საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 2, №2, 2008
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 2, no. 2, 2008

Metallurgy

Stress-Deformed State of Compositional Medium in High Pressure Condition

Jemal Sharashenidze

F. Tavadze Institute of Metallurgy and Materials Science

(Presented by Academy Member I. Zhordania)

ABSTRACT. Plasticity flow peculiarities have been investigated during two structurally non-homogeneous simultaneous deformations. The implementation analysis allows to produce projection of a die and blank and evaluate expected change during deformation of the composite material. *© 2008 Bull. Georg. Natl. Acad. Sci.*

Key words: *plasticity, flow, medium, force, stress, deformation, rheology, sift, blank, die.*

The production quality of structurally inhomogeneous materials mostly are indicated by the conditions in which constiuent material components in plastic flow are deformed simultaneously without breakage. The given problem is rather difficult and may be resolved by definite assumptions.

The principal purpose of the given investigation is to study some peculiarities of plastic flow (stress-deformed state) and conditions of simultaneous deformation of two mediums with different rheology. It is necessary for working out recommendation for designing tool (matrix) and billet, and marking expected changes of load while the compositional medium suffers deformation.

To resolve this problem complex theoretical and experimental analysis is carried out by making separate assumptions.

Equilibrium equation and plastic condition are accepted as

$$\frac{\partial \sigma_r}{\partial r} + \frac{\partial \tau_{r\theta}}{\partial \theta} + \frac{1}{r}\left(\sigma_r + \partial_\theta\right) = 0,$$

$$\frac{\partial \tau_{r\theta}}{\partial r} + \frac{\partial \sigma_\theta}{\partial \theta} + \frac{1}{r}\tau_{r\theta} = 0$$

$$\left(\sigma_r - \sigma_\theta\right)^2 + 4\tau_{r\theta}^2 = 4K^2(\theta).$$

It should be suggested that the condition when material resistance to shearing $K=f(\sigma)$ (σ - hydrostatic pressure) may be reduced to problem $K=K(\theta)$.

That is why the system is written down for a plastically inhomogeneous body ($K=K(\theta)$) in polar coordinates.

Physical state equations are taken to be

$$\sigma_r = \sigma + 2K(\theta)\frac{\dot{\varepsilon}_r}{H},$$

$$\sigma_\theta = \sigma + 2K(\theta)\frac{\dot{\varepsilon}_\theta}{H}$$

$$\tau_{r\theta} = K(\theta)\frac{\dot{\gamma}_{r\theta}}{H},$$

where σ_r, σ_θ, $\tau_{r\theta}$ are stress tensor components; $\dot{\varepsilon}_r$, $\dot{\varepsilon}_\theta$, $\dot{\gamma}_{r\theta}$, H – speed deformation tensor components and speed deformation shearing intensification - $H = \sqrt{4\dot{\varepsilon}_r^2 + \dot{\gamma}_{r\theta}^2}$.

From the incompressibility condition we find that

$U = \frac{U(\theta)}{r}$ and accept speed field as:

$$U = -U_0 \frac{r_0}{r} \cdot \exp\left(-\frac{\mu}{\alpha} \theta^2 \right).$$

In conditions of inhomogeneous plasticity (from the temperature field)

$$K(\theta) = K_0 \sqrt{1 + \left(\frac{\mu}{\alpha}\right)^2 \theta^2},$$

K_0 is yield point when $\theta = 0$ (on body axis). After substitution we have got:

$$\sigma_r = -K_0 \left[\left(2 + \frac{\mu}{\alpha}\right) \ln r + \frac{\mu}{\alpha} \cdot \theta^2 - 1 \right] + C,$$

$$\sigma_\theta = -K_0 \left[\left(2 + \frac{\mu}{\alpha}\right) \ln r + 1 \right] + C,$$

$$\tau_{r\theta} = \mu \cdot K_0 \frac{\theta}{\alpha},$$

where μ is parameter proportional to friction factor; U_0 – speed extrusion; α - solution angle; r, r_0 – parameters of matrix (Fig.).

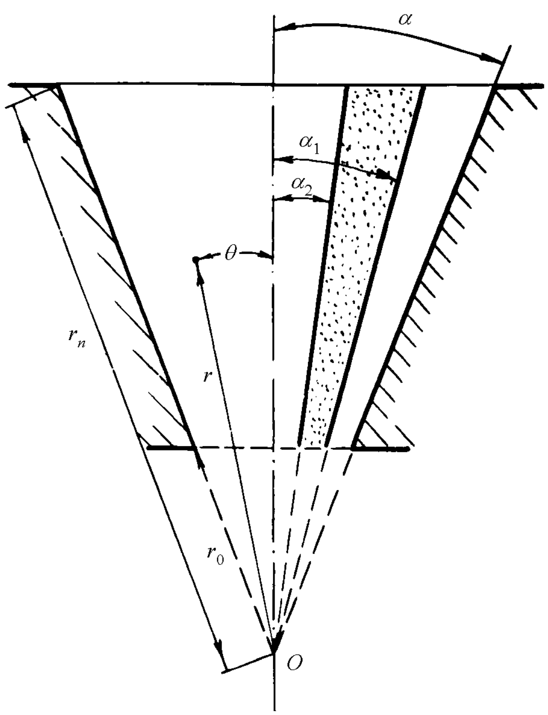

Figure.

