

Effects of Pre-Form Thickness Variations on Product Thickness Accuracy in Multi-Rollers Flow-Forming

R.Jafari Nedoushan and M.Farzin

ABSTRACT

An advantage of the flow-forming process is high accuracy of products. Most researches in the past decades studied product diametric accuracy but to the authors' knowledge, they investigated rarely thickness accuracy. In this paper, a procedure is proposed to predict effects of the process parameters such as pre-form thickness variation and mandrel and rollers stiffness on product thickness accuracy. For this purpose, rollers forces are calculated as a function of pre-form thickness variation and mandrel and rollers deflections. Using this function, product thickness variation and mandrel deflection are calculated and it is concluded that pre-form thickness variation causes product thickness variation with similar distribution but the amount of variation largely decreases. The experiments also verify this prediction.

In addition, the applied force to the mandrel is investigated and it is also concluded that a periodic force with similar distribution to the pre-form thickness is applied to the mandrel. Finally, it is shown that flow-forming with three rollers produce more accurate products than a two rollers case.

KEYWORDS : flow-forming, product accuracy, pre-form thickness variation, mandrel and roller deflection

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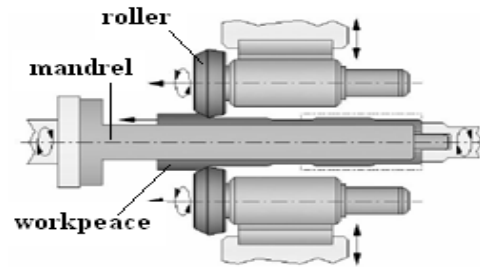
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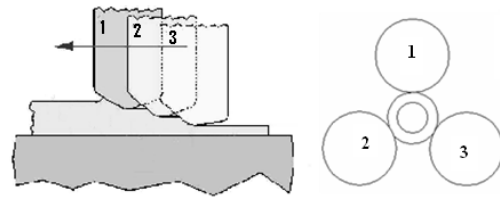
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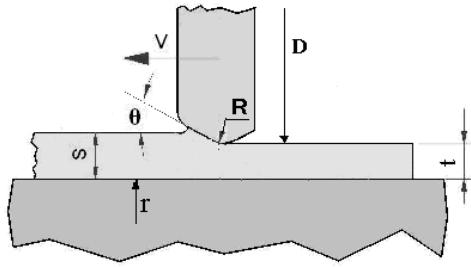
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$$F_r = f(s, t, D, V, \sigma, \theta, \mu, \omega, R) \quad (1)$$

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$$(1) \quad (2)$$

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$$F_{ri} = f(s_i, t_i) \quad (3)$$

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$$F_{ri} = f(s_{oi}, t_{oi}) + \frac{\partial f(s_{oi}, t_{oi})}{\partial s} (s_i - s_{oi}) + \frac{\partial f(s_{oi}, t_{oi})}{\partial t} (t_i - t_{oi}) \quad (4)$$

$$t_{oi} \quad s_{oi} \quad (5)$$

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$$(6) \quad [] [] [] []$$

(μ)

$$(7)$$

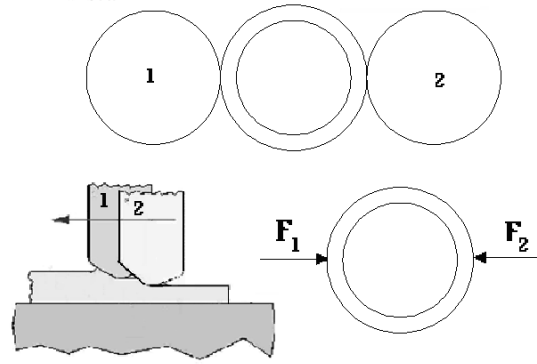
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(R)

$$t_2 - t_{o2} = -\delta_{m\theta} + \delta_{r2\theta} \quad ()$$



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$$F_{r1} = f_1(s_{o1}, t_{o1}) + \frac{\partial f_1(s_{o1}, t_{o1})}{\partial s} (s_1 - s_{o1}) + \frac{\partial f_1(s_{o1}, t_{o1})}{\partial t} (t_1 - t_{o1}) \quad ()$$

