Design an Interactive System for Construction the Cold Rolling Line

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Abstract

Thermal expansion of rolled material can threaten the mechanical dimensions if they are heated, this heat can softening the metal. Aluminum cold rolling strips are reduced to tight mechanical tolerances. Strips below the critical temperature run faster without loss any properties of metal. Due to friction between metal and rolls, metals suffer high compressive stresses through operation until the final product. Products of cold rolling are with high surface finishing and good mechanical properties. Cold rolling assist to close product dimensions. We are modeling the cold rolling mill by studying all factors affected and relations between them, so we improved the mill productivity with high quality and low loss scrap for products. We are also scheduling the cold rolling process to reach the optimal throughput.

Key words: Cold rolling, Strips, Mill, Thickness, Pass, Slab, Productivity.

Introduction

Various shapes can be cold rolled if the cross section is relatively uniform and the transverse dimension is relatively small. Cold rolling shapes requires a series of shaping operations. Cold rolling process was developed to increase quality of strip and productivity of rolling mill. [1] presents optimal scheduling for tandem cold rolling mill based on genetic algorithm. [2] has applied nonlinear simplex optimization method for cold rolling mill process parameters, also developed set up on optimization system to calculate cold rolling process parameters. [3] present adaptation procedure for setting up generation of cold rolling mill at Cosipa plant Brazil. [4] developed two combination method used for optimization of rolling process parameters according chatter phenomenon. Friction factor, reductions, tensions and strip, speed were selected as design factors. First combination method is central composite design of experiment and response surface methodology. The result shows 29% increase in rolling speed using first method. Taguchi method of design of experiment and neural network technique used in second combination method. More than 26% growth in critical speed achieved using second method. He infers that increasing all reductions and rolling speed, increases the risk of chatter severely. However, tensions have very little effect on chatter phenomenon while friction coefficient should be maximize to avoid chatter. [5] presented computational Intelligence based process modeling and optimization for tandem cold rolling mill process in order to maximized throughput and minimize cost and crop losses. [6] develop heuristic optimum design of rolling schedules for cold rolling Mills. [7] presented paper on optimization of cooling spray water in cold strip mill to optimize the amount of cooling spray water that can contribute to the shape performance of the final strip products. [8] set up optimization for tandom cold mills. [9] using an accurate and rapid new mode for mill deflection. [10] using neutral networks to determine thickness through the sensitivity method. [11] analysis roll load prediction [12] study algorithm to select optimal neutral network of hot rolling process. [13]-[14] study roll processing of steel. Other researchers study multi parameters affected on cold rolling.

The Research Methodology

Methodology of the research according to the following tab:

1. Objective of Research: The research aims at identifying the designing a model which studying all factors affected on cold rolling process and relations between all of them to improve mill productivity with high quality and low loss scrap.

2. Importance of Research: Developed and increase the quality of strip and overall productivity of rolling mill.

3. Problem of Research: It embodied the problem of this study of the low production and uncontrolled automatically on production**.**

Mathematical Modelling of Cold Rolling Process

The method at which the resistance to deformation equation obtained from Alder and Phillip's curves to enable us to use it in this model is as shown in Fig (1). Analysis is as shown below:

A- At temperature (150 ºc)

1- at λ 1

$K = a_1 + a_2 \times r + a_3 \times r^2$ …………………(1)

2- at λ 2

$K = b_1 + b_2\ rx\ r + b_3\ r^2$ …………………….……(2)

3- at λ 3

$K = c_1 + c_2\ r + c_3\ r^2$ ……………………..(3)

4- at λ 20

$K = z_1 + z_2 r + z_3 r^2$ ……………………..(4)

Relations obtained between (λ, y_1)(λ, y_2), (λ, y_3) as shown.

$Y_1 = a_{11} + a_{22}\lambda + a_{33}\lambda^2$ ……………………………………………..……..(5)

$Y_2 = b_{11} + b_{22}\lambda + b_{33}\lambda^2$ ……………………………………………….……(6)

$Y_3 = c_{11} + c_{22}\lambda + c_{33}\lambda^2$ ………………………………………………….… (7)

The resistance to deformation for temperature obtained by $K_{T=150} = (a_{11} + a_{22}\lambda + a_{33}\lambda^2) + (b_{11} + b_{22}\lambda + b_{33}\lambda^2) + xr + (c_{11} + c_{22}\lambda + c_{33}\lambda^2) \times r^2$ ……………………………………………………………..…….. (8)

B- At temperature (250 ºc)

The resistance to deformation for other temperatures as shown;

$K_{T=250} = (a_{111} + a_{222}\lambda + a_{333}\lambda^2) + (b_{111} + b_{222}\lambda + b_{333}\lambda^2) + xr + (c_{111} + c_{222}\lambda + c_{333}\lambda^2) \times r^2$ ………………………….……………… ….…………(9)

C- At temperature (450 ºc)

$K_{T=450} = (a_{1m} + a_{2m}\lambda + a_{3m}\lambda^2) + (b_{1m} + b_{2m}\lambda + b_{3m}\lambda^2) + xr + (c_{1m} + c_{2m}\lambda + c_{3m}\lambda^2) \times r^2$ ……………………………………………………….………...(10)

