Karakteristike progresivnih baruta

To su baruti kod kojih se pri sagorevanju povećava površina sagorevanja. Najpoznatiji oblik je cilindrično sedmokanalno zrno (1 centralni kanal i 6 kanala u temenima pravilnog šestougla).

U praksi je usvojen sledeći odnos dimenzija:

$$d = e_0$$

$$D = 3d + 4 \cdot 2e_0 = 11d = 11e_0$$

$$L = 2c = (2.0 \div 2.5) D_0$$

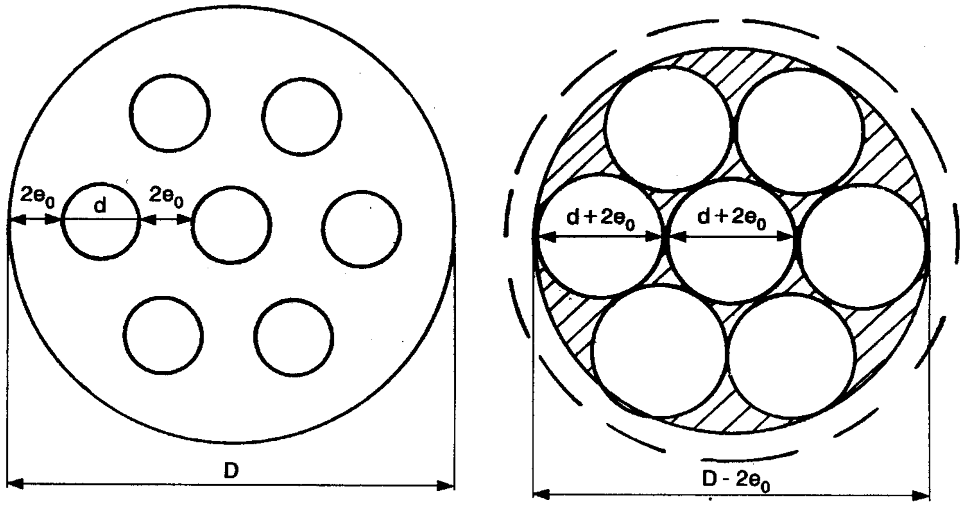
Pri sagorevanju dolazi do raspada zrna: kada iznutra i spolja dodje do sagorevanja e_0 , zrno se raspada na 12 "slivera" (6 unutrašnjih i 6 spoljnih)

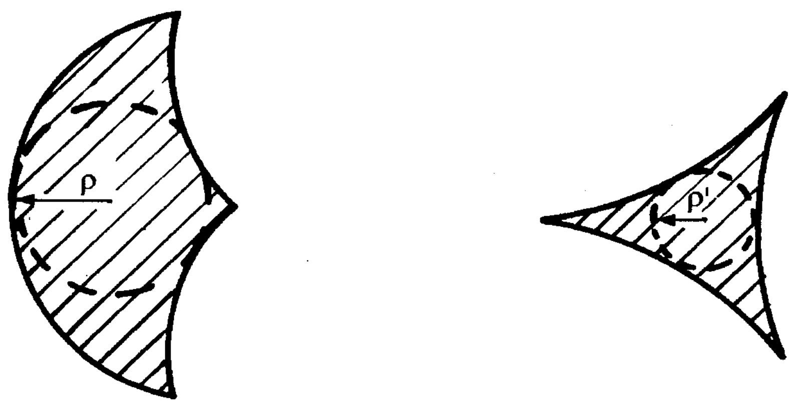
$$\rho = 0.532 e_0$$

$$\rho' \approx 0.23 e_0$$

ρ, ρ' – radijusi kružnica upisanih u "sliver"-ima

Raspad zrna je pri $z_s = 1$, pri čemu je $\sigma_s \approx 1.37$, a $\psi_s \approx 0.85$. Kraj sagorevanja je pri $e_k = e_0 + \rho = 1.532 \cdot e_0$ i $z_k = 1.532$.





