Selim Hocaoğlu

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ection 02

AE361 - HW#2

1) Known: Cross-sectional area, thickness and internal pressure of the vessel, loading, welding angle.

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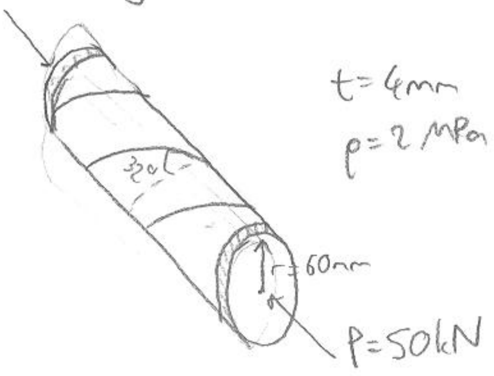
Find: a) Normal stress perpendicular to the weld.

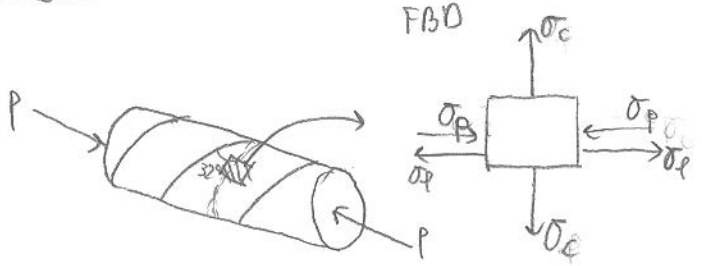
b) Shearing stress parallel to the weld.

Schematic:



Assumptions: Neglect weight
Radius also covers the thickness of the vessel.

Analysis: Pick a small element on the side of the pressure vessel.



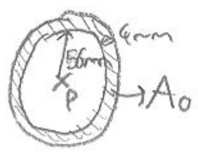
σ_c = circumferential stress due to internal pressure

σ_p = longitudinal stress due to internal pressure

σ_p = compressive stress due to axial loading

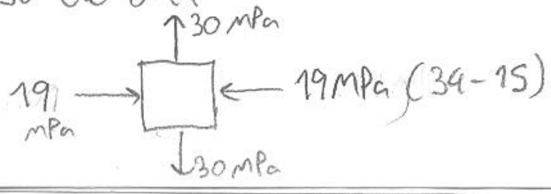
$$\sigma_c = \frac{pr}{t} = \frac{\cancel{2}\times10^6 \times \cancel{60}\times\cancel{10^{-3}}}{\cancel{4}\times\cancel{10^{-3}}} = 30 \text{ MPa}$$

$$\sigma_p = \frac{pr}{2t} = \frac{\cancel{2}\times10^6 \times \cancel{60}\times\cancel{10^{-3}}}{\cancel{2}\times\cancel{4}\times\cancel{10^{-3}}} = 15 \text{ MPa}$$



$$\sigma_p = -\frac{P}{A_0} = -\frac{50\times10^3}{\pi\left((60\times10^{-3})^2-(56\times10^{-3})^2\right)} = 34 \text{ MPa}$$

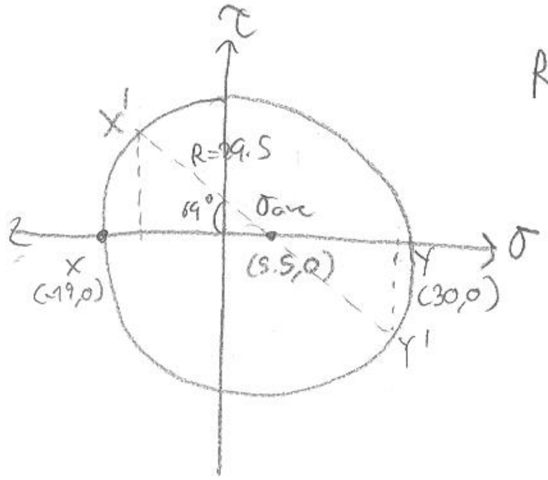
- So the differential element becomes,



- Then for Mohr's Circle,

X(-19,0)

