THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX METALLURGY AND MATERIALS SCIENCE, ISSN 1453 – 083X. N^0. 1 – 2006

EXPERIMENTAL RESULTS AT MODELLING OF THE FLOW AND DEFORMATION FIELDS AT THE PROFILES ROLLING

Nicolae CANANAU, Ionel PETREA,
Gheorghe COROBETE
"Dunarea de Jos" University of Galati
e-mail: cananau.nicolae.ugal.ro

ABSTRACT

This paper presents the results for modeling of the rolling process based at the deformable continuous medium mechanics, the theory of field lines. The rolling of the profiles and plates may be evaluated as the plane strain state process. Using the equations of the continuous medium and the initial conditions and the limits conditions we solved the speed field, the strain rate field, the strain field. Applying an adequate computation program we obtained the values of the field factors of modeling process. The results are showed into this paper.

KEYWORDS: modeling, rolling process, field lines

1. Introduction

In a previous paper [1] was presented a method for modeling of the rolling process based at the deformable continuous medium mechanics, the theory of field lines. Using the calculus algorithm described above we developed a computation program. The results of the calculus program are presented in this paper. We consider the rolled body as a deformable continuous medium. The volume occupied by the continuous medium, at the really moment, is divided in three domains (figure 1):

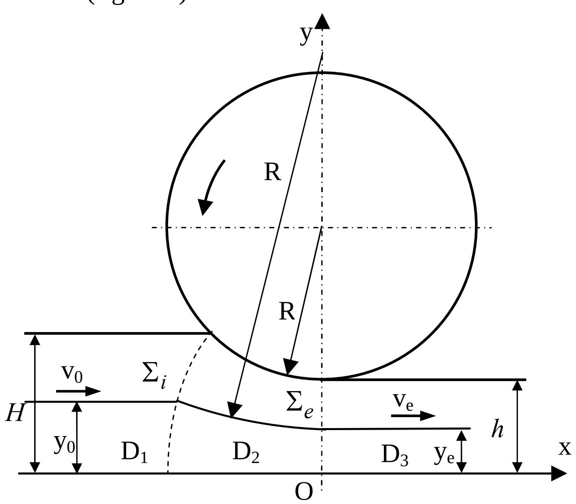


Fig.1. *The deformation domain and field line.*

- the domain D_1 before the entrance of medium between the rolls (rigid plastic medium),
- domain D_2, deformation domain, the medium is between the rolls. In this domain is developed the deformation process,
- domain D_3 at the exit of material between the rolls (rigid plastic, too).

For the numerical calculus we use the following normalized coordinates:

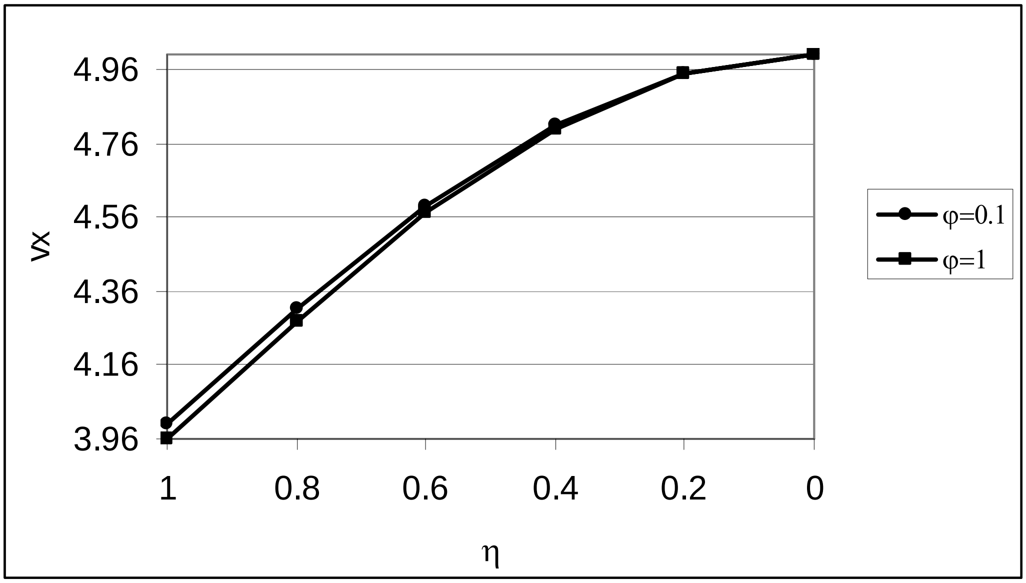
$$\eta = \frac{x}{x_o} \quad \text{respective ly,} \quad \varphi = \frac{y_o}{H} \qquad (1)$$

The data used by the computation program are the following:

R=500 mm
H=25 mm
h=20 mm
v_0=4 m/s

2. The speed field

In the conditions of a stationary regime of the continuous medium flow the field lines coincide to the movement trajectories of the material particles. In the Figure 2 we represent the field line of the material particles that are situated to y_0 of the axe Ox, the symmetry axe of the body. The continuity condition is defined by the constant material flux in the long of the field line. The components of the speed field are presented in figure 2.