$$F_{r2} = f_2(s_{o2}, t_{o2}) + \frac{\partial f_2(s_{o2}, t_{o2})}{\partial s} (s_2 - s_{o2}) + \frac{\partial f_2(s_{o2}, t_{o2})}{\partial t} (t_2 - t_{o2}) \quad ()$$

$$F_{r3} = f_3(s_{o3}, t_{o3}) + \frac{\partial f_3(s_{o3}, t_{o3})}{\partial t} (t_3 - t_{o3}) + \frac{\partial f_3(s_{o3}, t_{o3})}{\partial s} (s_3 - s_{o3}) \quad ()$$

$$F_{r1} = f_1(s_{o1}, t_{o1}) + \frac{\partial f_1(s_{o1}, t_{o1})}{\partial s} (s_1 - s_{o1}) + \frac{\partial f_1(s_{o1}, t_{o1})}{\partial t} (t_1 - t_{o1}) \quad ()$$

$$F_{r2} = f_2(s_{o2}, t_{o2}) + \frac{\partial f_2(s_{o2}, t_{o2})}{\partial s} (s_2 - s_{o2}) + \frac{\partial f_2(s_{o2}, t_{o2})}{\partial t} (t_2 - t_{o2}) \quad ()$$

$$s_1 - s_{o1} = e_\theta \quad ()$$

(\delta)

$$\vec{\delta} = a\vec{i} + b\vec{j} \quad ()$$

$$s_1 - s_{o1} = e_\theta \quad ()$$

$$t_1 - t_{o1} = \vec{\delta}_\theta \cdot \vec{n}_1 + \delta_{r1\theta} = (a_\theta \vec{i} + b_\theta \vec{j}) \cdot (-\vec{j}) + \delta_r = -b_\theta + \delta_{r1\theta} \quad ()$$

$$t_1 - t_{o1} = \delta_{m\theta} + \delta_{r1\theta} \quad ()$$

$$\vec{F}_1 \quad \vec{n}_1$$

$$\delta_r = \frac{K_{roller}}{F_r} \quad ()$$

$$s_2 - s_{o2} = (t_1 - t_{o1})_{\theta-120} \quad ()$$

$$s_2 - s_{o2} = (t_1 - t_{o1})_{\theta-180} \quad ()$$



$\theta - 180$

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$$t_2 - t_{o2} = \bar{\delta}_\theta \cdot \bar{n}_2 + \delta_{r2\theta} = (a_\theta \bar{i} + b_\theta \bar{j}) \cdot (0.866\bar{i} + 0.5\bar{j}) + \delta_{r2\theta} = 0.866a_\theta + 0.5b_\theta + \delta_{r2\theta} \quad ()$$

$$t_3 - t_{o3} = \bar{\delta}_\theta \cdot \bar{n}_3 + \delta_{r3\theta} = (a_\theta \bar{i} + b_\theta \bar{j}) \cdot (-0.866\bar{i} + 0.5\bar{j}) + \delta_{r3\theta} = -0.866a_\theta + 0.5b_\theta + \delta_{r3\theta} \quad ()$$

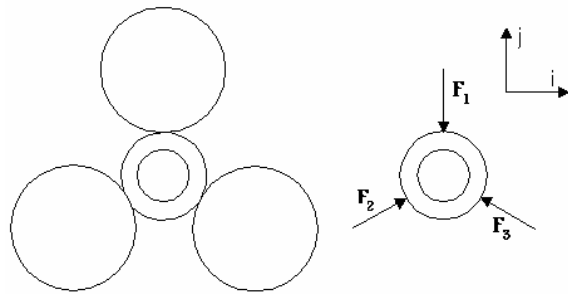
$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \vec{F}_m \quad ()$$

$$\vec{F}_m = K\vec{\delta} = K(a\bar{i} + b\bar{j}) \quad ()$$

$$\bar{n}_3 \quad \vec{F}_2 \quad \bar{n}_2 \quad \delta_{r2\theta} \quad \vec{F}_3 \quad \delta_{r3\theta}$$