D- At temperature (550 ºc)

$K_{T=550} = (a_{1f} + a_{2f}\lambda + a_{3f}\lambda^2) + (b_{1f} + b_{2f}\lambda + b_{3f}\lambda^2) + xr + (c_{1f} + c_{2f}\lambda + c_{3f}\lambda^2) \times r^2$ ………………………………………………………………………...(11)

E- At temperature (650 ºc)

$K_{T=650} = (a_{1j} + a_{2j}\lambda + a_{3j}\lambda^2) + (b_{1j} + b_{2j}\lambda + b_{3j}\lambda^2) + xr + (c_{1j} + c_{2j}\lambda + c_{3j}\lambda^2) \times r^2$ ………………………………………………………………….….. (12)

Relations obtained by fitting between (Te, y_{ll}), (Tie, y_{22}), (Te, y_{33}) are shown

$Y_{ll}\ a_{1111} + a_{2222}\,Te + a_{3333}Te^2 = F_1(Te)$ …………………(13)

$Y_{11} = b_{1111} + b_{222}Te + b_{3333} = F_1(Te)$ …………………(14)

$Y33 = c_{1111} + c_{222}Te + c_{3333} = F_1(Te)$ ………………… (15)

Relations obtained between (Te, y_{lll}) (Te, y_{222}), (Te, y_{333}) are shown

$Y_{111} = a_{1v} + a_{2v}Te + a_{v3}\,Te^2 = F_4(Te)$ ……………………………………….(16)

$Y_{111} = b_{1v} + b_{2v}Te + b_{v3}\,Te^2 = F_5(Te)$ ………………………………… …...(17)

$Y_{111} = c_{1v} + c_{2v}Te + c_{v3}\,Te^2 = F_6(Te)$ ………………………………………(18)

Relations obtained between (Te, y_{1111}), (Te, y_{2222}), (Te, y_{3333}) are shown

$Y_{1111} = a_{11v} + a_{22v}Te + a_{v33}\, Te^2 = F_7(Te)$

$Y_{1111} = b_{11v} + b_{22v}Te + b_{v33}\, Te^2 = F_8(Te)$

$Y_{1111} = c_{11v} + c_{22v}Te + c_{v33}\, Te^2 = F_9(Te)$

The general form of the theoretical resistance to deformation obtained
$K=[F_{1(Te)}+F_{2(Te)}\ \lambda\ F_{3(Te)}\lambda\ 2] + [F_{4(Te)} + F_{5(Te)}\lambda\ F_{6(Te)}\lambda 2]\ x\ r + [\ F_{7(Te)} + F_{8(Te)}\lambda + F_{9(Te)}\lambda 2]xr\ 2$

So we can say that the resistance to deformation (K) is a function of (reduction, Temperature, and strain rate)

Where ; $(\lambda\, 1 \ldots \lambda 20)$ = strain rate: r = reduction : K = resistance to deformation ai ,bi, ci, zi = constants: Te = Temperature.

Consider the forces acting on the vertical element plane section of the sheet of width (dx), measured in the direction of rolling, the height of the element (H) is situated at a distance (z) from the line joining the roll centers and lying between the entry plane and the neutral plane. The forces acting on the element are, the tangential friction force and the radial pressure force. The analysis of this affecting forces are;

1. The vertical and the horizontal radial pressure forces.
The forces affecting on the element with the area (ax) due to radial pressure effectivetly.

Pr = F/A ………………(19)

F = Pr dx ……………...(20)

cosØ = Pr dx cosØ …………….. (21)

Fv =Pr dx / cosØ ………………(22)

sin Ø = FH / (Prdx / cosØ) ………………(23)

FH =Pr cosØ dx /sinØ ……………...(24)

FH = Pr tan Ø dx ……………… (25)

2.The horizontal and the vertical tangential friction forces.
The forces are effecting on the unit element.

$\mu =$ Ft /Fv …………….. (26)

$\mu =$ Ft (Prax COSØ) …………….. (27)

$Ft = \mu$ Prax / cos∅ ……………...(28)

cos∅ = Fth / Ft ……………. (29)

Fth = Ft cos∅ ……………. (30)

Substitute eq (28) into eq. (30), obtain.

Fth = μ Prdx ……………… (31)

sin∅ = Ftv /Ft ……………….(32)

substitute eq (28) into eq. (32) obtain

Ftv =μ Pr tan ∅ dx ……………… (33)

3.The horizontal stresses acting on the segment in the direction of rolling.

The stresses are affecting on the unit element.

A_1 =H * 1= H ………………. (34)

$\sigma = F_1/\ A_1$ ………………. (35)

substitute eq. (34) into eq. (35) obtain,

F1 = σ * H ……………....(36)

A_2 = (H + dH) *1 ……………… (37)

$\sigma = d\sigma = F_2/\ A_2$ ……………… (38)

F_2 = $(\sigma + d\sigma)$ (H+ dH) : F1=-F2 ……………… (39)

4.The resultant of the equilibrium horizontal forces, radial pressure horizontal force forces due to horizontal stresses.

