Analysis over the Deformation and Force Applied in Rolling

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Abstract— There are various type structures, machine components, tools and domestic appliances are made by rolling process. Besides it the long channels, railway lines etc. are also obtained by rolling process. It is clear that as well as the hardness of the workpiece material (metal or alloy) is increased the power or energy required for rolling process is also increased. So it is necessary to search such type factors which may improve the rolling process sufficiently. These factors may be change rolling technique, change in rollers, change in working parameters and change in workpiece material structure etc.

Keywords: Structures, Machine Components, Tools, Domestic Appliances, Rolling

I. Introduction

Generally to obtain the good bending strength and compressive strength the components are made by forging and rolling processes. The hot rolling process is good because here the less compressive force is required but by this oxidation is provided fastly over the upper surface of the component and a oxidized layer is provided. By this the upper surface of component becomes rough and a machining process is required to obtain finish over it. But in the cold rolling process the oxidizing or scaling problem is not created but here the large compressive force is required. So it is required that such type improvements should be provided which may help to minimize compressive force required in cold rolling process.

II. Methodology or literature survey

A. *Methodology Related to Change in Rolling Technique –*

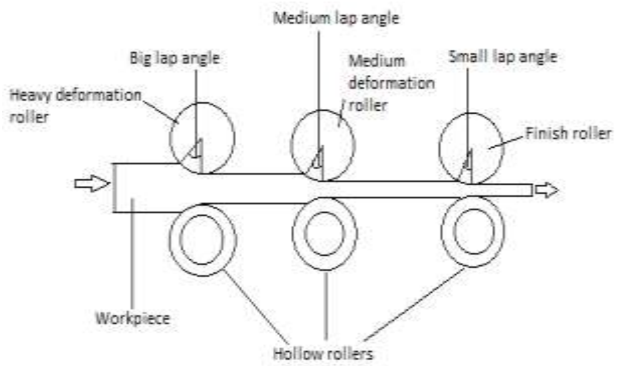

Fig. A:

If we want to obtain the final shape in single stroke of rolling then it will be to early and the product obtained will be defected completely. If it is obtained by using minimum three number of rollers as given fig.(A) the product obtained will be clear with the surface finish. Besides it if some changes are provided in rolling technique the required shape product may be obtained easily in less time on consuming less effort or compressive force. Here if the total deformation is provided in number of steps by using three same number of rolling pairs as given fig.(A) where the first rolling pair creates the 40 % deformation, second rolling pair also creates the 40 % deformation and the last creates only 20 % deformation.

The initial two rolling pairs create the deformation at some above the lower critical temperature while the third rolling pair creates the deformation at some below the lower critical temperature so that the scaling problem is avoided sufficiently. The last rolling pair provides the surface finish over the surface of product and avoids the external and internal surface defects because here the angle of lap is reduced sufficiently.

B. *Methodology Related to Material Used for Rollers –*

First the hardness of roller should be 4 to 5 times minimum the material to be rolled. The proper lubrication is necessary between the contact surfaces of the roller and material to be rolled to avoid the friction. For this we can use the lubricant externally. But if the lubricating element is mixed already with roller material then it will provide lubrication automatically between roller and workpiece material surfaces. Besides it if the workpiece material structure is refined and improved by using heat treatment processes as in normalizing then the deformation is provided easily and uniformly. The roller speed should be provided such that the there is no defect over the product surface after passing from the second stage.

C. *Methodology Related to the Weight of Roller –*

If the weight of upper roller is increased and the weight of lower roller is decreased then the weight of upper roller will add with force required for deformation. By this the externally amount of force applied for deformation will reduce and by this energy required to drive the rollers also will be reduced. Here there is no advantage of the weight of the lower rollers so its weight should be reduced but these lower rollers should be strengthfull and stable to support the heavy upper force.

Mean the lower rollers should be made hollow but should be made of hard and tough material.

III. Analysis

A. *Analysis over the relationship between compressive force applied (F_C), density of material of the product (ρ), size of particles of product material (Z), area of surface in contact (A), temperature of body (T), resistive strength of the material of the body (S) and the time (t) –*

By using Buckingham's π theorem →
$f(F_C, \rho, Z, A, t, T, S) = 0$
→ Equation (A)
Then number of variables (n) = 7
Now on putting the all dimensions of all variables →
$F_C = (MLT^{-2})$, $\rho = (ML^{-3})$, $Z = (L^3)$, $A = (L^2)$, $S = (ML^{-1}T^{-2})$, $T = (\theta)$, $t = (T)$
So the number of dimensions (m) = 4