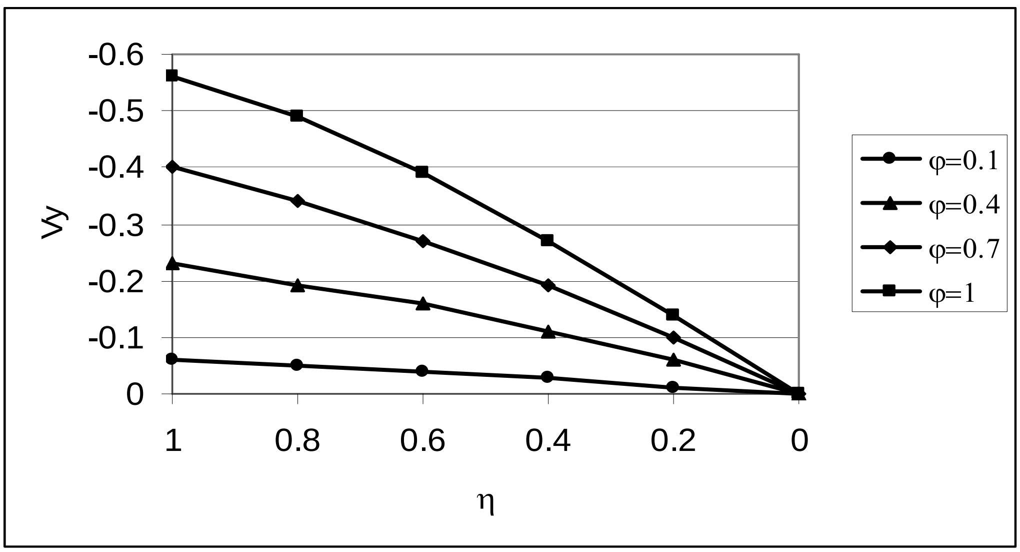


Fig.2. *The components of the speed field.*

3. The strain rate field

The components of the strain rate tensor are defined by equations:

$$\dot{\varepsilon}_{xx}=\frac{\partial v_x}{\partial x};\quad \dot{\varepsilon}_{yy}=\frac{\partial v_y}{\partial y};\quad \dot{\varepsilon}_{xy}=\frac{1}{2}\left(\frac{\partial v_x}{\partial y}+\frac{\partial v_y}{\partial x}\right)$$

The strain rate intensity is defined by the relation:

$$\bar{\dot{\varepsilon}}=\frac{2}{3}\sqrt{\dot{\varepsilon}_{xx}^2+\dot{\varepsilon}_{yy}^2+2\dot{\varepsilon}_{xy}^2} \qquad (2)$$

The components of the strain rate tensor are presented in Figure 3.
The strain rate intensity is presented in figure 4.