The forces due to horizontal stresses balanced the difference between the radial pressure horizontal force and the tangential friction horizontal.

ε of horizontal forces

2 Pr tan ∅d x 2 μ Pr = $(\sigma + d\sigma)$ (H+ dH) - σH ………….(40)

2Pr (tan∅ $\mp \mu)\ dx = d\ (\sigma H\ )$ ………… (41)

but; μ tan f sbstitue (40) in to (41) obtian.

Pr (ten∅ $\mp$ tan f) =d (σ H/2) /dx ………….(42)

- \- = refers to equation from entry plane to neutral. plane.
- \+ = refers to equation from neutral plane to exit plane .

The force pax is the vertical component of the force (Prax / cos∅) hence ;

Pax = (Pr dx / cos∅) * cos ∅ Pr dx ……………....(43)

P = Pr ……………...(44)

From Fig. (B-1)

tan ∅ (dH/2) / dx = $\frac{1}{2}\frac{dH}{dX}$ …………… (45)

substitute eq. (43), eq. (44) into eq. (42), obtain:

$\frac{1}{2}\ P\ \frac{dH}{dX} \mp$ Pten f $= d\ (6H/\ 2)\ /\ dx$ ……………(46)

5.The resultant of the equilibrium vertical force, radial pressure, vertical force, tangential friction vertical force.

the vertical forces are affecting on the element.

P_1dx =Fv + Ftv …………… (47)

P_1 dx = prdx + μ pr tan ∅ dx ……………. (48)

Substitute eq . (27) into eq. (31) obtain

P_1 dx = p (1+ μ tan ∅) dx ……………...(49)

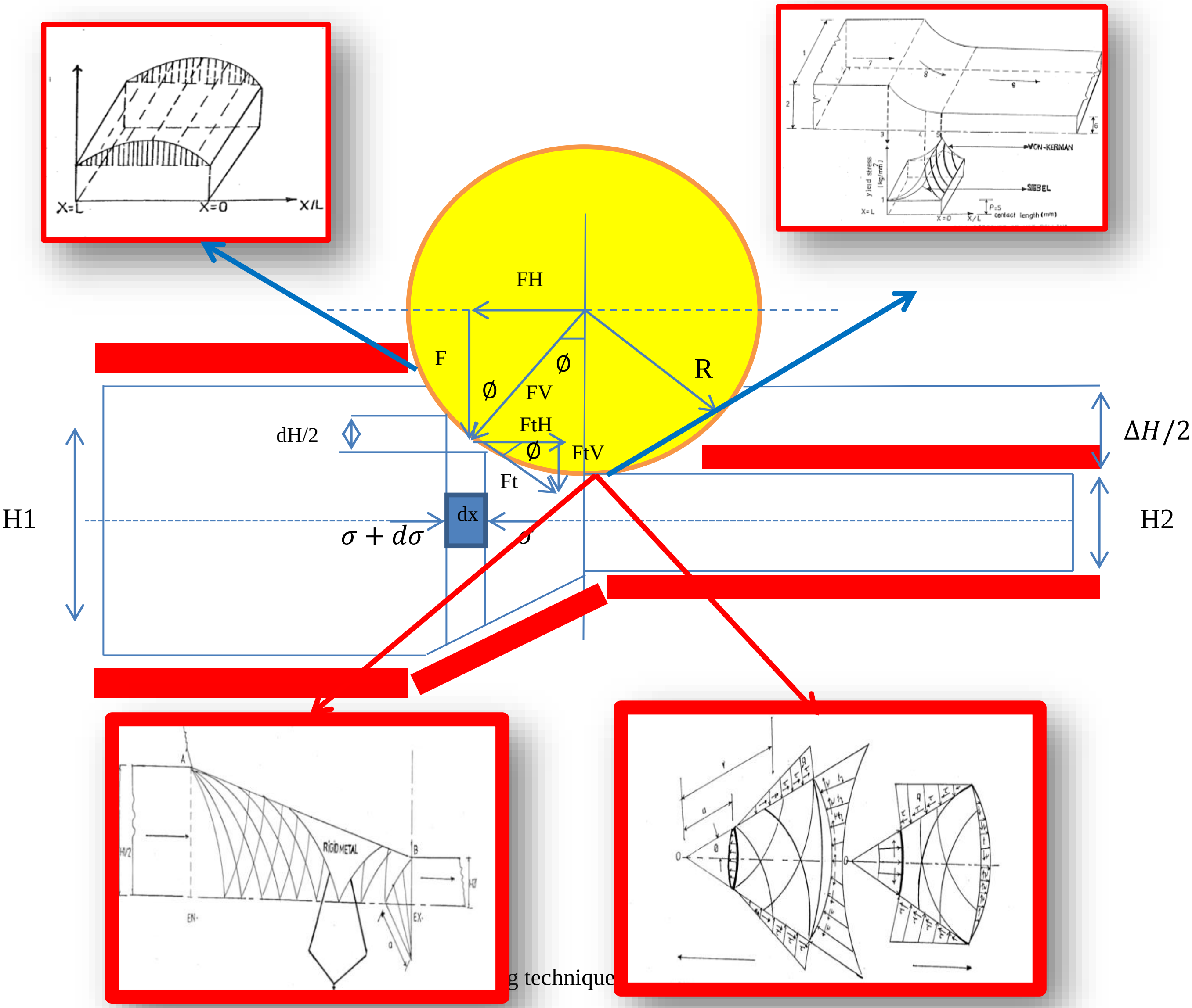
P_1 = p(1 + μtan ∅) ……………..(50)

