RESEARCH OF COMPACTING REGULARITIES OF POWDER MATERIALS SYSTEM FE-AL

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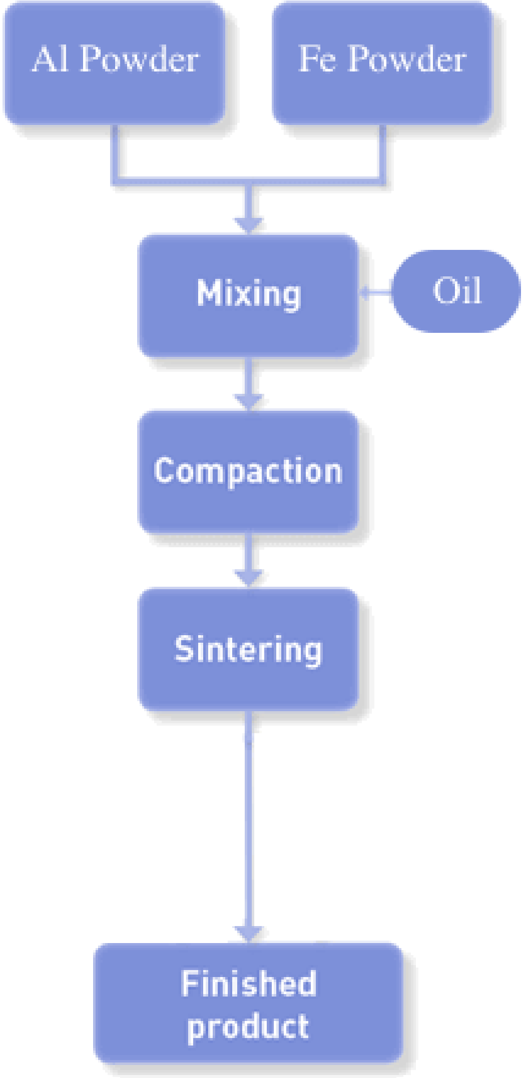
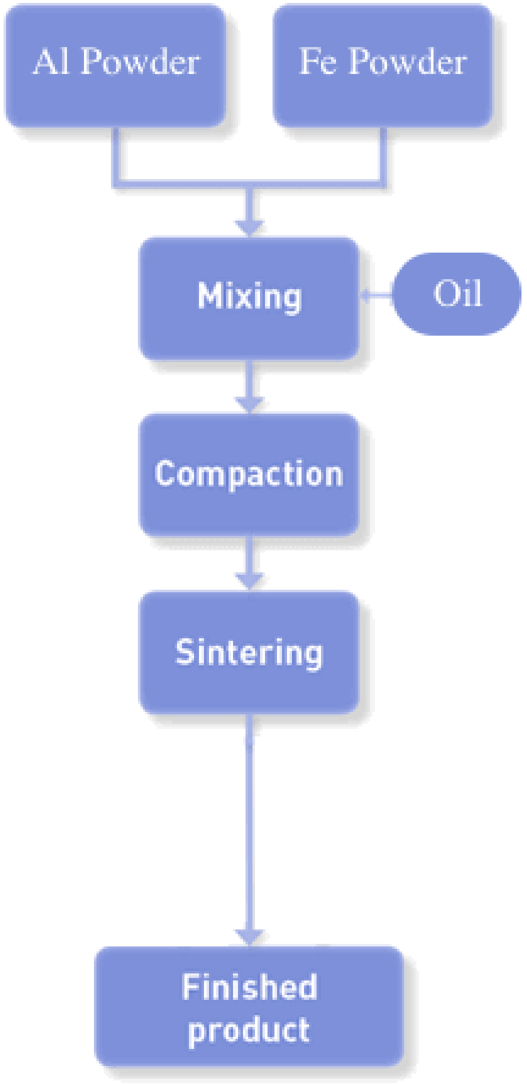
Analysis of the current state of the research object



Materials and methodic of research



Characteristic of Powders

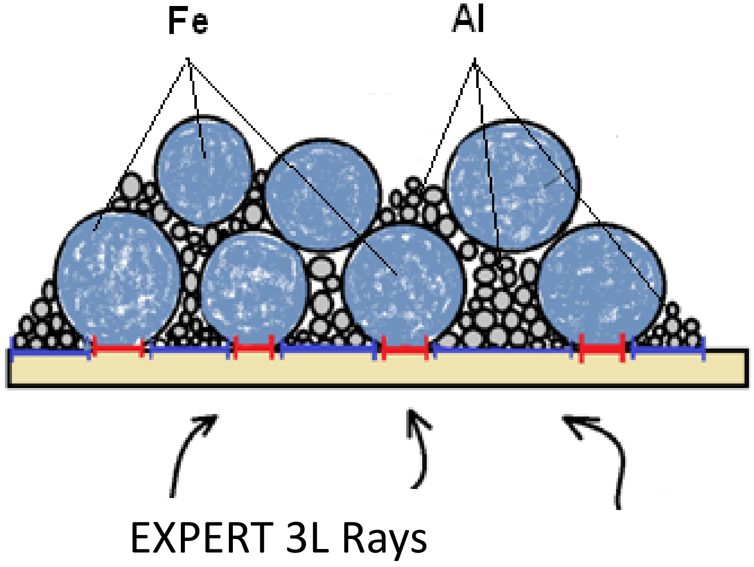
Powder	Quantity of main element , %	Average powders size , µm	Density, g/cm^3	Pouring density, g/см^3	Fluidity, g/c
Iron	99,6	0,2 – 0,2% 016 – 5% 0045 – 77,3% -0045 – 17,5 80	7,2	3,2	2,1
Aluminum	99,8	32	2,68	0,76	–