Karakteristike κ, λ i μ

Prva faza sagorevanja (do raspada zrna). Karakteristika β je ista: $\beta = 2e_o/2c = 2e_o/L$.
Umesto karakteristike α uvode se dve nove karakteristike:

1. Π_1 - odnos obima poprečnog preseka zrna prema obimu kružnice formirane na dužini 2c, odnosno L kao prečniku:

$$\Pi_1 = \frac{\pi(D+nd)}{\pi \cdot 2c} = \frac{D+nd}{2c} \qquad n \text{ - broj kanala}$$

2. Q_1 - odnos površine poprečnog preseka višekanalnog zrna prema površini kruga prečnika 2c

$$Q_1 = \frac{\frac{\pi}{4}\left(D^2 - nd^2\right)}{\frac{\pi}{4}(2c)^2} = \frac{D^2 - nd^2}{(2c)^2}$$

$$\boxed{\kappa = \frac{2\Pi_1 + Q_1}{Q_1}\beta} \qquad \boxed{\lambda = \frac{n-1-2\Pi_1}{2\Pi_1 + Q_1}\beta} \qquad \boxed{\mu = -\frac{n-1}{2\Pi_1 + Q_1}\beta^2}$$

Za sedmokanalni barut (n=7) je:

$$\kappa = \frac{2\Pi_1 + Q_1}{Q_1}\beta \quad , \quad \lambda = \frac{6-2\Pi_1}{2\Pi_1 + Q_1}\beta \quad , \quad \mu = -\frac{6}{2\Pi_1 + Q_1}\beta^2$$

Koeficijenti κ_1 i λ_1 za dvočlanu formulu odredjuju se prema poznatim vezama:

$\kappa_1 = \kappa(1-\mu/2)$ $\qquad \lambda_1 = 1/\kappa_1 - 1$

Potreban odnos dimenzija barutnog zrna da bi ono od početka sagorevalo progresivno dobija se z uslova: $\lambda > 0$ (treba da bude $\sigma = S/S_o = 1+2\lambda z+3\mu z^2 > 0$, a $\mu < 0$, jer je $\Pi_1 > 0$ i $Q_1 > 0$).

$$\lambda > 0$$
$$6 - 2\Pi_1 > 0 \qquad \Rightarrow \qquad L > 6d \quad \text{tj.} \quad L > 6e_0$$
$$6 - 2\frac{D+7d}{L} > 0$$

Druga faza sagorevanja (posle raspada zrna). Sagorevanje je izrazito degresivno. Pomerimo koordinatni početak u tačku raspada $z = z_s = 1$, $\psi = \psi_s$. Tada imamo:

$$\psi - \psi_s = \kappa_2 (z-1)\left[1 + \lambda_2 (z-1)\right] \qquad 1 < z < z_k \qquad \psi_s < \psi < 1$$

$$\frac{d\psi}{dz} = \kappa_2\left[1 + 2\lambda_2 (z-1)\right]$$

Za odredjivanje κ_2 i λ_2 postavljaju se dva uslova:

1. za $z = z_k$ $\qquad \psi = \psi_k = 1$
2. za $z = z_k$ $\qquad \sigma = 0$ tj. $(d\psi/dz) = 0$ $\qquad \Rightarrow$

$$1-\psi_s=\kappa_2(z_k-1)\left[1+\lambda_2(z_k-1)\right]$$

$$1+2\lambda_2(z_k-1)=0$$

Rešavanjem ove dve jednačine dobijamo:

$$\kappa_2=\frac{2(1-\psi_s)}{z_k-1} \qquad \lambda_2=-\frac{1}{2(z_k-1)}$$

Za standardno sedmokanalno zrno je $z_k = 1.532$ i $\psi_s = 0.85$ $\Rightarrow$

$$\kappa_2=0.564 \qquad \lambda_2=-0.94$$

<u>ZADATAK 3</u>

Odrediti $\psi(z)$ i $\sigma(z)$ za sedmokanalno barutno zrno sledećih dimenzija:
$D = 3.22$ mm, $d = 0.21$ mm, $L = 6.51$ mm (NC barut za BsT 82 mm)