P - $\sigma = s$ ……………..….(51)

$\sigma = p - s$ ……………..….(52)

substitute eq. (52) into eq. (47) obtain,

$\frac{1}{2}\ P\ \frac{dH}{dX} \mp P$ tanf =d [$\frac{H}{2}\ (P - S)$] / dx ……………... (53)



g technique

Cold rolling process occurs at room temperature, room temperature increased strip strength and improved the final surface finishing. Cold rolling products are smaller than hot rolling products. Metals thickness at cold rolling cannot reduced as in hot rolling at single pass. Cold rolling used to produce a smooth surface, uniform thickness, and reduce the yield point of metal, it locks dislocations at the surface and thereby reduces the possibility of formation bands.

At beginning the slab temperature must be between (500-530^{o}c). The slab must be is at the center line of rolling mill. Rolls speed must not more than (80mt/min). The slab enters between the two rolls, emulsion oil must continue to schedule completed. Rolling process continued by reversing the direction of rotation of the line for the next pass until the final product thickness reachs (6.5-7mm), the process continued at room temperature until reached (1.5mm), The total number of passes must be odd. Load is an important factor affected on rolling process, it depends on yield stress and resistance to deformation of metal as shown in Fig. (3), behavior of load along processing line is shown in Fig. (9). Reduction, strain rate, and temperature are depending on many factors like, yield stress, ultimate tensile strength, elongation, and hardness of metal. The final metal production is depending on load, reduction percent, time, and temperature, which dropped until reach room temperature. The ductility of the rolled material is very important mechanical property because the metal with the higher ductility bears higher stresses during deformation before fracture occurs and the ability of the metal for forming will increase, so that it is very important at mechanical forming processes, metals ductility governs the maximum draft that's must be taken at each pass without the risk of surface cracks. Effect of pass No on temperature and inner thickness is shown in Fig (2) , while Behavior of temperature along processing line is shown in Fig (8). We see from Fig (4) the change of resistance during total schedule, deformation of slab along processing line is shown in Fig (10). Percentage reduction during total schedule is shown in Fig (5), while reduction of slab along processing line is shown in Fig (11). Time needed to complete one schedule is shown in Fig (6), but schedule time needed to for final product is shown in Fig (12). The final slab length after end of processing is shown in Fig (7), behavior of processing to get final slap length is shown in Fig (13). Relation between strain rate, time, and resistance to deformation is shown in Fig (14). Relation between strain rate, time, and temperature is shown in Fig (15). Relation between Strain rate, pressure, and reduction is shown in Fig (16). Relation between, pressure, input thickness, output thickness, and length is shown in Fig (17), while the relation between, time, productivity, and no of passes is shown in Fig (18). As mention above, we work hard to connect these relations practically, these factors are related with them to governing the cold rolling technique to get final products with have high mechanical specifications.