$$s_3 - s_{o3} = (t_2 - t_{o2})_{\theta-120} \quad ()$$

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$$f_2(s_{o2}, t_{o2}) \quad f_1(s_{o1}, t_{o1})$$

$$f_3(s_{o3}, t_{o3})$$

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$$\frac{\partial f_1(s_{o1}, t_{o1})}{\partial s}$$

$$\frac{\partial f_2(s_{o2}, t_{o2})}{\partial s} \quad \frac{\partial f_1(s_{o1}, t_{o1})}{\partial t}$$

$$\frac{\partial f_3(s_{o3}, t_{o3})}{\partial s} \quad \frac{\partial f_2(s_{o2}, t_{o2})}{\partial t}$$

$$\vec{F}_1 + \vec{F}_2 = \vec{F}_m \quad ()$$

F_m

$$\frac{\partial f_3(s_{o3}, t_{o3})}{\partial t}$$

$$\vec{F}_m = K\vec{\delta} \quad ()$$

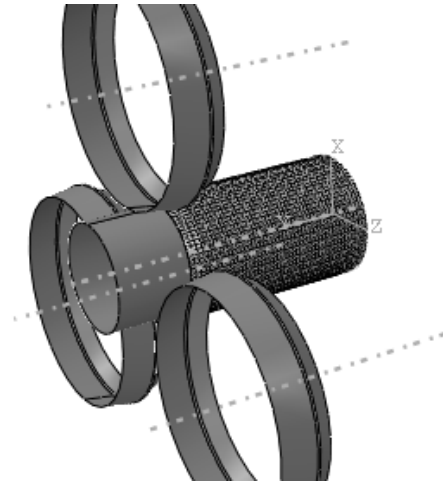
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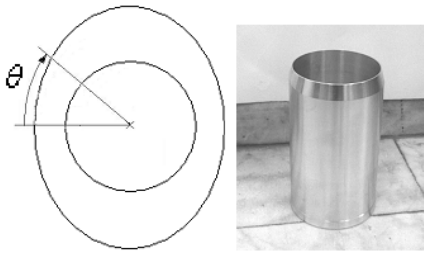
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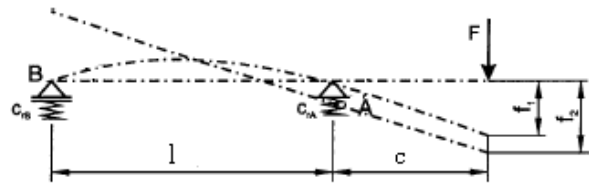
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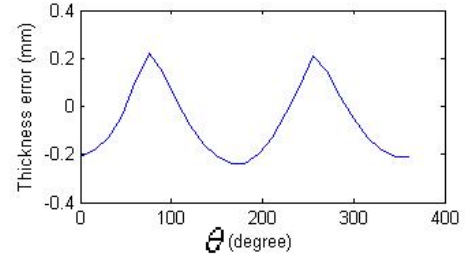
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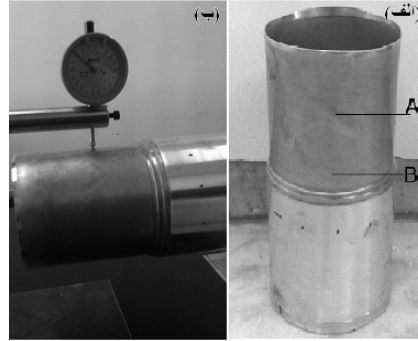
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/ (KN)	$f_1(s_{o1}, t_{o1})$
/ (KN)	$f_2(s_{o2}, t_{o2})$
/ (KN)	$f_3(s_{o3}, t_{o3})$
/ (KN/mm)	$\frac{\partial f_1(s_{o1}, t_{o1})}{\partial s}$
/ (KN/mm)	$\frac{\partial f_1(s_{o1}, t_{o1})}{\partial t}$
/ (KN/mm)	$\frac{\partial f_2(s_{o2}, t_{o2})}{\partial t}$
/ (KN/mm)	$\frac{\partial f_3(s_{o3}, t_{o3})}{\partial t}$
/ (KN/mm)	$\frac{\partial \tilde{f}_2(s_{o2}, t_{o2})}{\partial s}$
/ (KN/mm)	$\frac{\partial \tilde{f}_3(s_{o3}, t_{o3})}{\partial s}$
/ (KN/mm)	A
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/ (KN/mm)	