Quality of mixing

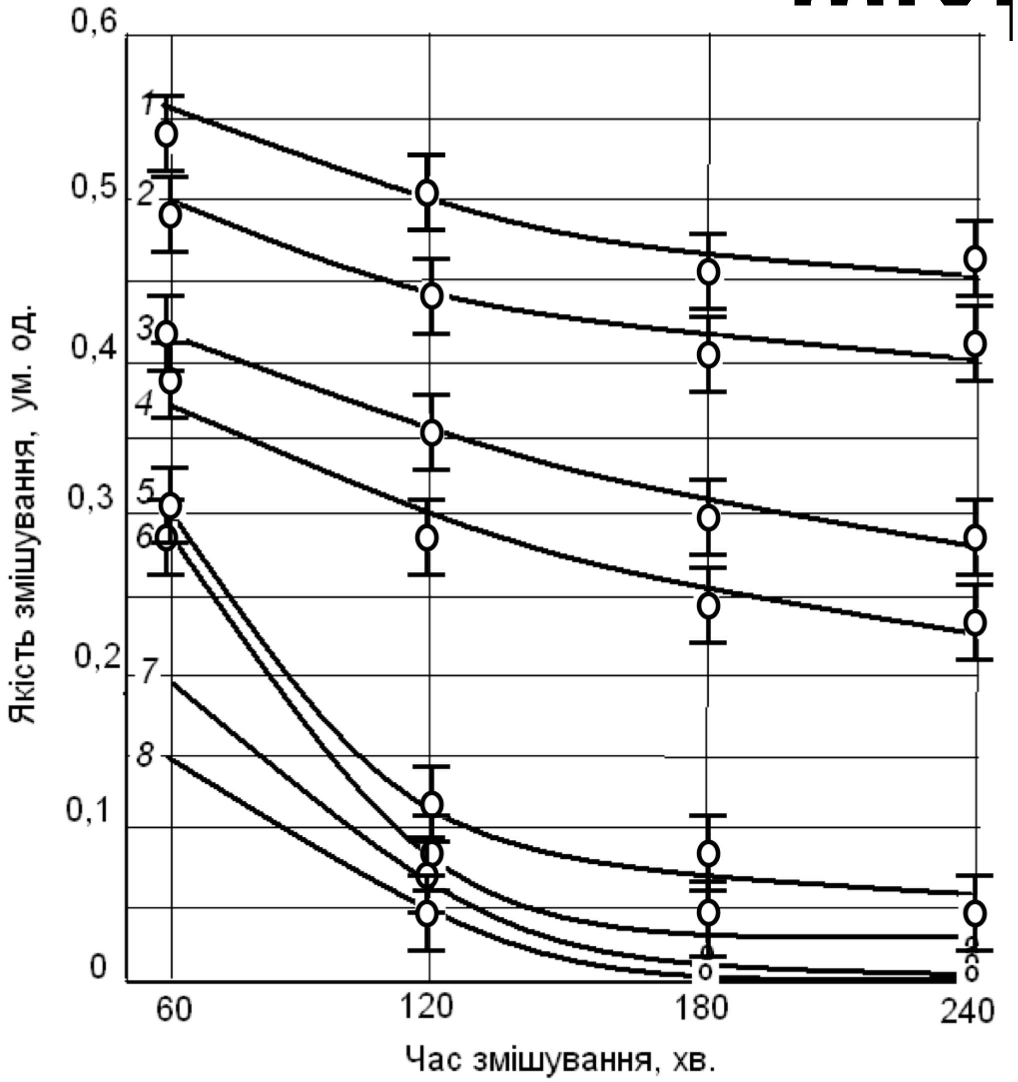
Practical aluminum quantity

$$Q_m = \left| \frac{G_{ø}}{G_{ð}} - 1 \right|$$

Counted aluminum quantity



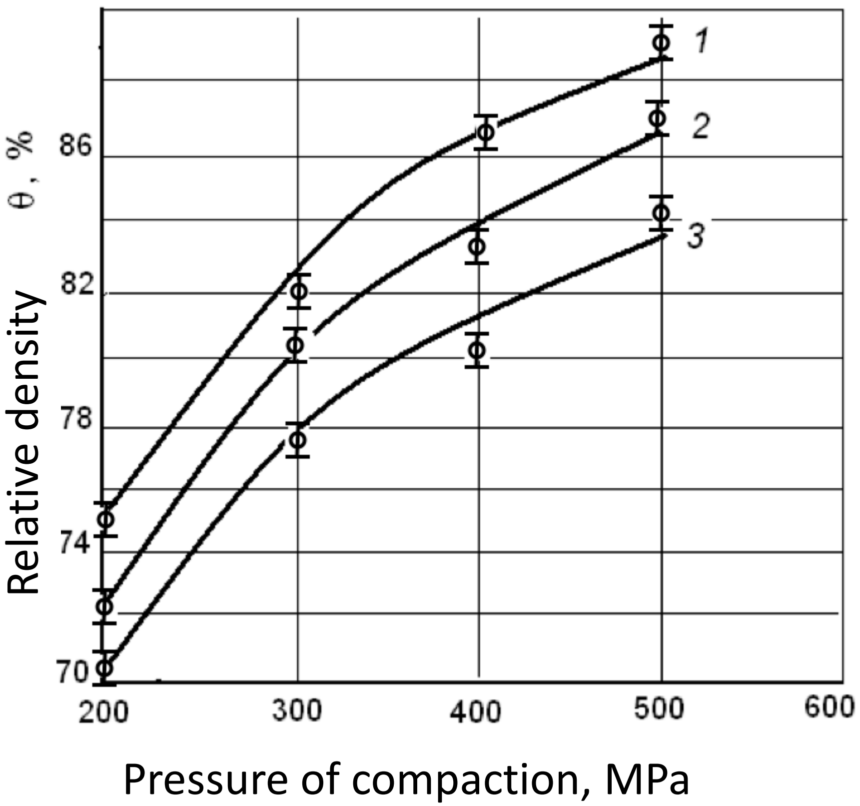
Influence of mixing conditions on mixing quality