Rešenje:

a) do raspada zrna:

$$\Pi_1=\frac{D+7d}{2c}=\frac{D+7d}{L}=\frac{3.22+7\cdot 0.21}{6.51}=0.72043$$

$$Q_1=\frac{D^2-7d^2}{(2c)^2}=\frac{D^2-7d^2}{L^2}=\frac{3.22^2-7\cdot 0.21^2}{6.51^2}=0.23737$$

$$2e_0=\frac{D-3d}{4}=\frac{3.22-3\cdot 0.21}{4}=0.6475 \qquad \beta=\frac{2e_0}{2c}=\frac{2e_0}{L}=\frac{0.6475}{6.51}=0.09946$$

$$\kappa=\frac{2\Pi_1+Q_1}{Q_1}\beta=\frac{2\cdot 0.72043+0.23737}{0.23737}\cdot 0.09946=\frac{1.67823}{0.23737}\cdot 0.09946=0.70319$$

$$\lambda=\frac{6-2\Pi_1}{2\Pi_1+Q_1}\beta=\frac{6-2\cdot 0.72043}{1.67823}\cdot 0.09946=0.27020$$

$$\mu=-\frac{6}{2\Pi_1+Q_1}\beta^2=-\frac{6}{1.67823}\cdot 0.09946^2=-0.03537$$

$$\boxed{\psi=\kappa z\left(1+\lambda z+\mu z^2\right)=0.70319\cdot z\cdot\left(1+0.27020\cdot z-0.03537\cdot z^2\right)}$$

$$\boxed{\sigma=1+2\lambda z+3\mu z^2=1+0.5404\cdot z-0.10611\cdot z^2}$$

Trenutak raspada zrna $z = z_s = 1$:

$$\psi_s = 0.70319 \cdot (1 + 0.27020 - 0.03537) = 0.8683$$

$$\sigma_s = 1 + 0.5404 - 0.10611 = 1.4343$$

b) posle raspada barutnog zrna:

$$\boxed{z_k = 1 + \frac{2\rho}{2e_0}}$$

ρ - prečnik ~~unutrašnjeg~~ spoljašnjeg "slivera"

$$\boxed{\rho = 0.1772(d + 2e_0)}$$

$$\boxed{\rho = 0.1772 \cdot (0.21 + \cancel{2} \cdot 0.6475) = 0.15195}$$

$$z_k = 1 + \frac{2 \cdot 0.15195}{0.6475} = 1.4693$$

$$\kappa_2 = \frac{2(1-\psi_s)}{z_k - 1} = \frac{2 \cdot (1 - 0.8683)}{1.4693 - 1} = 0.56126$$

$$\lambda_2 = -\frac{1}{2(z_k - 1)} = \frac{1}{2 \cdot (1.4693 - 1)} = -1.06542$$

$$\psi - \psi_s = \kappa_2 (z-1)\left[1 + \lambda_2 (z-1)\right]$$

$$\boxed{\psi - 0.8683 = 0.56126 \cdot (z-1) \cdot \left[1 - 1.06542 \cdot (z-1)\right]}$$

provera: za kraj sagorevanja (z_k = 1.4693) treba da se dobije $\psi_k = 1$

$$\psi_k - 0.8683 = 0.56126 \cdot 0.4693 \cdot \left[1 - 1.06542 \cdot 0.4693\right]$$