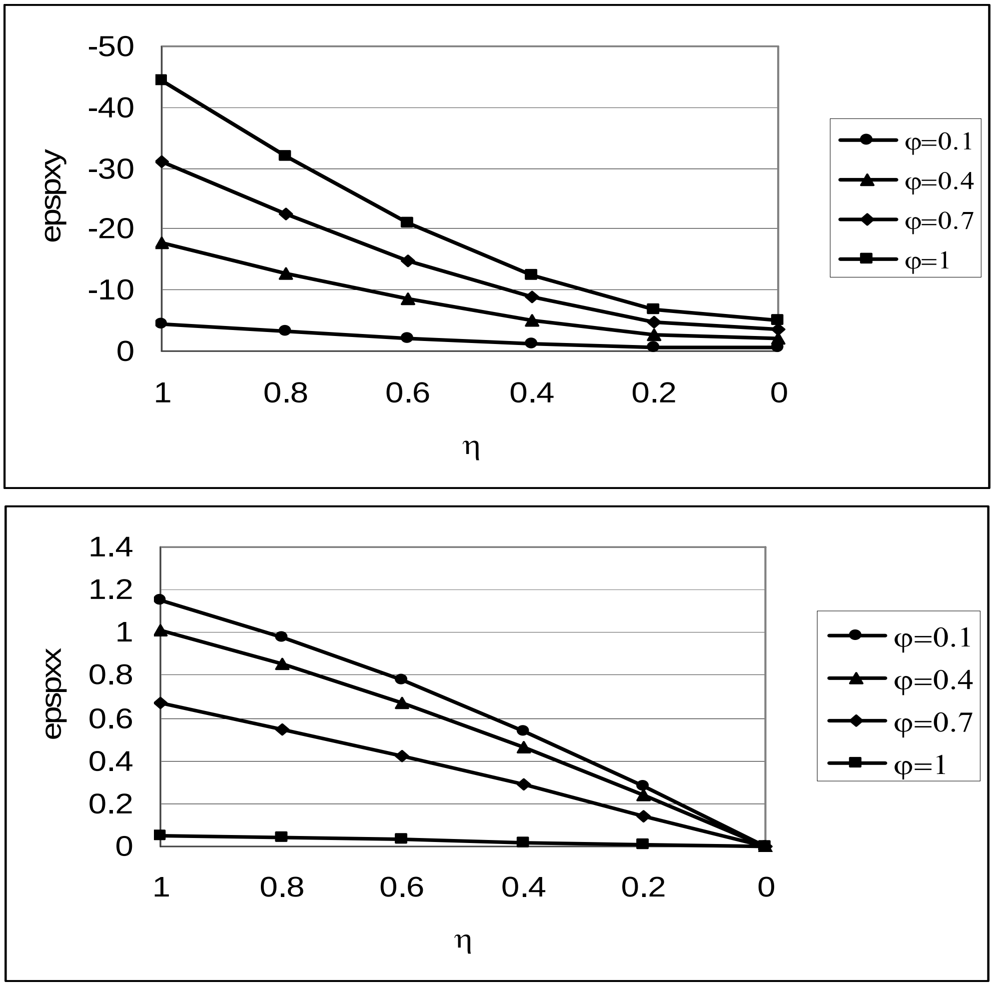


Fig. 3. *The components of the strain rate tensor.*

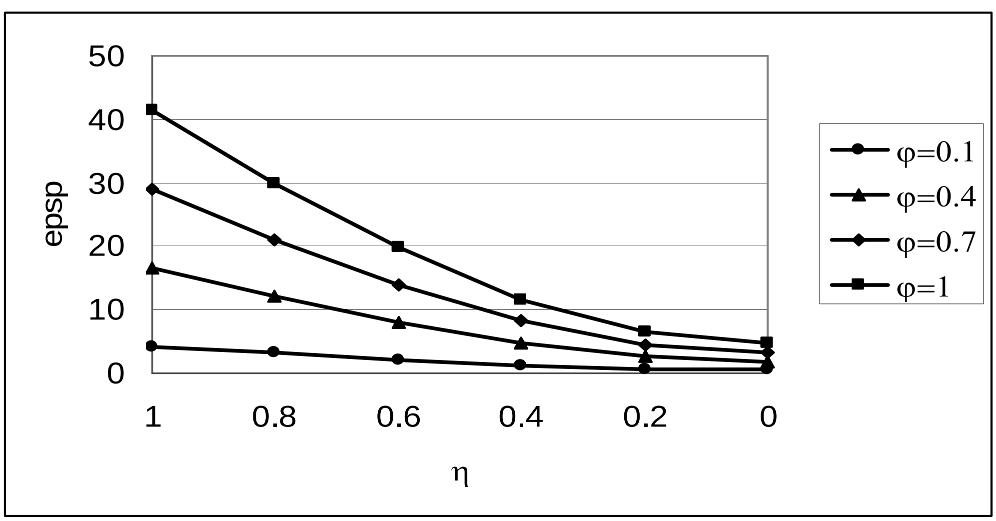


Fig. 4. *The strain rate intensity.*

4. The field of strain intensity

The field of strain intensity is defined by the expression:

$$\bar{\varepsilon} = \int_0^t \bar{\dot{\varepsilon}} \cdot dt \qquad (3)$$

For the numerical solve we will use the following principle (fig.5):

We defined the time differential as:

$$dt = \frac{dx}{v_x}$$

The numerical expression of the equation (3) is:

$$\bar{\varepsilon}_k = \bar{\varepsilon}_{k-1} + \left(\bar{\dot{\varepsilon}}_{k-1} + \bar{\dot{\varepsilon}}_k\right) \cdot \frac{x_k - x_{k-1}}{v_{x_k} + v_{x_{k-1}}} \qquad (4)$$

In this expression the index k is defined in function of the index i as $k=n-i$, where i is the division operator in the long of the field line ($i=1,2,...,n$).

For initialization of the values of $\bar{\varepsilon}$ we consider what at the $k=0$, respectively, $i=n$, that is in the point of surface Σ_i the deformation is defined by the rotation of speed vector of angle θ_o.

Thus the initial strain is:

$$\bar{\varepsilon}_0 = \mathrm{tg}\,\theta_0 \qquad (5)$$

The field of strain intensity is presented in figure 6.