1 – pressured mixing of powders 90 Vol.% Fe + 10 Vol. % Al (up);
2 – pressured mixing of powders 80 Vol.% Fe + 20 Vol. % Al (up);
3 – pressured mixing of powders 90 Vol.% Fe + 10 Vol. % Al (down);
4 – pressured mixing of powders 80 Vol.% Fe + 20 Vol. % Al (down) ;
5 – pressured mixing of powders with oil 90 Vol.% Fe + 10 Vol. % Al (up);
6 – pressured mixing of powders with oil 90 Vol.% Fe + 10 Vol. % Al (down);
7 – pressured mixing of powders with oil 80 Vol.% Fe + 20 Vol. % Al (up);
8 – pressured mixing of powders with oil 80 Vol.% Fe + 20 Vol. % Al (down)

Dependence of mixing quality from mixing time and charge composition

Dependence of sample density from pressure compression and their composition



1 – Fe + 30 vol.% Al; *2* – Fe + 20 vol.% Al; *3* – Fe + 10 vol.% Al

Dependence of sample density from pressure compression

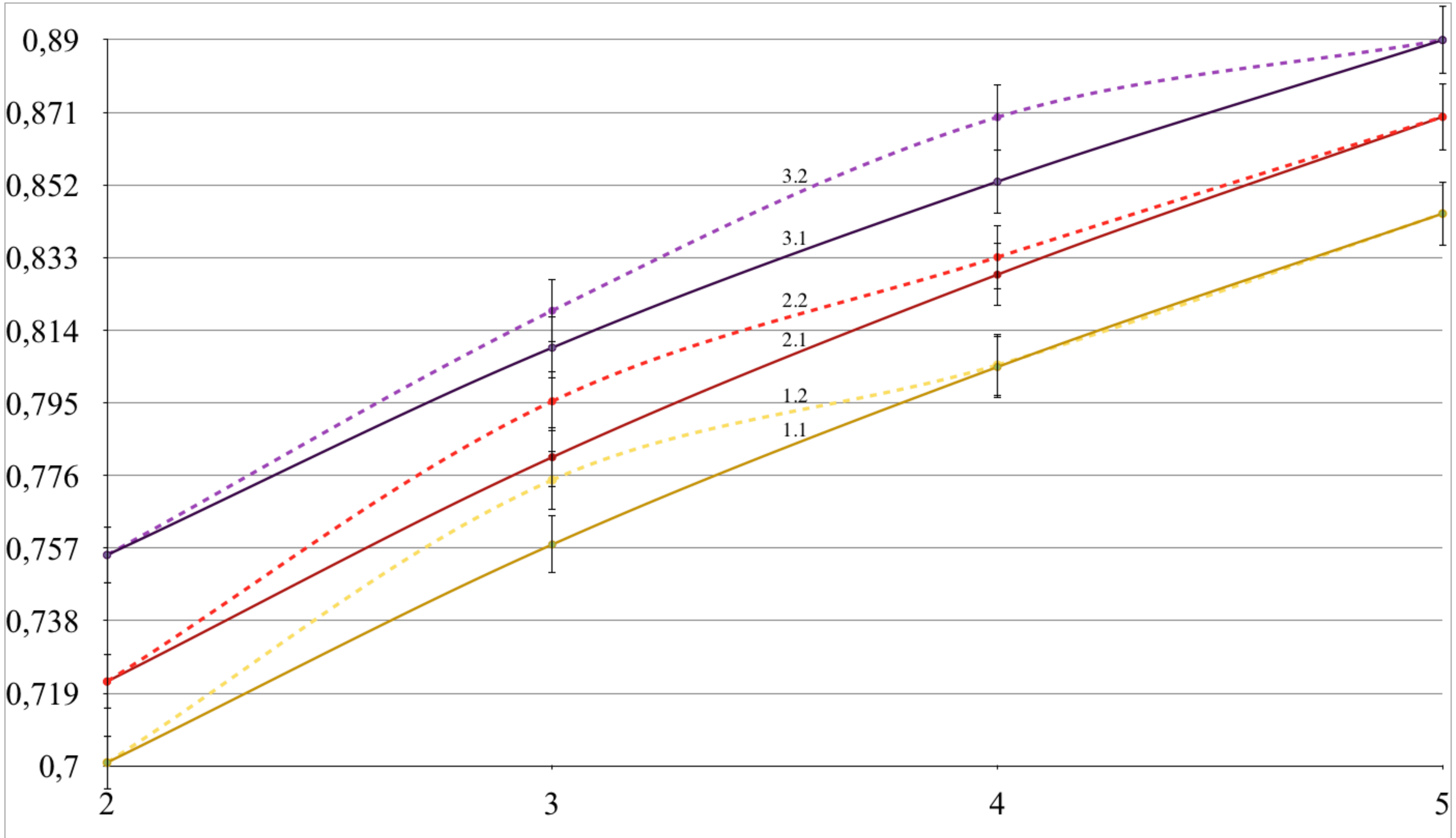
Pressured samples Fe 80%-Al 20%

Pressing equation

Al 10% Lg $P = -1{,}64(\beta-1)+1$

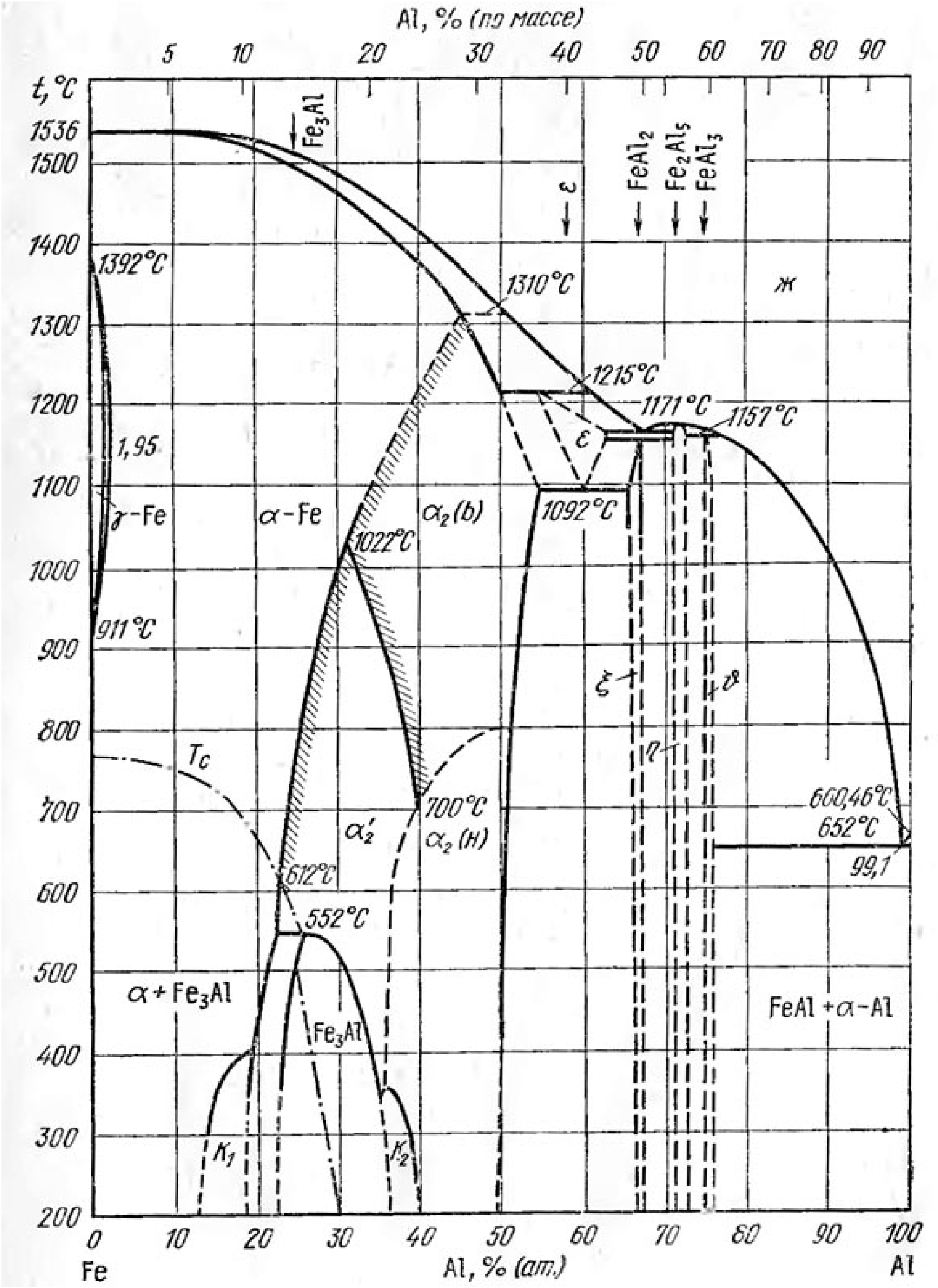
Al 20% Lg $P = -1{,}69(\beta-1)+0{,}95$

Al 30% Lg $P = -1{,}98(\beta-1)+0{,}94$



1.1-Al 10%(experimental) 1.2-Al 10%(theoretical) 2.1-Al 20%(experimental) 2.2-Al 20%(theoretical) 3.1-Al 30%(experimental) 3.2-Al 30%(theoretical)

