350 - 580}{580} = 0.2069$$

HW 01.5

Since $\sigma_s = 750\text{MPa}$,

$$\frac{[(K_\sigma)_D + \psi_\sigma]\sigma_s - 2\sigma_{-1}}{[(K_\sigma)_D - \psi_\sigma]\sigma_s} = \frac{[1.4118 + 0.2069]\times 750 - 2\times 350}{[1.4118 - 0.2069]\times 750} = 0.5688 > r,$$

Therefore, the working stress state point should be within the OA’D’ area.

（2）According to the fatigue diagram obtained in (1), the fatigue limit

$$\sigma_r = \frac{\sigma_{-1}(\sigma_a + \sigma_m)}{(K_\sigma)_D\sigma_a + \psi_\sigma\sigma_m} = \frac{350\times(125 + 75)}{1.4118\times 125 + 0.2069\times 75} = 364.6\text{MPa}$$

（3）According to Eq.2-1, since $\sigma_r = 364.6\text{MPa}$, the factor of safety $[S] = 1.5$, then the allowable stress

$$[\sigma] = \frac{\sigma_r}{[S]} = \frac{364.6}{1.5} = 243.1\text{MPa},$$

$\sigma_{max} = 200\text{MPa}$, then

$$\sigma_{max} < [\sigma],$$

Therefore this part is safe.

HW 01.5

According to Eq. 2-11, since $(K_\sigma)_D = 1.4118$, $\psi_\sigma = 0.2069$, $\sigma_{-1} = 350\text{MPa}$, $\sigma_a = 125\text{MPa}$, $\sigma_m = 75\text{MPa}$, then the safety factor:

$$S_\sigma = \frac{\sigma_{-1}}{(K_\sigma)_D\sigma_a + \psi_\sigma\sigma_m} = \frac{350}{1.4118\times125 + 0.2069\times75} = 1.82$$

The allowable safety factor $[S] = 1.5$,

$$S_\sigma > [S],$$

Therefore, this design is safe.