Mašinski Fakultet Univerziteta u Beogradu

Mašinski elementi II

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Geometrija i kinematika zupčanih parova sa pravim zupcima

deo 2.

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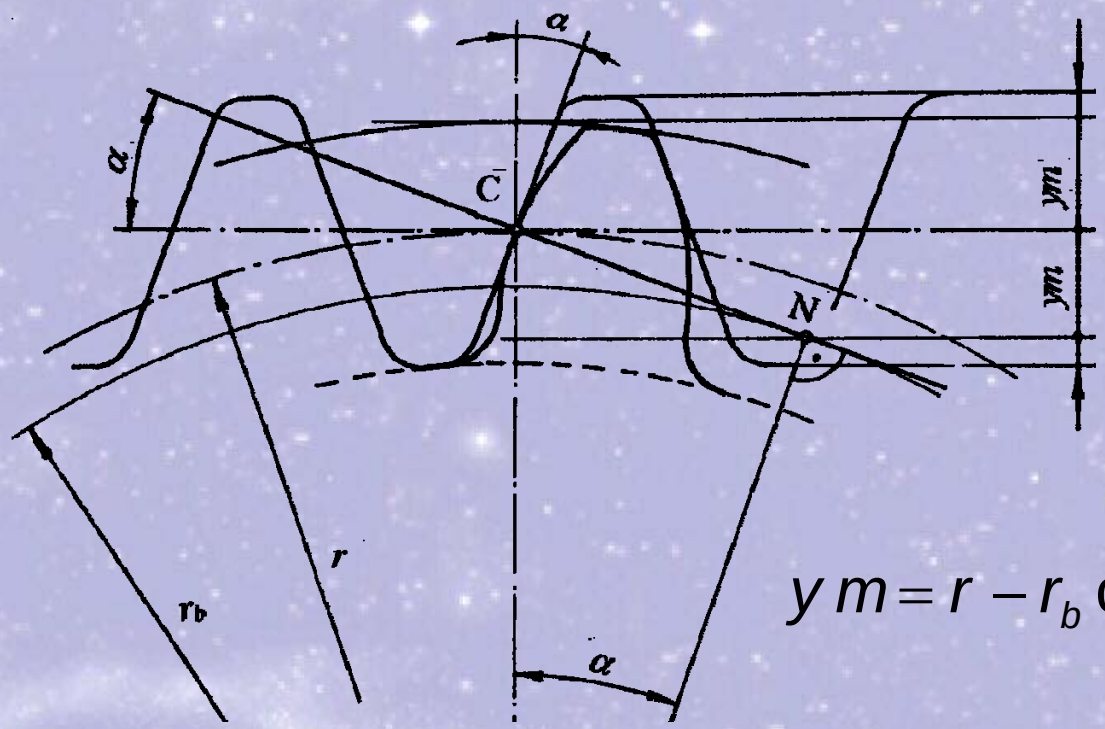
Granični broj zubaca