$$\psi_k = 0.8683 + 0.1317 = 1$$

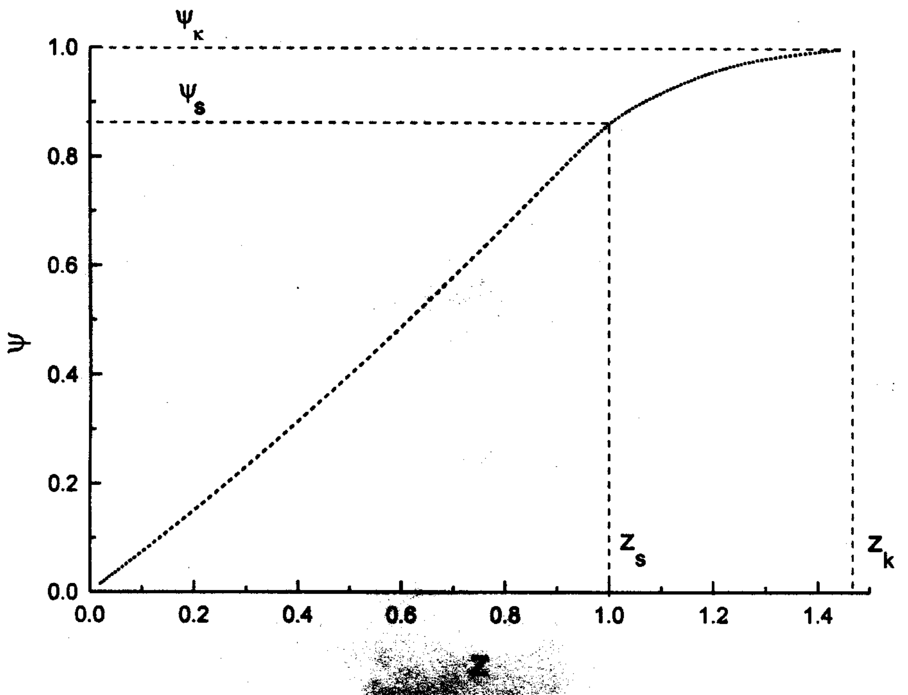
$$\sigma = \frac{1}{\kappa_2}\frac{d\psi}{dz} = 1 + 2\lambda_2 (z-1)$$

$$\boxed{\sigma = 1 - 2.13084 \cdot (z-1)}$$

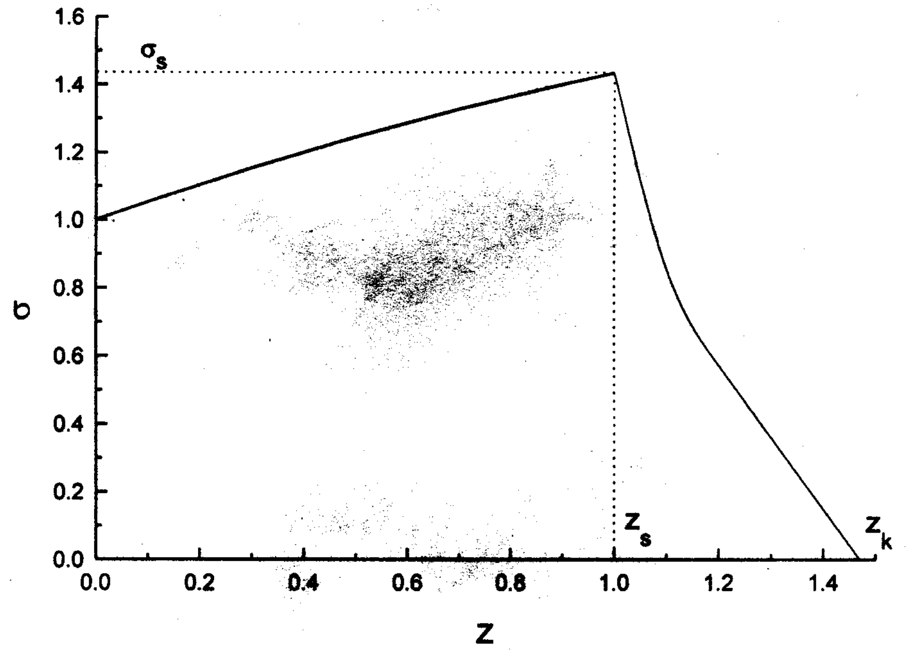
provera: za kraj sagorevanja (z_k = 1.4693) treba da se dobije $\sigma_k = 0$

$$\sigma = 1 - 2.13084 \cdot 0.4693 = 0$$

z	0	0.1	0.3	0.5	0.7	0.9	1	1.1	1.2	1.3	1.4693
ψ	0	0.0722	0.2274	0.3960	0.5768	0.7686	0.8683	0.9184	0.9566	0.9829	1
σ	1	1.0530	1.1526	1.2437	1.3263	1.4004	1.4343	0.7869	0.5378	0.3607	0



ψ_κ
ψ_s
ψ
z_s
z_k
z



σ_s
σ
z_s
z_k
z