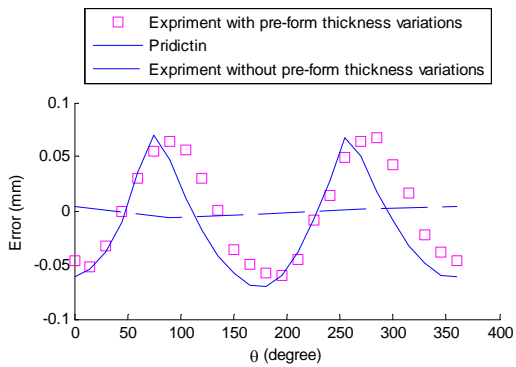
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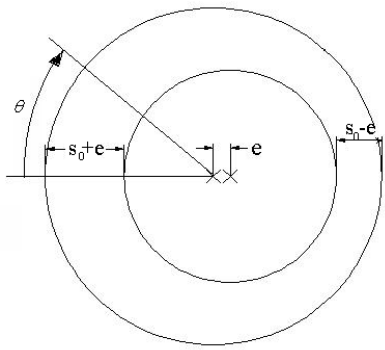
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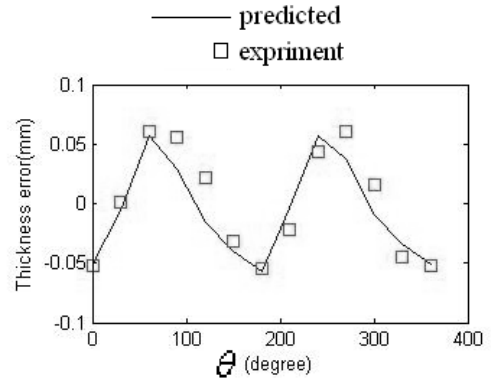
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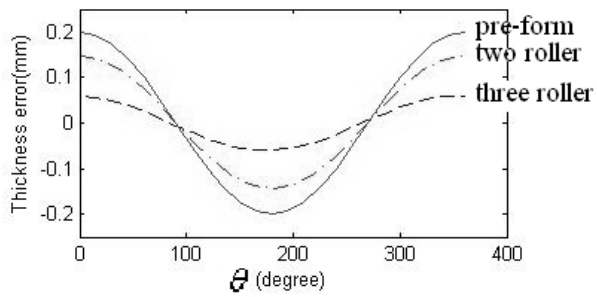
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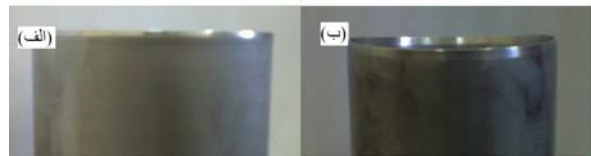
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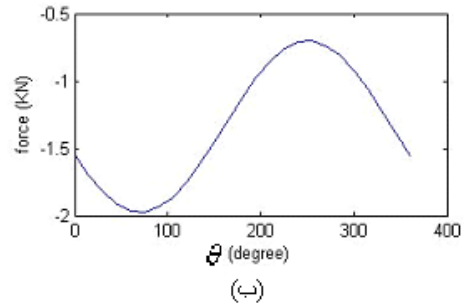
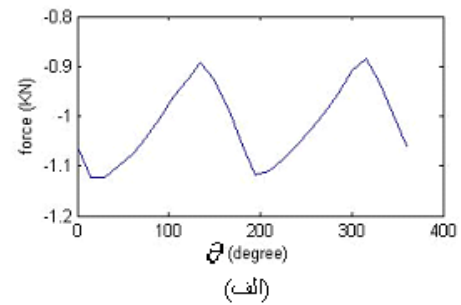
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Slab method
Stream function
Upper bound
Grid line
Hardness
Taguchi
Stiffness