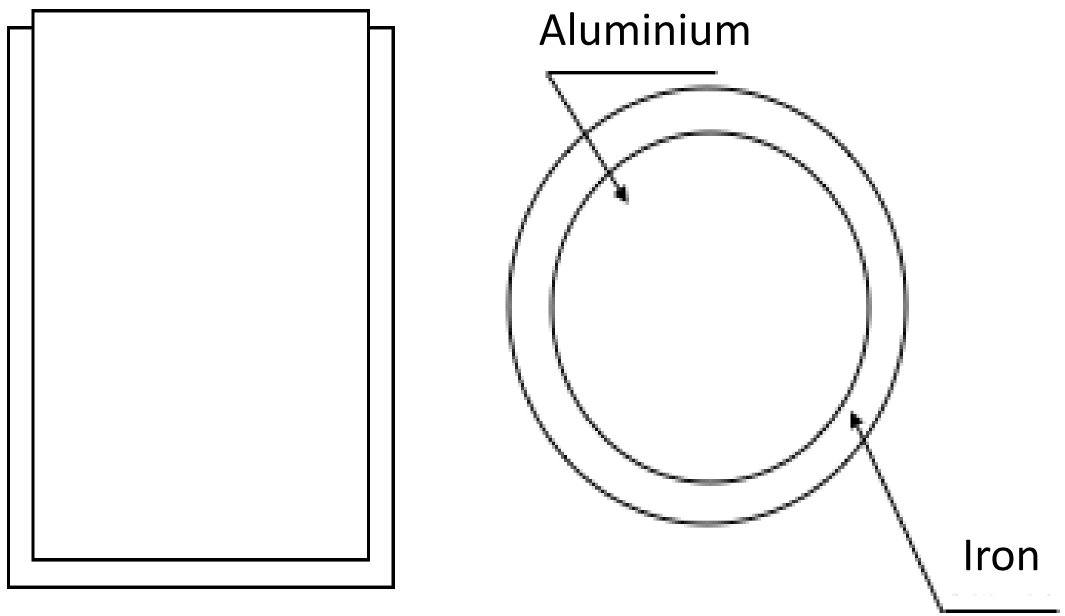
First sintering



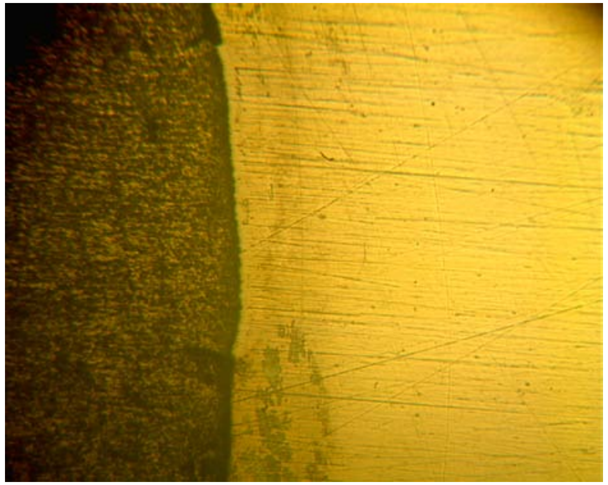
Results of Al-Fe interaction

Metallography

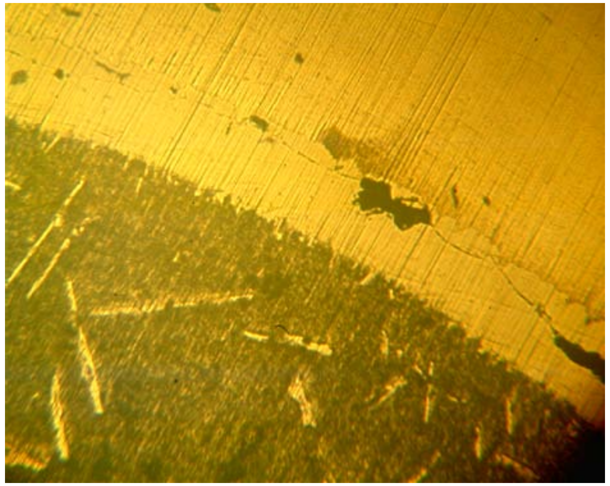
Micro hardness



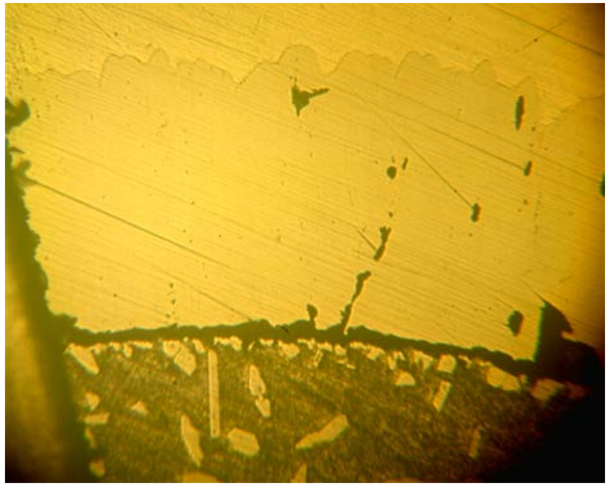
Magnification x100



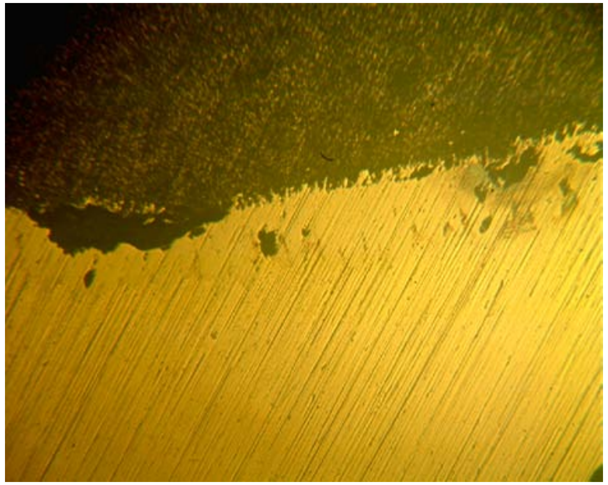
650^0C 15 min



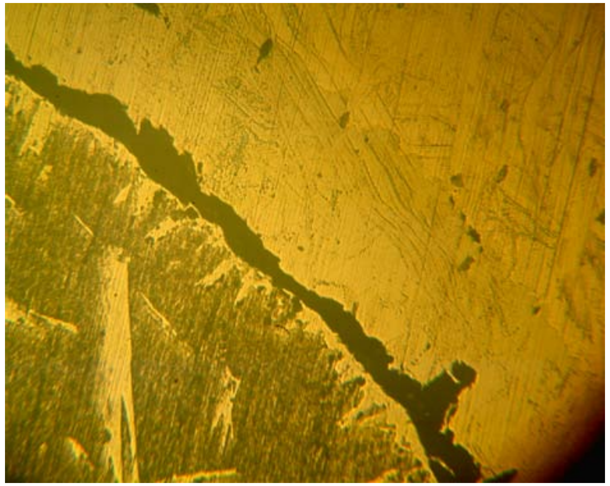
800^0C 15 min



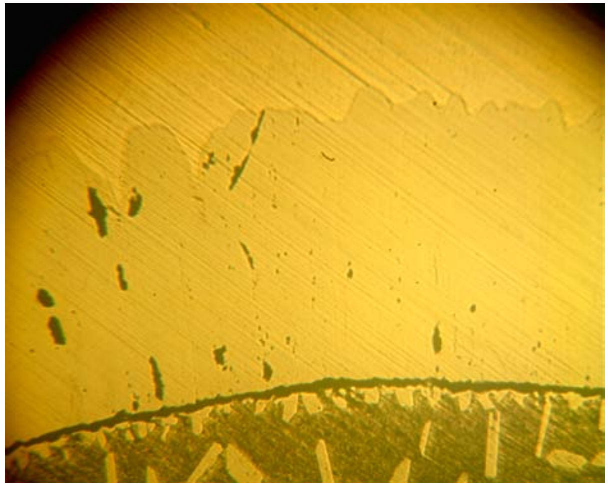
1000^0C 15 min



700^0C 30 min

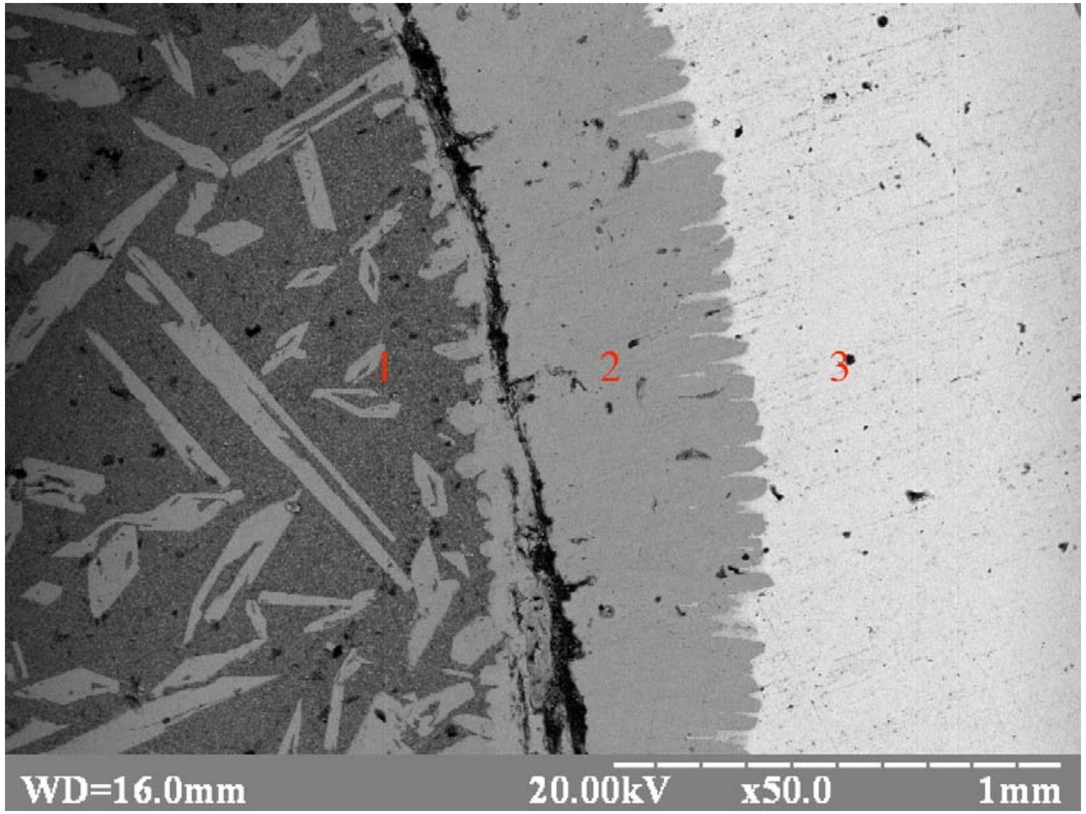