So the number of π – terms = 7-4 =3
So we write as $f_1(\pi_1, \pi_2, \pi_3) = 0$ → Equation (B)
Where $\pi_1 = (A^{a1} * T^{b1} * \rho^{c1} * t^{d1} * F_C)$ → Equation (C)
$\pi_2 = (A^{a2} * T^{b2} * \rho^{c2} * t^{d2} * S)$
→ Equation (D)
$\pi_3 = (A^{a3} * T^{b3} * \rho^{c3} * t^{d3} * Z)$ →Equation (E)
Now on putting the all dimensions on both sides in Equation(C) →
$(M^0L^0T^0) = \{ (L^2)^{a1} * (\theta)^{b1} * (ML^{-3})^{c1} * (T)^{d1} * (MLT^{-2})\}$
On comparing the dimensions on both sides →
2a1-3c1+1 = 0 → Equation (F), c1 + 1= 0 or c1 = -1 , then from Equation (F) → a1 = -2
$b_1 = 0$, $d_1 - 2 = 0$ or $d_1 = 2$
then again from Equation(C) →
$\pi_1 = (A^{-2} * T^0 * \rho^{-1} * t^2 * F_C)$
$\pi_1 = (F_C t^2/\rho A^2)$ → Equation (G)
Now on putting the all dimensions on both sides in Equation(D) →
$(M^0L^0T^0) = \{ (L^2)^{a2} * (\theta)^{b2} * (ML^{-3})^{c2} * (T)^{d2} * (ML^{-1}T^{-2})\}$
On comparing the dimensions on both sides →
2a2-3c2-1 = 0 →Equation (H), c2 + 1 = 0 or $c_2 = -1$
then from Equation(H) →a2 = -1
$d_2 - 2 = 0$ or $d_2 = 2$, $b_2 = 0$
then again from Equation (D)
$\pi_2 = (A^{-1} * T^0 * \rho^{-1} * t^2 * S)$
$\pi_2 = (t^2 S / \rho A)$ → Equation (I)
Now on putting the all dimensions on both sides in Equation(E) →
$(M^0L^0T^0) = \{ (L^2)^{a3} * (\theta)^{b3} * (ML^{-3})^{c3} * (T)^{d3} * (L^3)\}$
On comparing the dimensions on both sides →
2a3-3c3+3 = 0 →Equation (J) c3 = 0 , then from equation (J)
a3 = -3/2 , $d_3 = 0$, $b_3 = 0$
then again from Equation (E)
$\pi_3 = (A^{-3/2} * T^0 * \rho^0 * t^0 * Z)$
$\pi_3 = (Z/A^{3/2})$→ Equation (K)
then from equation (B) → $f_1(F_C t^2/\rho A^2, t^2 S/\rho A , Z/A^{3/2}) = 0$
$F_C t^2/\rho A^2 = \phi (t^2 S/\rho A , Z/A^{3/2})$
$F_C = \rho A^2/t^2 \, \phi (t^2 S/\rho A , Z/A^{3/2})$
$F_C = \rho AZ/t^2 A^{1/2} \phi(t^2 S A^{1/2}/\rho Z , 1)$
→ Equation (L)
If $\phi(t^2 S A^{1/2}/\rho Z , 1)$ is constant then from equation (L) →
$F_C \; \alpha \; \rho A^{1/2} Z/t^2$ Equation (M)
Hence from equation (M) it is clear that to decrease the value of F_C the values of ρ, A, Z should be low.

B. Analysis over the relationship between weight of roller (W), force applied for deformation (F_C), density of workpiece material (ρ), linear velocity of roller (v), volume of material to be deformed (V) –

Then by Buckingham's π theorem →
$f (V, v, W, \rho, F_D) = 0$ → Equ.(A)
So the number of variables
(n) = 5

Now on putting the dimensions of all variables →
$V = (L^3)$, $v = (LT^{-1})$, $\rho = (ML^{-3})$, $W = (MLT^{-2})$, $F_D = (MLT^{-2})$
So it is clear that the number of dimensions (m) = 3
So the number of π terms = 5-3 = 2

So we can write as $f_1(\pi_1 ,\pi_2) = 0$ → Equ.(B), where
$\pi_1 = (V^{a1}.v^{b1}.W^{c1}.\rho)$ → Equ.(C)
$\pi_2 = (V^{a2}.v^{b2}.W^{c2}.F_D)$ → Equ.(D)
Now on putting the all dimensions at both sides of the equation (C) →
$(M^0L^0T^0) = \{(L^3)^{a1}. (LT^{-1})^{b1}(MLT^{-2})^{c1}. (ML^{-3})\}$

On comparison of dimensions at both sides →
$3a_1 + b_1 + c_1 - 3 = 0$ Equ.(E) $c_1 + 1 = 0$ or $c_1 = -1$ - $b_1 - 2c_1 = 0$ or $b_1 = 2$
Then from equation (E)→ $a_1 = 2/3$
Then again from equation(C) –
$\pi_1 = (V^{2/3}.v^2.W^{-1}. \rho)$
$\pi_1 = \{ \rho v^2 / WV^{2/3} \}$ → Equ.(F)
Now on putting the all dimensions at both sides of the equation (D) →
$(M^0L^0T^0) = \{(L^3)^{a2}. (LT^{-1})^{b2}(MLT^{-2})^{c2}. (MLT^{-2}) \}$
On comparison of dimensions at both sides →
$3a_2 + b_2 + c_2 + 1 = 0$ Equ.(G) $c_2 + 1 = 0$ or $c_2 = -1$ and - $b_2 - 2c_2 - 2 = 0$ or $b_2 = 0$
Then from equation(G)→ $a_2 = 0$
Then again from equation(D) –

$\pi_2 = (V^0.v^0.W^{-1} . F_D)$
$\pi_2 = \{ F_D/ W\}$ → Equ.(H)
Then from equation (B) →
$f_1 (\rho v^2 / WV^{2/3}, F_D/ W)$ → Equ.(I)
$\rho v^2 / WV^{2/3} = \phi (F_D/ W)$
$v^2 = WV^{2/3}/\rho \; \phi (F_D/ W)$
If $\phi (F_D/ W)$ is constant then →
$v \; \alpha \; (WV^{2/3}/\rho)^{1/2}$ → Equ.(J)
According equation (J) it is clear that if the value of W is taken constant then to obtain the high deformation by volume (V) the value of density of workpiece material (ρ) should be low.

IV. Final Result

So it is clear that if some changes are provided in roller, s shape and size and working parameters the effective results may be obtained and by this the energy is consumed and productivity is increased.

V. Conclusion

Sometimes the required changes in tool geometry, machining parameters, technique and physical conditions may provide the better results which may help in increasing the production capacity of the cell.

VI. References of the Books

[1] Buckingham, s π theorem, Fluid Mechanics, Author R.K Bansal.
[2] Manufacturing science, Author Amitabh Gosh and Asok Kumar Malik.
[3] Material science, Author K.M Gupta.