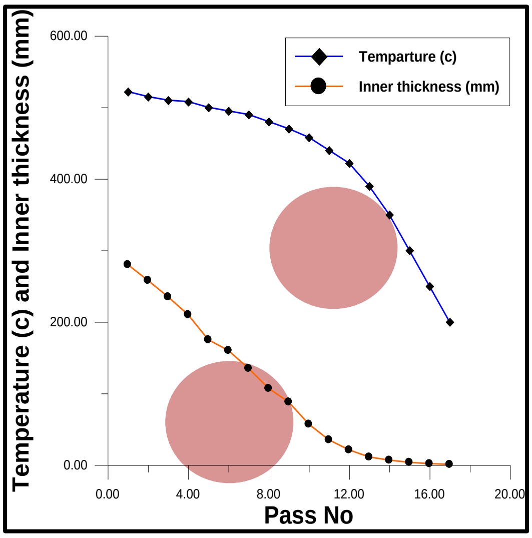


Fig. (2) Effect of pass No on temperature and inner thickness

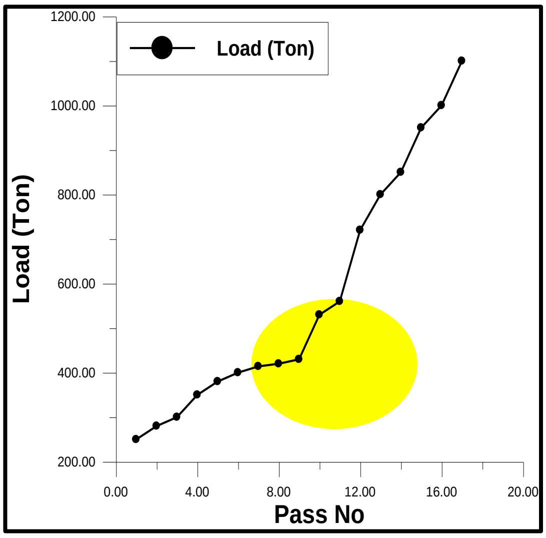


Fig. (3) Roils pressure through operation

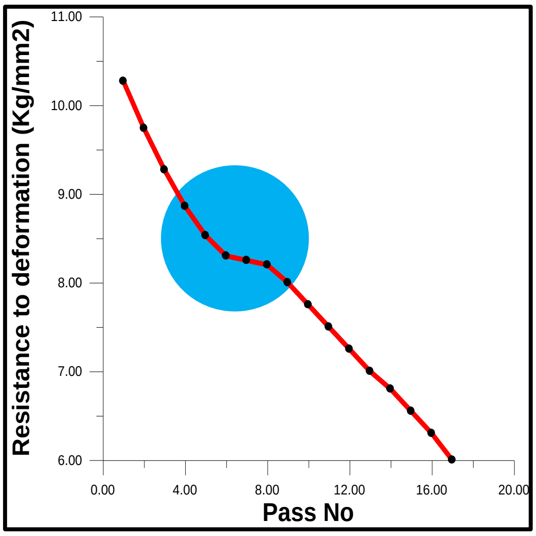


Fig. (4) Change of resistance during total schedule

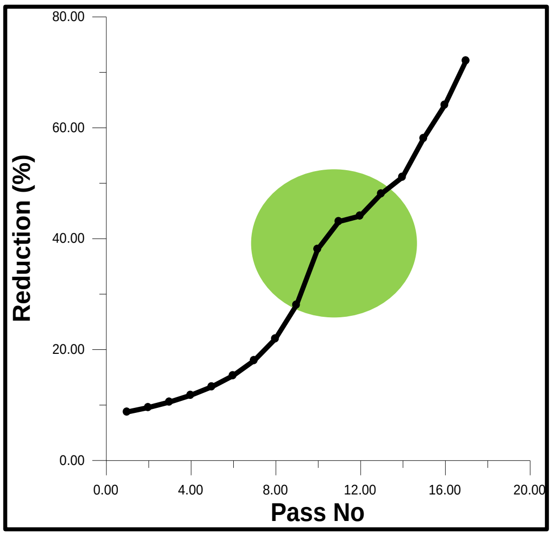


Fig. (5) Percentage reduction during total schedule

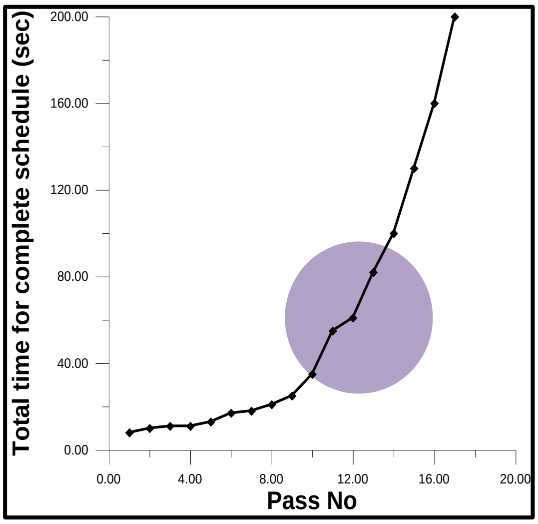


Fig. (6) Time needed to complete one schedule

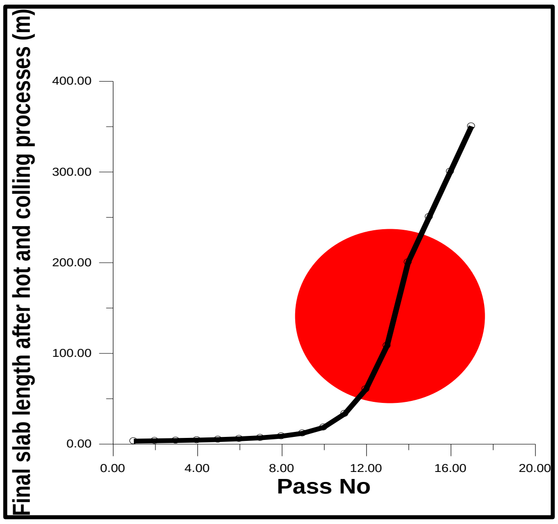


Fig. (7) Final slab length after cold rolling process

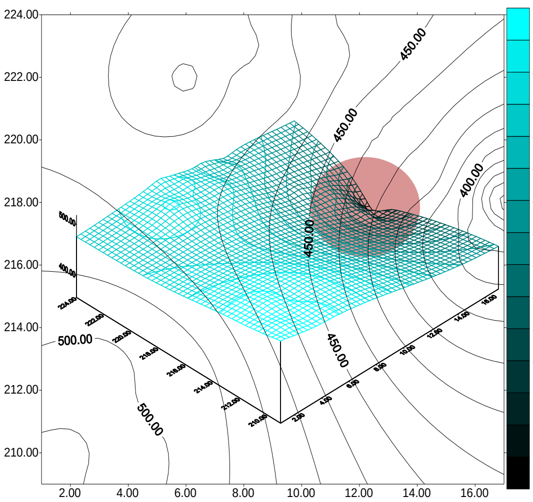


Fig. (8) Behavior of temperature along processing line

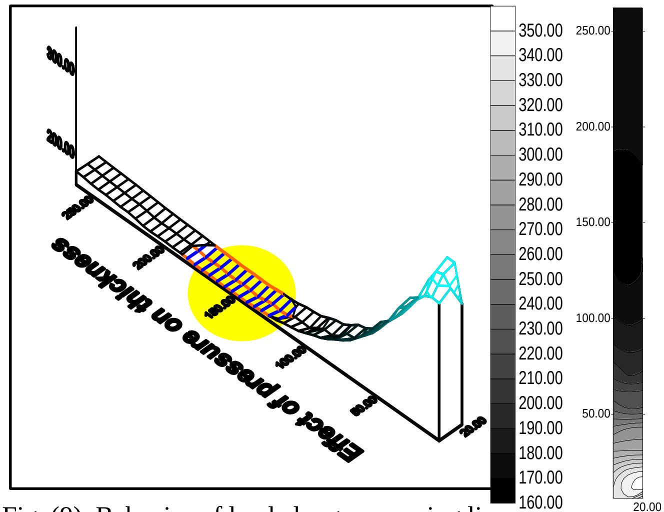


Fig. (9) Behavior of load along processing line

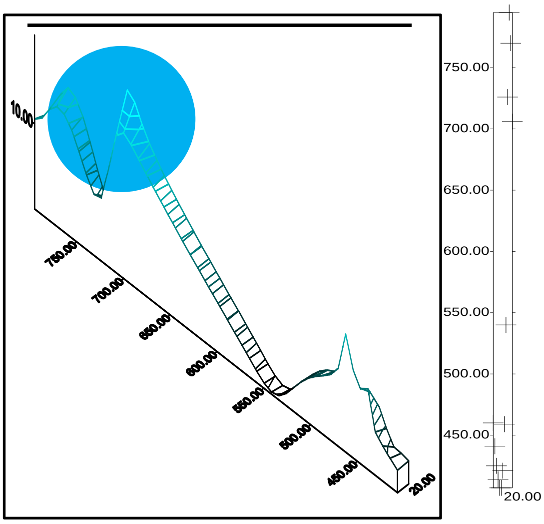


Fig. (10) Deformation slab along processing line

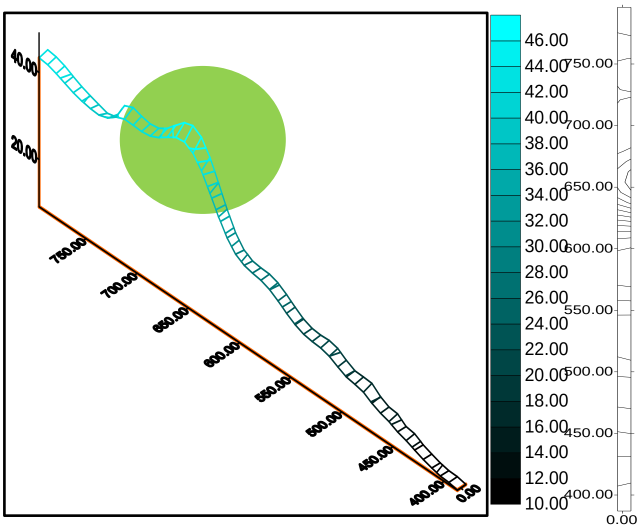