800^0C 30 min



1000^0C 30 min

Results of metallography

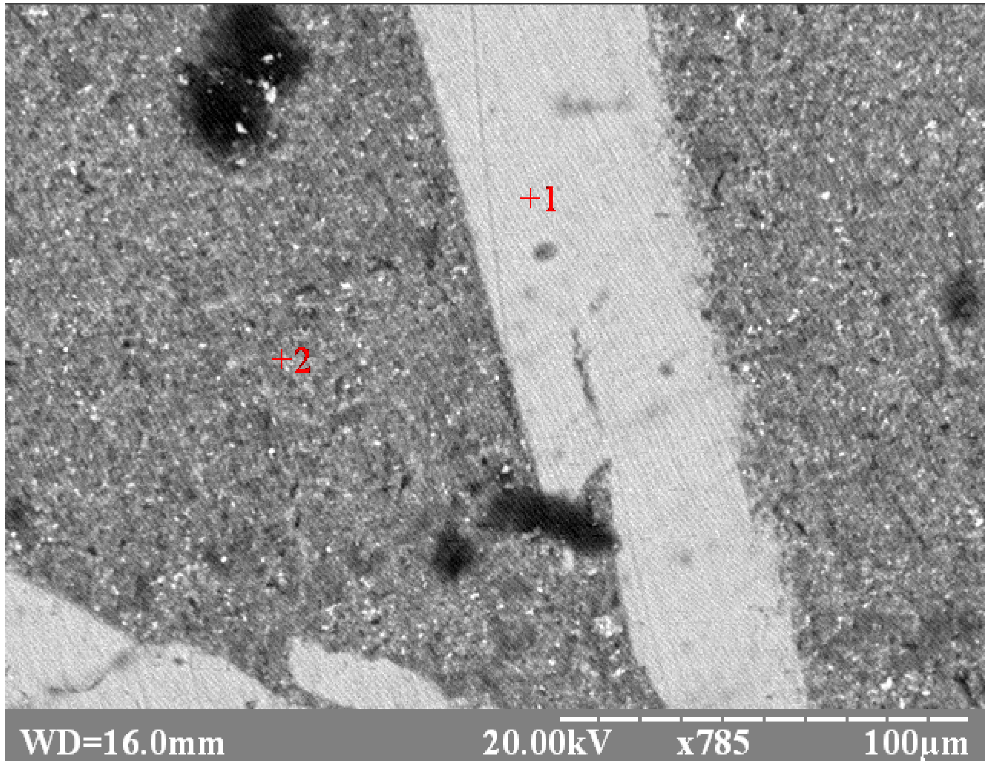


900^{0}C 15 min

Chemical composition of samples after interaction

Точка	Al %	Fe %	Si %
1	29,45	70,51	0,04
2	23,82	75,97	0,21
3	0,01	99,61	0,38

Results metallography



900^{0}C 15 min

Chemical composition of samples after interaction

Point	Al, at. %	Fe , at. %	Phase
1	33,87	66,11	Fe_3Al
2	68,10	31,90	$FeAl_3$

Results of micro hardness research

Phase	Micro hardness, point	Impreint diagonal, μm	Micro hardness , GPa