$$r_b = r\cos\alpha$$

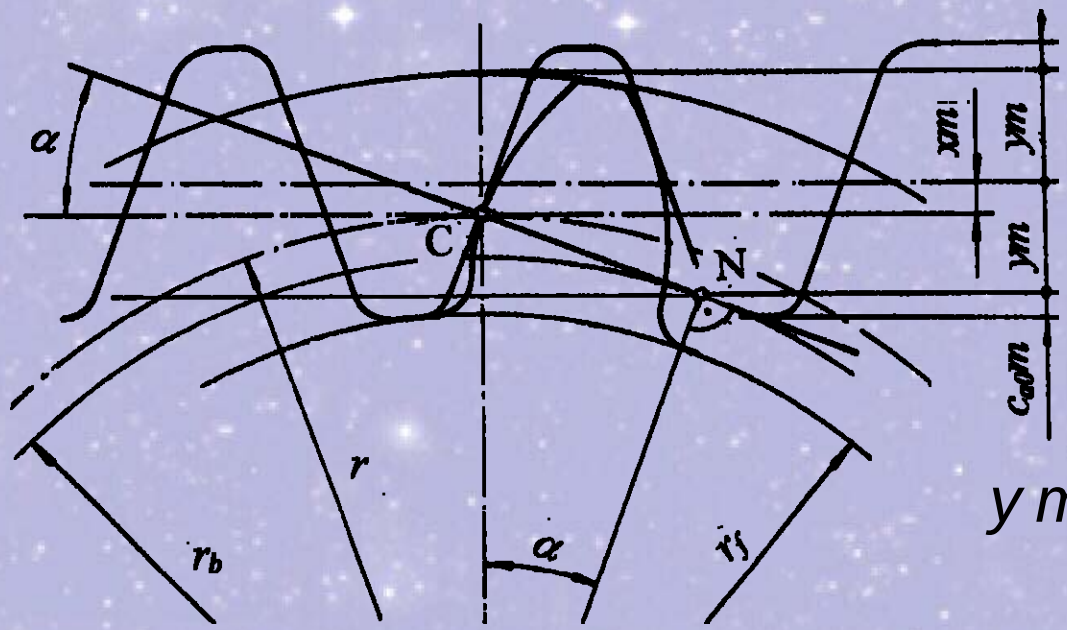
$$y\,m = r - r_b\cos\alpha = \frac{mz}{2} - \frac{mz}{2}\cos^2\alpha$$

Za koeficijent visine zupca y=1, sledi:

$$m = \frac{mz}{2}\left(1-\cos^2\alpha\right)$$

Granični broj zubaca $z_g = \dfrac{2y}{\sin^2\alpha} = \dfrac{2}{\sin^2\alpha} = 17{,}1$ za $\alpha = \alpha_n = 20^o$

Koeficijent pomeranja profila



Pomeranje profila
x·m

$$y\,m = r - r_b \cos\alpha + x_{\min} m$$

$$x_{\min}\, m = y\,m - \left(r - r_b \cos\alpha\right) = y\,m - \left(\frac{mz}{2} - \frac{mz}{2}\cos^2\alpha\right)$$

Minimalni koeficijent pomeranja profila

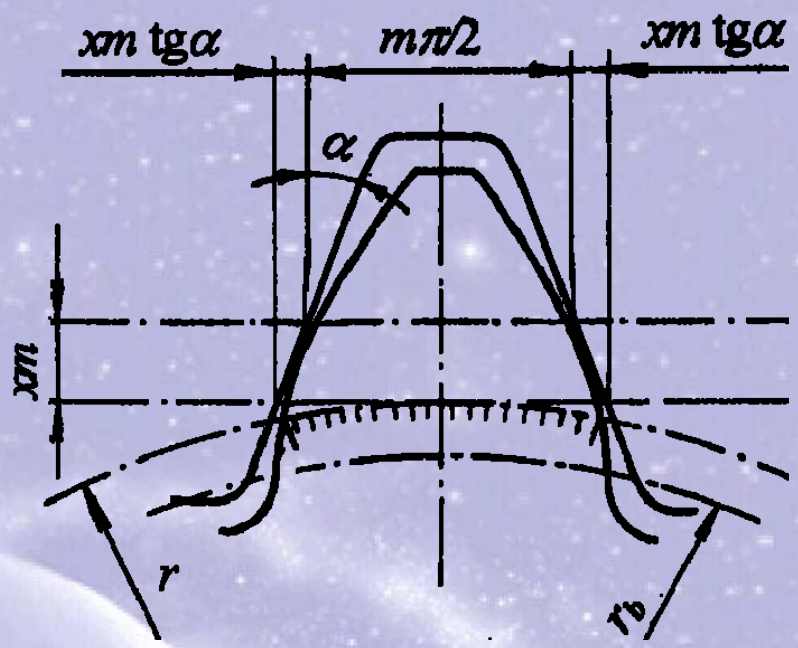
$$x_{\min} = y - \frac{z}{2}\sin^2\alpha$$

za z=17,1 $x_{\min} = 0$

za z<17,1 $x_{\min} > 0$

Mere profila zupca

Lučna debljina zupca



Lučna debljina zupca na podeonoj kružnici:

$$s = m\left(\frac{\pi}{2} + 2x\,\mathrm{tg}\,\alpha\right)$$

bez pomeranja profila, xm=0

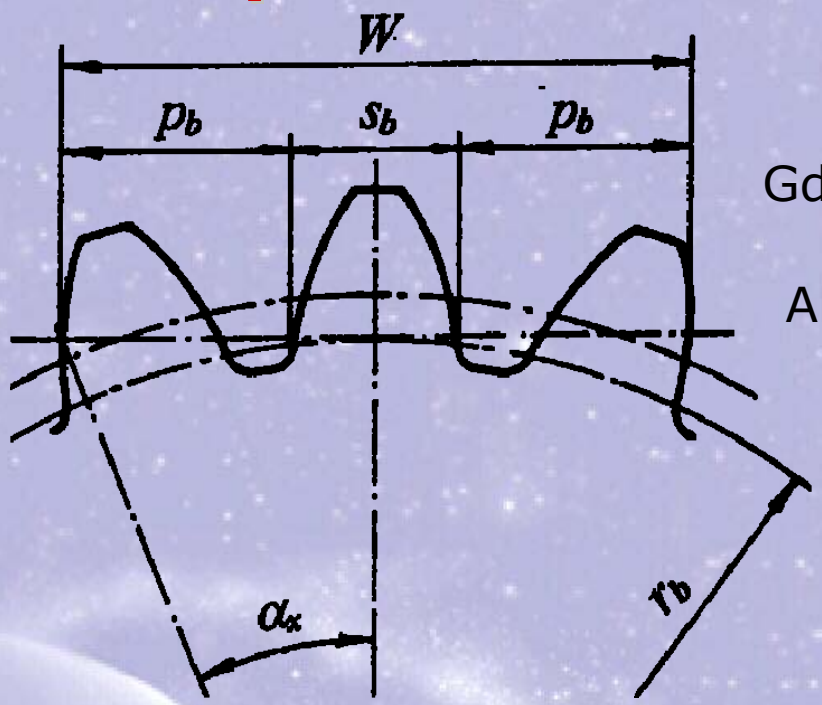
$$s = m\frac{\pi}{2} = \frac{p}{2}$$

Lučna debljina zupca na bilo kojoj kružnici:

$$s_y = d_y\left(\frac{s}{d} + \mathrm{inv}\,\alpha - \mathrm{inv}\,\alpha_y\right)$$

Mere profila zupca

Mera preko zubaca



$$W = (z_w - 1)p_b + s_b$$

Gde je z_w merni broj zubaca (na slici z_w=3)

Ako se zameni:

$$p_b = p\cos\alpha = m\pi\cos\alpha$$

$$s_b = d_b\left(\frac{s}{d} + \mathrm{inv}\,\alpha\right)$$ gde su:

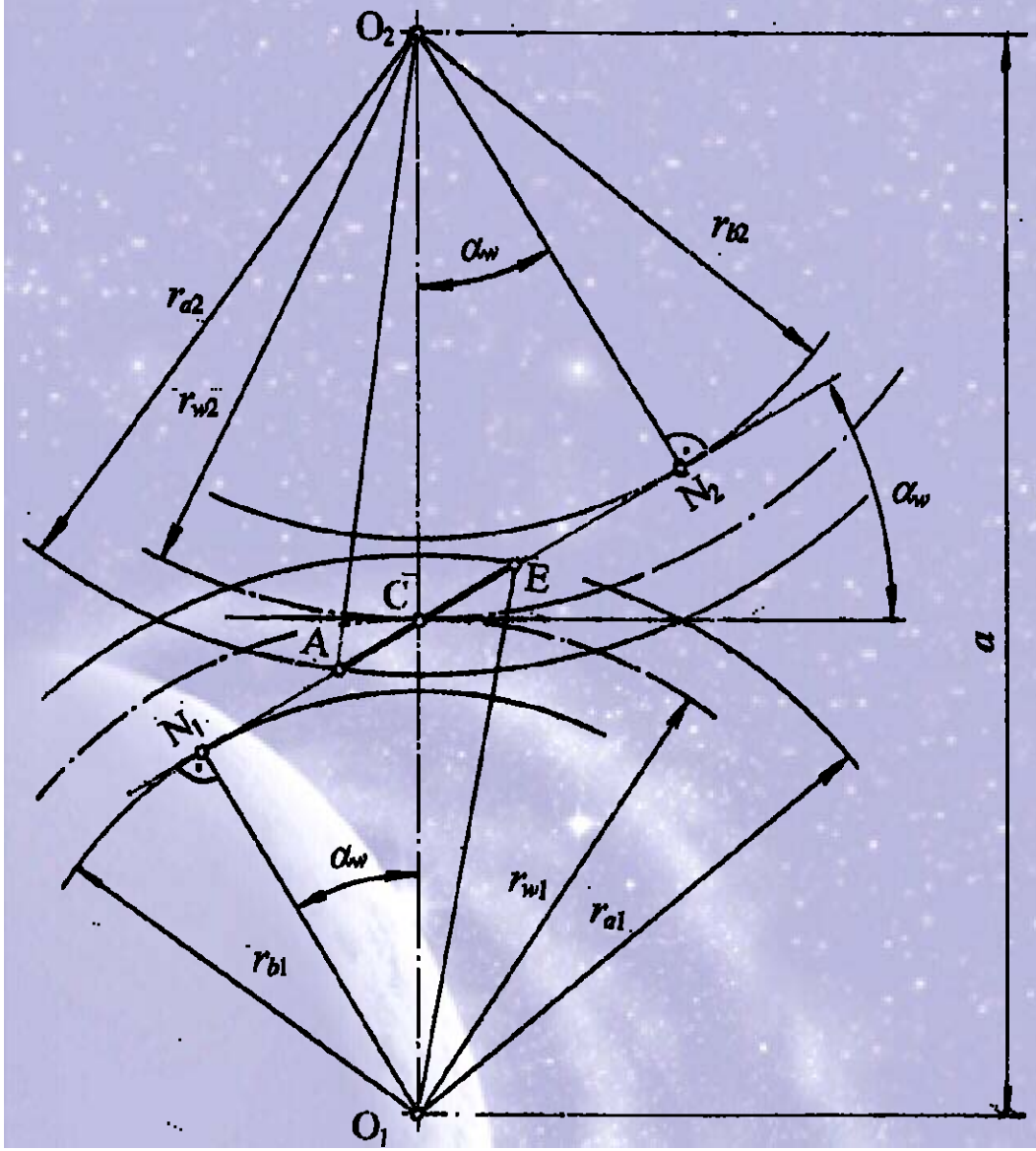
$$d = m\,z \qquad s = m\left(\frac{\pi}{2} + 2x\,\mathrm{tg}\,\alpha\right)$$

dobija se: $$W = m\cos\alpha\left[\pi(z_w - 0{,}5) + z\,inv\alpha + 2x\,tg\alpha\right]$$

bez pomeranja profila, xm=0 $$z_w = \frac{\alpha}{\pi} + 0{,}5$$ gde je α / rad

Sprezanje pravozubih zupčanika

$O_1O_2 = a$ - međuosno rastojanje



$$N_1N_2 = N_1C + CN_2 =$$
$$= r_{w1}\sin\alpha_w + r_{w2}\sin\alpha_w =$$
$$= \left(r_{w1} + r_{w2}\right)\sin\alpha_w$$

odakle sledi:

$$N_1N_2 = a\sin\alpha_w$$

gde su:

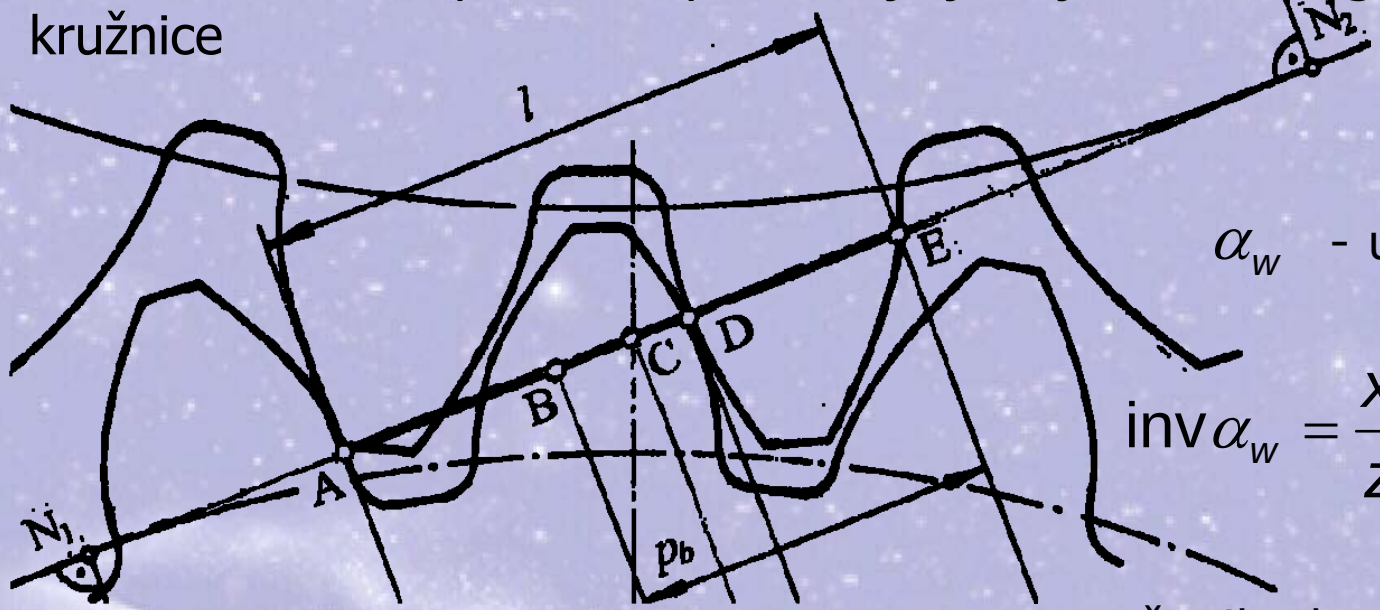
r_{w1} i r_{w2} - poluprečnici kinematskih kružnica

α_w - ugao dodirnice

Dodirnica

Dodirnica - geometrijsko mesto tačakadodira u nepokretnoj ravni

Kod cilindričnih zupčanika - prava koja je zajednička tangenta na osnovne kružnice



α_w - ugao dodirnice

$$\mathrm{inv}\,\alpha_w = \frac{x_1 + x_2}{z_1 + z_2} 2\mathrm{tg}\,\alpha + \mathrm{inv}\,\alpha$$