Fig. (11) Reduction of slab along processing line

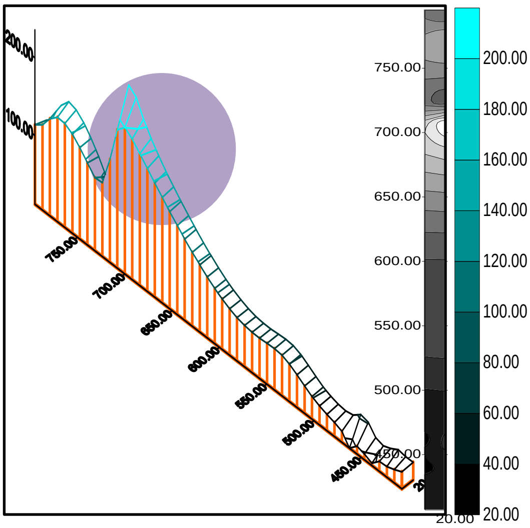


Fig. (12) Time needed to complete schedule

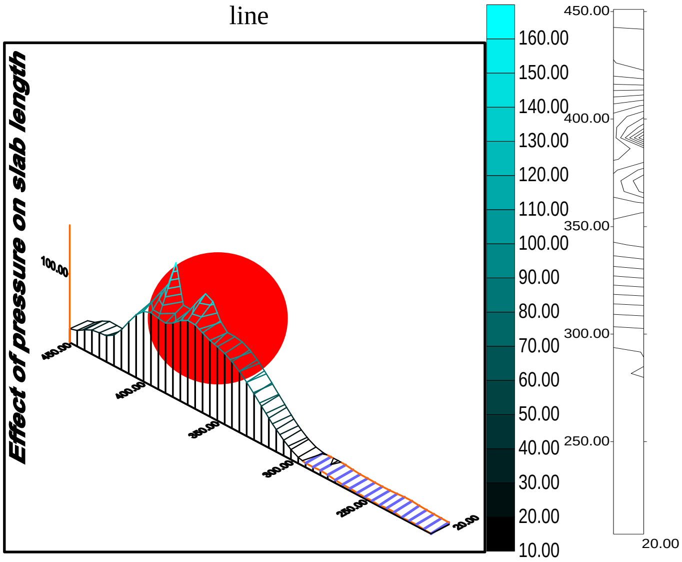


Fig. (13) Change strip length along processing line

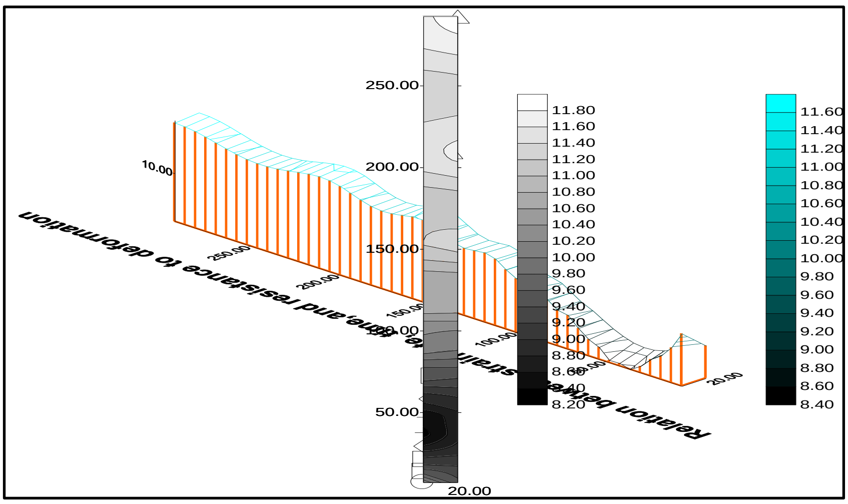


Fig. (14) Relation between strain rate, time, and resistance to deformation

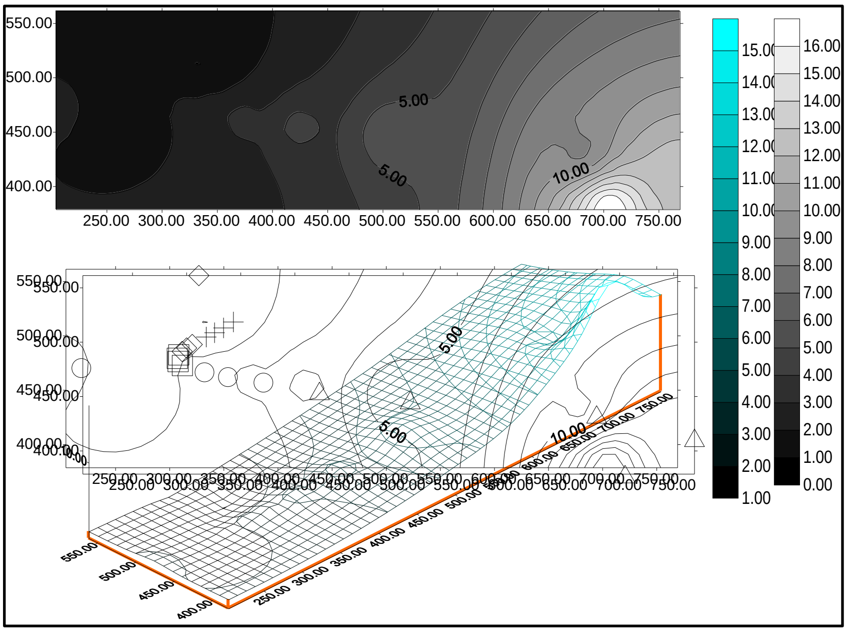


Fig. (15) Relation between strain rate, time, and temperature

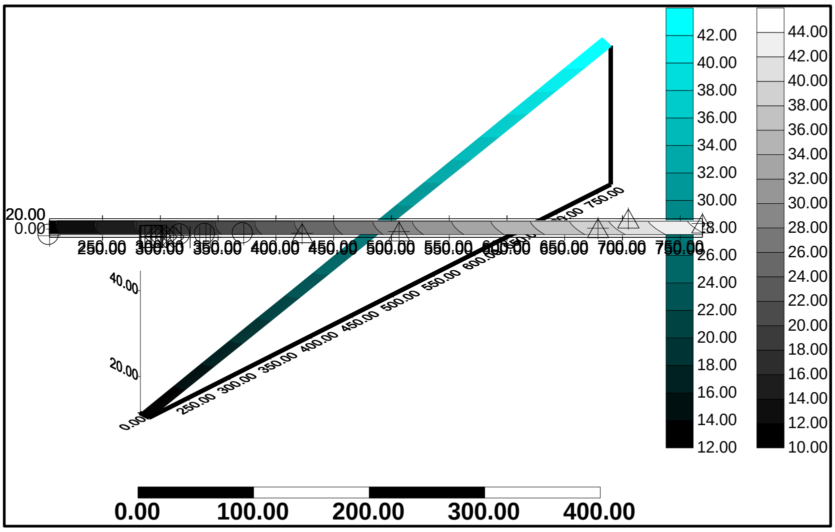


Fig. (16) Relation between Strain rate, pressure, and reduction

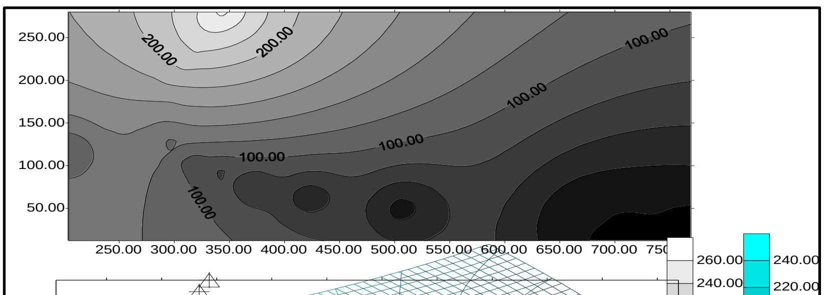


Fig. (17) Relation between, pressure, input thickness, output thickness, and length

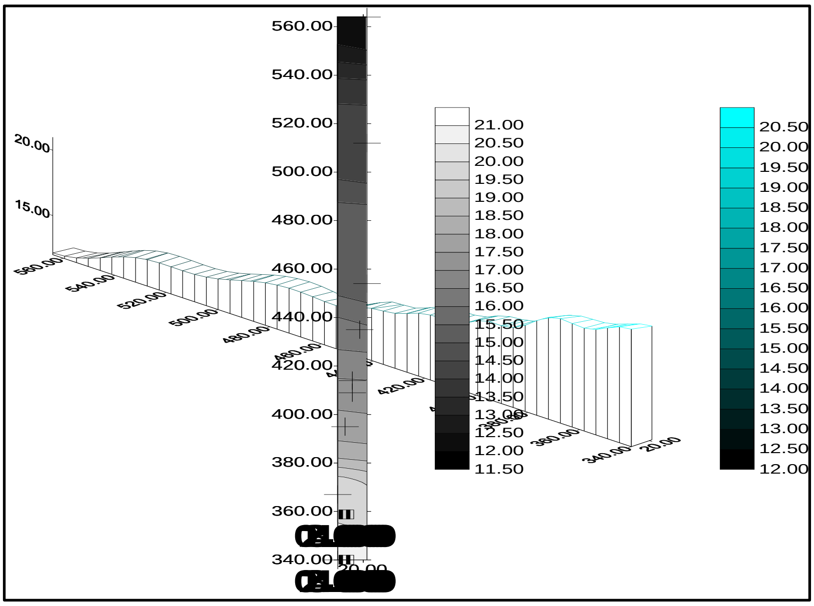


Fig. (18) Relation between, time, productivity, and no of passes

Conclusion