Y(30,0)



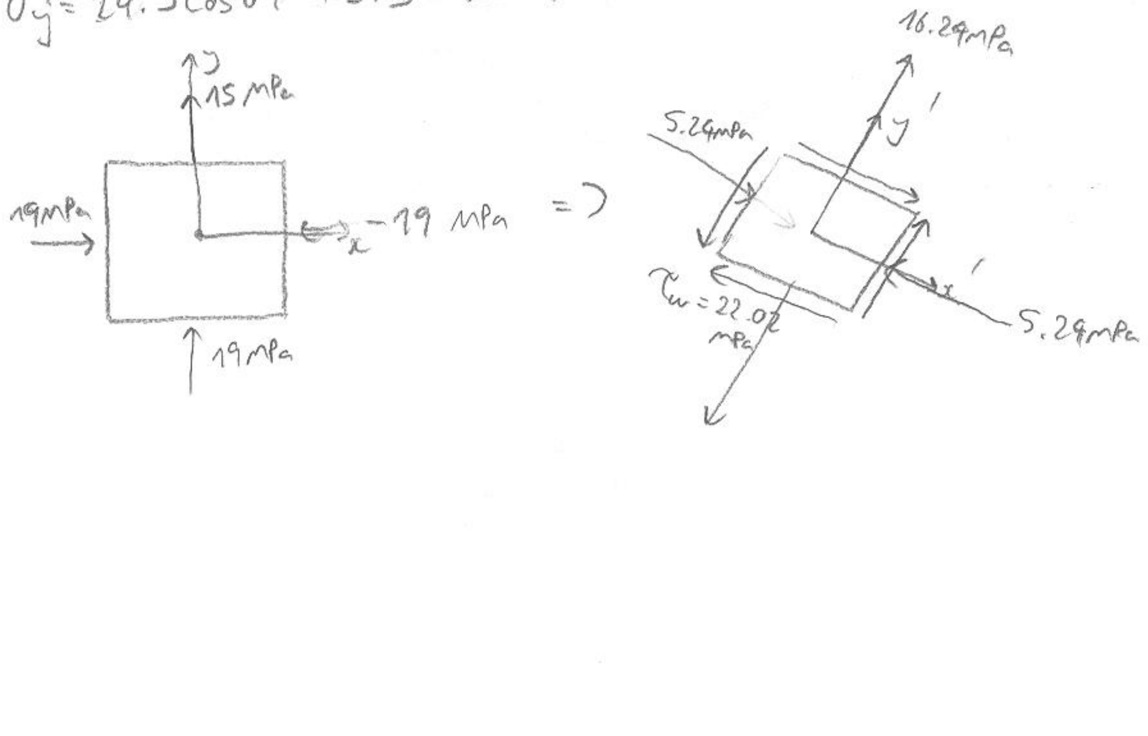
$$R = \frac{30-(-19)}{2} = 24.5$$

- To find the normal and shearing stresses at the weld location, we have to rotate our element by 32°, which is 64° in Mohr's Circle.

$\tau_{weld} = 24.5 \sin(64°) = 22.02$ MPa (cw in x-axis)