Black	125	3,75	1,3
Black	120	3,6	1,4
White	62	1,86	5,3
White	50	1,5	6,2
Interaction field	62	1,86	5,3
Interaction field	49	1,47	5,7

Shrinkage during sintering

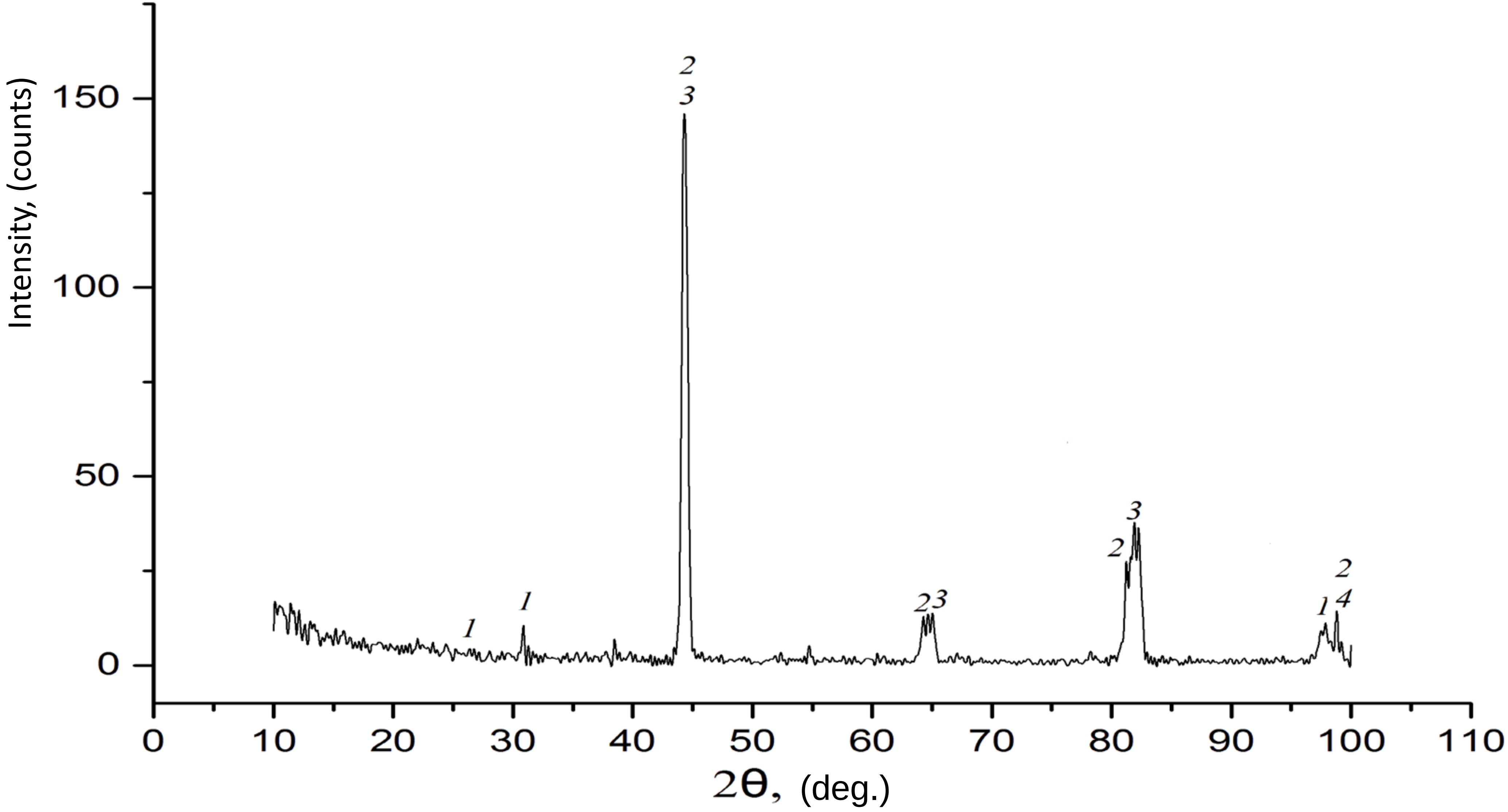
Schrinkage calculations of sintered samples with Al 20%(vol.)

m г	h см	d см	V $см^3$	$\gamma_{(тео)}$ $г/см^3$	$\gamma_{(практ.)}$ $г/см^3$	θ	V/V
6,98	0,575	1,784	1,43	4,86	6,85	70,93	1,08
7,02	0,588	1,786	1,47	4,77	6,85	69,60	1,09
7,05	0,59	1,79	1,48	4,75	6,85	69,35	1,10