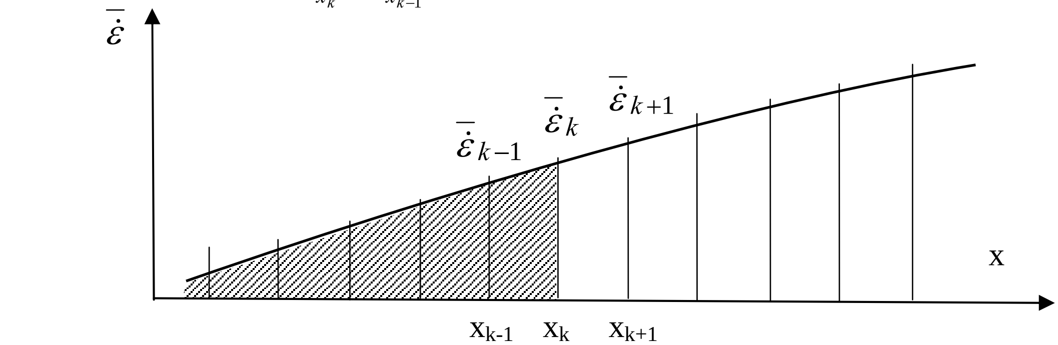


Fig. 5. *The calculus scheme of the strain intensity.*

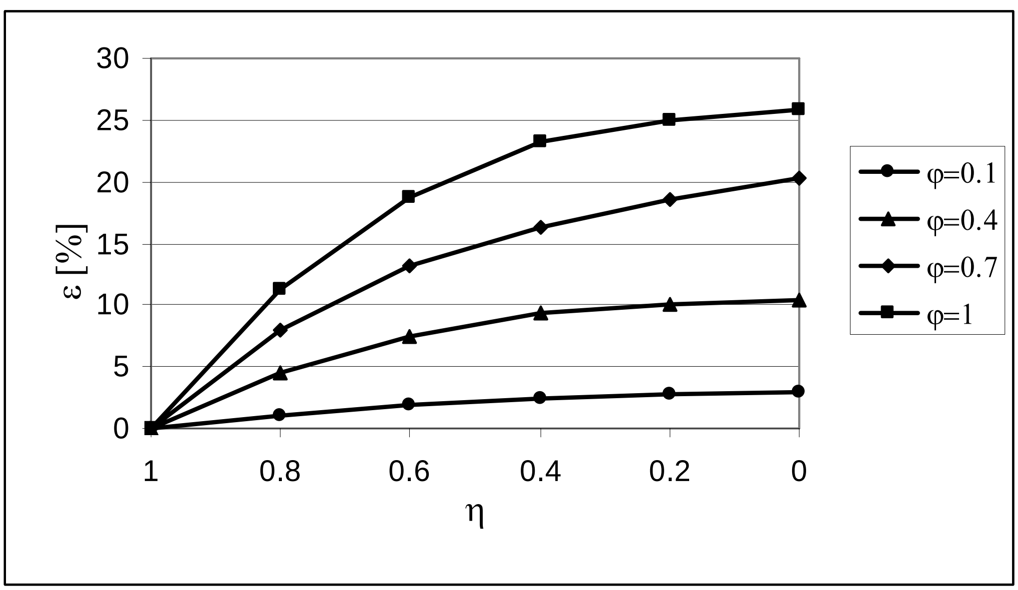


Fig. 6*. The field of strain intensity.*

5. Conclusions

The solving of the deformation process is possible using various methods. The field (or flow) line is one of these.

First we must defined clearly the domain that, at the real moment, is occupied of the body and the initial and limit conditions. The body is considered as deformable continuous medium. Then, we must define the equation of the flow line.

Using the equations of the mechanics of the deformable continuous medium, applying the initial conditions and the conditions at the limits we obtained, in the analytical form, the expressions of the components of the speed, and, derived by these, the components of the strain rate tensor.

If the components of strain rate tensor are defined, that is the field of strain rate tensor is defined, we can calculate the strain rate intensity, and finally, the strain intensity. Thus, the analyze of cinematic process is solved.

The data presented in this paper will be used for the calculation of the process parameters of the profiles rolling.

References

[1] Cananau N., Petrea I, Corobete G., *Modelling of the flow and deformation fields at the profiles rolling by field lines method* , The Annals of "Dunarea de Jos" University of Galati, Fascicle IX, Nov. 2005

[2] Moussy F., Franciosi P. *Physique et mecanique de la mise en forme des meteaux*. Presses du CNRS, Paris, 1990, ISBN 2-87682-023-4

[3] Dumitrescu A.T. *Contributii la modelarea laminarii in calibre. T*eza de doctorat, Institutul Politehnic Bucuresti, 1986.

[4] Adrian M., Badea S. *Bazele teoretice ale proceselor de deformare plastica.* Editura tehnica, Bucuresti, 1983.

[5] Cananau N. *Teoria deformarii plastice*. Universitatea Dunarea de Jos din Galati, vol.2, 1995.