$\sigma_{x'} = -24.5 (\cos 64° - (-5.5)) = -5.24$ MPa

$\sigma_{y'} = 24.5 \cos 64° + 5.5 = 16.24$ MPa



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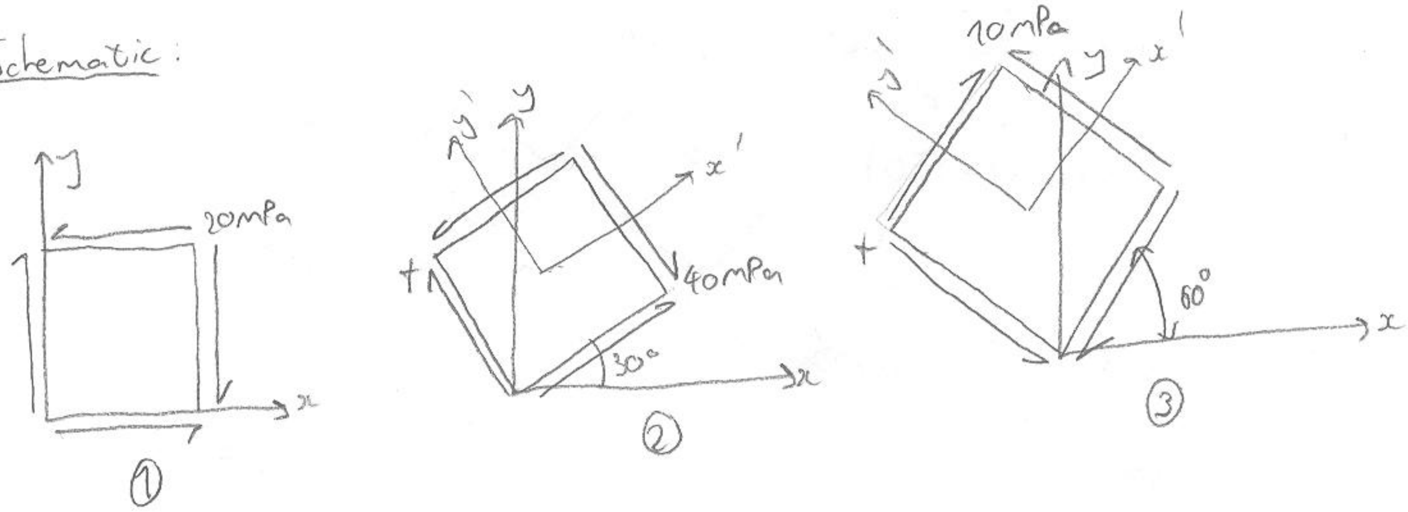
2) <u>Known</u>: The orientations and loadings of stress conditions at a point under different conditions.

<u>Find</u>: The principal stresses and their orientations at the point under combined loading.

<u>Schematic</u>:



<u>Analysis</u>:

(1) will remain the same

(2) will be rotated 30° clockwise, so it will be at x-y coordinates.

(3) will be rotated 60° clockwise, " " " " " "

For (2),

$$\sigma_x = \frac{\sigma_{x'} + \sigma_{y'}}{2} + \frac{\sigma_{x'} - \sigma_{y'}}{2} \cos 2\theta + \tau_{x'y'} \sin 2\theta$$

$$= 0 + 0 + 40 \times \sin(-60°)$$

$$= +34.64 \text{ MPa}$$

$$\tau_{xy} = \frac{\sigma_y - \sigma_x}{2} \sin 2\theta + \tau_{x'y'} \cos 2\theta$$

$$= 0 - 40 \times \cos(-60°)$$

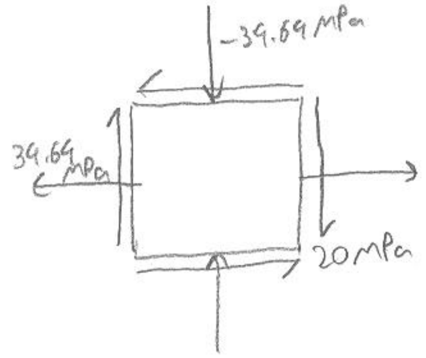
$$= -20 \text{ MPa}$$

$$\sigma_y = \frac{\sigma_{x'} + \sigma_{y'}}{2} + \frac{\sigma_{y'} - \sigma_{x'}}{2} \cos 2\theta - \tau_{x'y'} \sin 2\theta$$

$$= 0 + 0 + 40 \times \sin(-60°)$$

$$= -34.64 \text{ MPa}$$

- So ② is,



- For ③,

$$\sigma_x = \frac{\sigma_x' + \sigma_y'}{2} + \frac{\sigma_x' - \sigma_y'}{2}\cos 2\theta + \tau_{x'y'}\sin 2\theta$$