1 – before sintering; *2* – after first sintering; *3* – after second sintering

Sintered samples 1200 ^{0}C Fe 80 Vol.% + Al 20 Vol.%

X-ray crystallography

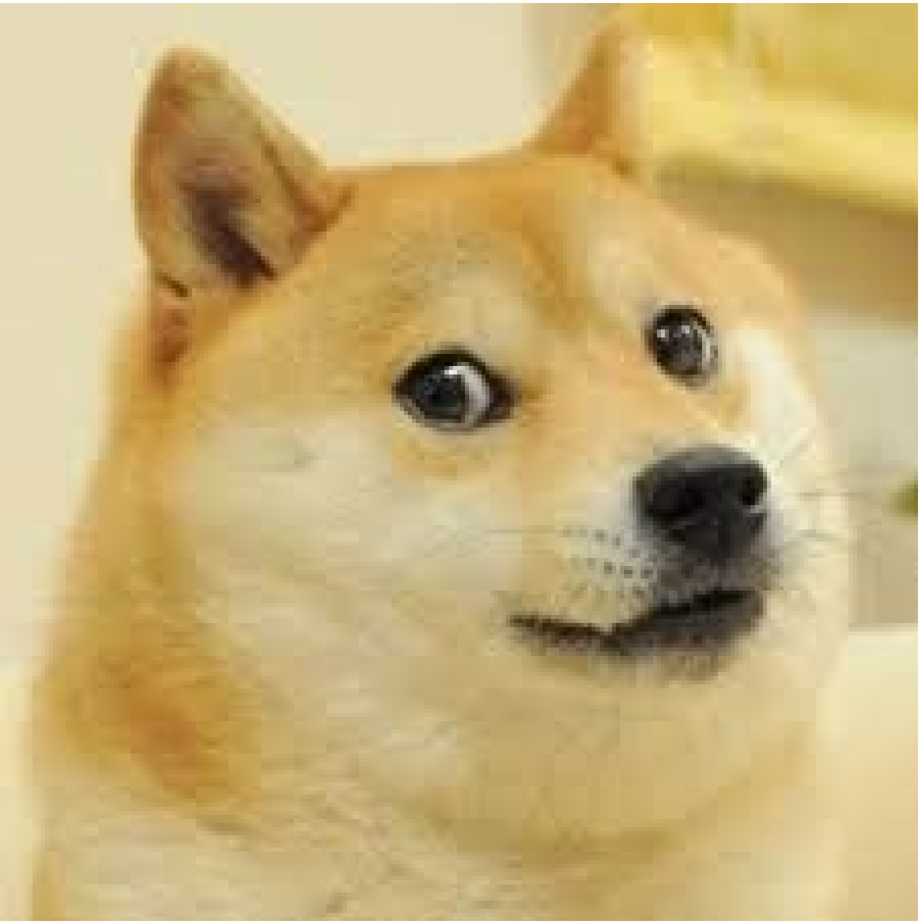


1 – Fe_3Al; *2* – Fe; *3* – Al; *4* – unknown

Conclusions

- 1. Analysis of published data on possible powder materials for use as metal inserts in train brake pads. It is shown that a promising material in this respect could be the insertion of the powder material based on iron and aluminum. As a method of manufacturing this material can be used traditional technology of powder metallurgy.
- 2. The processes of mixing powders and outgoing quality control methods of mixing. To reach best quality of mixing must be added oil to the starting mixture of oil in quantity 1.5%. Spending in furthering mixing 2.5-3.0 hours conical mixer speed with speed 50-60 rpm. / Min ..
- 3. The processes of pressing powder mixtures of iron and aluminum. It is shown through a process of consolidation is plastic deformation of the components of the initial charge. To optimize the pressing process can be used its analytical description by using the equation M.Y. Balshyn equation.
- 4. The processes of sintering compacts from powder mixtures of iron and aluminum and modeling processes of interaction between them. It is shown that the interaction with the sintering of iron and aluminum to form intermetallic Fe_3Al, $FeAl$, $FeAl_3$ with greater specific volume than the initial components that cause the destruction of the samples during the first sintering. Re-sintering samples obtained by pressing crushed material after the first sintering helps to ensure their high strength and density.

Публікації



1. *Клеков А.О., Степанчук А.М., Смик В.М., Шум Л.В.* Закономірності ущільнення порошкових матеріалів на основі композицій Fe – Al //Нові матеріали і технології в машинобудуванні: матеріали науково-технічної конференції. – Київ: НТУУ «КПІ», 2016, 167 с. (С. 71-72)
2. *Степанчук А.М., Клеков А.О., Деркач М.О.* Отримання плавлених карбідів деяких перехідних металів без підігріву розплаву //Нові матеріали і технології в машинобудуванні: матеріали науково-технічної конференції. – Київ: НТУУ «КПІ», 2016, 167 с. (С. 138-139)
3. *Степанчук А.Н., Деміденко А.А., Клеков А.О.* Взимодействие расплавов самофлюсующихся сплавов с железом // Труды 5-й междунар. конф. "HighMatTech". – Киев: 6–8 октября 2015 . – С.

Рівняння пресування

$$P_{ос} = \sigma_z = \frac{2}{3}k\frac{(1-f)^{2/3}}{\sqrt{f}}$$

Штерна

$$P = (1 + f_i tg\varphi)x_1\sigma_T \frac{\left\{1 + x_3\left[\frac{1-\beta_0\theta(1-\ln\beta_0\theta)}{3\beta_0\varepsilon_k\varepsilon_{ia}}\right]^m\alpha_k\right\}}{1 - x_2\frac{\alpha_k}{\theta}}$$

Ждановича