za zupčanike bez pomeranja profila

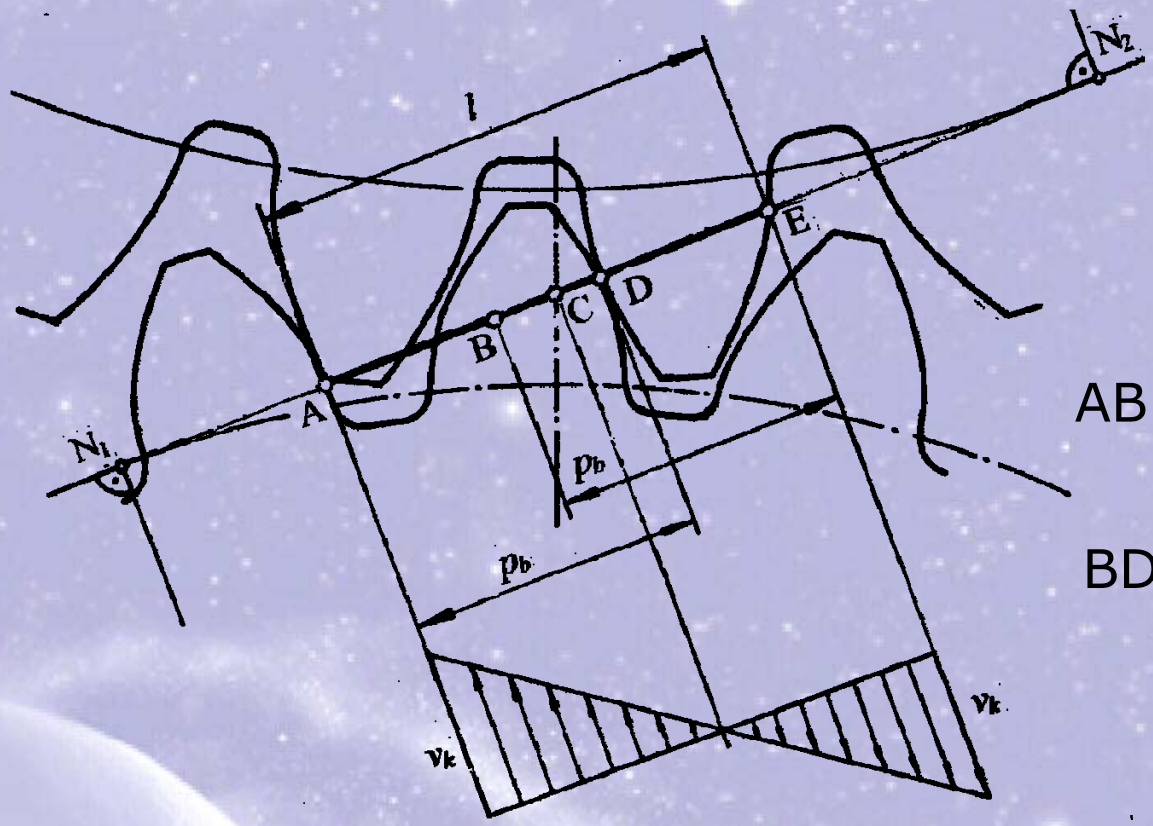
$$\alpha_w = \alpha$$

Aktivna dužina dodirnice:

$$AE = \ell = \sqrt{r_{a1}^2 - r_{b1}^2} + \sqrt{r_{a2}^2 - r_{b2}^2} - a \sin\alpha_w$$

jer je: $r_{w1} + r_{w2} = a$

Stepen sprezanja profila



AB i DE – dvoparna sprega

BD – jednoparna sprega

$$\varepsilon_\alpha = \frac{\ell}{p_b} = \frac{\ell}{m\pi\cos\alpha} = \frac{g_\alpha}{p} = 1...2$$

Dimenzije zupčanog para

Međuosno rastojanje

$$a = r_{w1} + r_{w2} = \frac{r_{b1}}{\cos\alpha_w} + \frac{r_{b2}}{\cos\alpha_w} = (r_1 + r_2)\frac{\cos\alpha}{\cos\alpha_w}$$

$$a = m\frac{z_1 + z_2}{2}\frac{\cos\alpha}{\cos\alpha_w}$$

Prečnici kinematskih kružnica

$$u = \frac{r_{w2}}{r_{w1}} = \frac{r_{b2}/\cos\alpha_w}{r_{b1}/\cos\alpha_w} = \frac{r_2\cos\alpha}{r_1\cos\alpha} = \frac{r_2}{r_1} = \frac{z_2}{z_1}$$

$$r_{w1} = \frac{a}{u+1}$$

za zupčanike bez pomeranja profila $\alpha_w = \alpha$

$$d_{w1} = d_1 = m\,z_1$$

$$r_{w2} = u r_{w1}$$

$$d_{w2} = d_2 = m\,z_2$$

Dimenzije zupčanog para

Prečnici temenih kružnica

$$r_{a1} + cm + r_{f2} = a$$

$$r_{a1} = a - r_{f2} - cm$$

$$r_{a2} = a - r_{f1} - cm$$

cm - temeni zazor

Prečnici podnožnih kružnica

$$r_f = r - m\left(1 + c_{a0} - x\right)$$

gde je C_{ao}=0,25

$$r_{f1} = r_1 - m\left(1{,}25 - x_1\right)$$

$$r_{f2} = r_2 - m\left(1{,}25 - x_2\right)$$