$= 0 + 0 + 10 \times \sin(-120^\circ)$

$= -8.66$ MPa

$$\sigma_y = \frac{\sigma_x' + \sigma_y'}{2} + \frac{\sigma_y' - \sigma_x'}{2}\cos 2\theta - \tau_{x'y'}\sin 2\theta$$

$= 0 + 0 + 10 \times \sin(-120^\circ)$

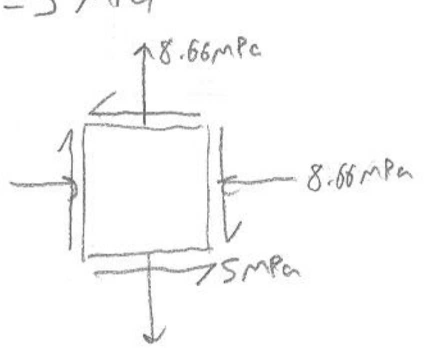
$= 8.66$ MPa

$$\tau_{xy} = \frac{\sigma_y' - \sigma_x'}{2}\sin 2\theta + \tau_{x'y'}\cos 2\theta$$

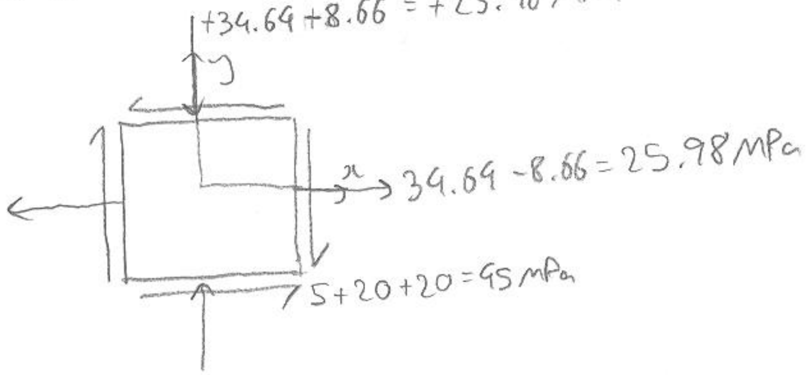
$= 0 + 10 \times \cos(-120)$

$= -5$ MPa

So ③ is,



- If we combine the three,

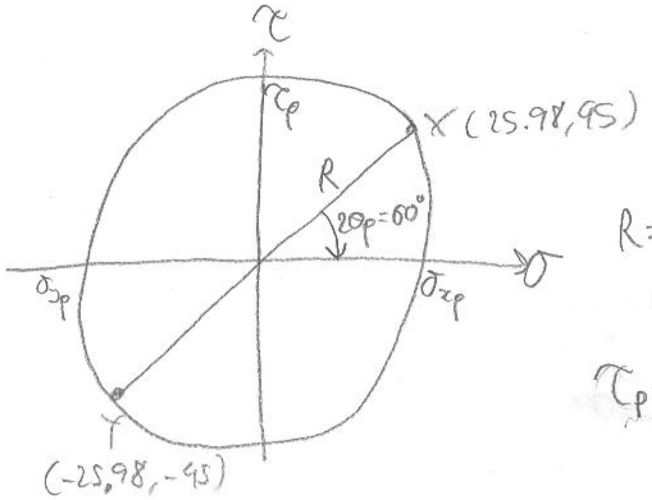


- For Mohr's Circle,

$X(25.98, 45)$

$Y(-25.98, -45)$

$$\sigma_{ave} = \frac{25.98 - 25.98}{2} = 0$$



$$\tan 2\theta_p = \frac{45}{25.98}$$

$\theta_p = 30^\circ$

$R = \sqrt{25.98^2 + 45^2}$

$= 51.96$

$\tau_p = \sigma_{x_p} = -\sigma_{y_p} = 51.96$ MPa

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