Physical state equations for the filling medium are:

$$\sigma_r = \sigma + 2K(\sigma) \frac{\varepsilon_r}{H} + K \cdot K'(\sigma),$$

$$\sigma_\theta = \sigma + 2K(\theta) \frac{\varepsilon_\theta}{H} + K \cdot K'(\sigma),$$

$$\tau_{r\theta} = K(\sigma) \frac{\gamma_{r\theta}}{H}.$$

Quantity -

$$K'(\theta) = \frac{\varepsilon_r + \varepsilon_\theta}{H} = \frac{\varepsilon_r + \varepsilon_\theta}{\sqrt{\left(\frac{\partial U}{\partial r} - \frac{U}{r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial U}{\partial \theta}\right)^2}}.$$

Quantity $K = K(\sigma)$ is adopted as

$$K(\sigma) = \sigma_0 + b = -\sin\rho + K_1 \cos\rho.$$

For radial speed filling we get:

$$U = C_n \cdot \exp\left(\frac{2}{\sin\rho} \cdot \theta \right) \cdot r,$$

here and above C_n is constant, θ - current angle, ρ - medium characteristics (internal friction coefficient).

This leads to the following expression for σ_r and $\tau_{r\theta}$:

$$\sigma_r = -\frac{1}{\sin\rho} \mu \cdot K_0 \cdot \ln r -$$
$$-\frac{1}{\sin^2\rho} \mu \cdot K_0 (\theta - \alpha) - K_0 (1 + \mu_a) + C,$$

$$\tau_{r\theta} = \frac{1}{\sin\rho} \mu \cdot K_0 (\theta - \alpha) + \mu \cdot K_0.$$

Comparison of metal stress components and filling medium leads us to the deduction that deformation of matrix solution with minor angles and significant increase of medium outcome density in billet are necessary. Thus, it is possible to approximate their flow kinetics and make deformation with minimum breakage.

Density force may be determined by integrating the expressions for σ_r and by empirical expressions which are the results of tests and determinations of structure expressions σ_r.

Density force θ in extrusion of composite mediums may be determined by the expression:

$$q = \frac{F_1}{F} \left(q_1 + q_2 \frac{F_2}{F_1} \right)$$

Here F_1, F_2, F are metal section area, filling and average areas, respectively; $q_1 \approx 4\sigma_i \varepsilon_i$, $q_2 \approx 2\sigma_{iH}\left(1+\alpha'\sigma_{cp}\right)\cdot\varepsilon_{ir}$, s_i, s_{iH} – metal yield point and resistance to deformation of filling medium; ε_i, ε_{ir} – degree of metal and medium deformation; α' – test factor.

$$\varepsilon_1 = \ln\frac{F_1}{f}.$$

Calculations and derivations on designing practice of bar and piping production were tested on producing foundry product by the methods of high-temperture extrusion, when P_{max}=1600 MMa, t=1100-1600°C.

The experimental investigation proved the statement that increasing the volume fraction of filling medium significantly increases the density forces of deformation. The problem of realization of simultaneous flows (without breakage) of two mediums may be only solved by the preceding seal of billet with filling medium.

მეტალურგია

კომპოზიციური არის დაძაბულ-დეფორმირებული მდგომარეობა მაღალი წნევების პირობებში

ჯ. შარაშენიძე

ფერდინანდ თავაძის მეტალურგიისა და მასალათმცოდნეობის ინსტიტუტი, თბილისი

(წარმოდგენილია აკადემიკოს ი.ჟორდანიას მიერ)

ნაშრომში თეორიულად გამოკვლეულია სტრუქტურულად არაერთგვაროვანი პლასტიკური დენადობის თავისებურებანი ორი არის ერთობლივი დეფორმაციის დროს. ჩატარებული ანალიზი საშუალებას იძლევა შესრულდეს ინსტრუმენტის (მატრიცა) და ნამზადის პროექტირება და შეფასდეს მოსალოდნელი ცვლილებები კომპოზიციური მასალის დეფორმირებისას.

REFERENCES

1. *А.А. Костава, Л.М.Прозоров, И.Г.Савчинский* (1981), Горячее гидропрессование труб и профилей с наполнителем. Кузнечно-штампованное производство, 5.

Received February, 2008