Modeling of cold rolling process will improve the mill productivity with high quality and low loss scrap for products. We are scheduling the cold rolling process. Cold rolling shapes requires a series of shaping operations Cold rolling products are smaller in comparison with the hot rolling products. We are beginning with temperature equals to 530 c^{o} and ending at room temperature. Cold rolling process produced smooth surfaces and uniform thickness. Metals ductility is very important because the metal with the higher ductility bears higher stresses during operation before the fracture occurs. We discuss such important relations between many factors to reach the optimal throughput of rolling mill.

Acknowledgements

The authors are grateful to all who assist them in this work.

CONFLICT OF INTERESTS.

There are non-conflicts of interest.

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الخلاصة

التمدد الحراري للمادة المدرفلة هو المتغير الأساسي لتغيير الابعاد الرئيسية للمادة اثناء عملية التشغيل. ان تسخين المادة يؤدي الى تليين المادة كي تكون قابلة للتشغيل والتشكيل النهائي. ان شرائط الألومنيوم المدرفلة على البارد يتم تغييرها نتيجة التأثير الحراري الى البعد المطلوب، ان شرائط الدرفلة على البارد عند تعرضها الى درجة حرارية اقل من الدرجة الحرارية الحرجة يكون تغييرها اسرع بدون فقدان أي خاصية من الخصائص الميكانيكية، ولكن بسبب معامل الاحتكاك العالي بين المادة واسطوانة الدرفلة فان المادة تتعرض الى اجهادات ضغطية عالية خلال مراحل التشغيل وصولاً الى المنتج النهائي. المنتج النهائي يتميز بسطح تشغيلي جيد ومواصفات ميكانيكية مقبولة كذلك. الدرفلة على البارد تحاول الحفاظ على الابعاد الحقيقية للمنتج المطلوب. نحن صممنا موديلاً رياضياً يتضمن كافة المتغيرات التشغيلية للحصول على المنتج النهائي بكفاءة جيدة، لذا وبوساطة استخدام هذا النموذج تم تحسين الخواص الميكانيكية بجودة عالية بمفقودات بعدية بسيطة من خلال جدولة المتغيرات الأساسية للحصول على الإنتاج المثالي لخط الدرفلة على البارد.