BEHAVIOUR OF SOME IMPORTANT COMPONENTS IN A COLD ROLLING MILL

**Stefan DRAGOMIR, Georgeta DRAGOMIR,
Marian BORDEI**
"Dunărea de Jos" University of Galati
e-mail: doromir@yahoo.com

ABSTRACT

For a good behaviour of mill parts and accurate functioning it is necessary to have an integrated system for all mill tandem. It is important to know the speed controls and strip tension in correlation with torque, laminated force and rotation angle. The management system incorporates all gap control existing inside the rolling mill machine.

KEYWORDS: system management, behaviour, rolling mill, gap control

1. Introduction

The simulation of the dynamic behavior of components or parts of a rolling mill has contributed at the decrease of hardness of these movement parts, a new and functional design, the diminishment of energetically consumption. During the workshop are tested and optimized the basic functions and the dynamic behavior. Taking into account the complexity of the geometric shape and loading it was studied the Stress State using the Finite Element Method.

The model accepted for simulation is composed of resorts which substitute the actual masses in work. The hardware and the software for function control in work are connected to the simulated model. The model must be simulated in real time function work.

The advantage of this system simulation is that both the hardware and software may be tested, regulated and optimized without any risk of comparison with the existent system.

During the works are tested and optimized the basic functions and the dynamic behavior.

To investigate the behavior of rolling mills we always first the model behavior. The dynamic simulations on the created stand show the influence of diverse causes during work such as:
- High − frequency torsion vibration in the drive system;
- Eccentricity and state surface of work roll shape;
- Mill speed;
- Reduction;
- Strip tension;
- Roll lubrication.

The model stands satisfy the most stringent requirements on control dynamics and shock capacity and are largely free of maintenance.

The equipment used has the following advantages:
- No limit in drive rating;
- Better control performance;
- Rotor of engine (machine) has lower moments of inertia;
- Less spare parts;
- Greater flexibility of parts;
- Simple start-up procedure;
- High reliability and availability;
- Output frequencies from 0 to 600 Hz;
- Frequency control with senseless vector control;
- Highly accurate speed and torque control;
- Fast serial interface communication between line speed and slave units;
- Positioning controls
- Parameter indicator, text display, graphic display.

2. Experiments and results

Now modern tandem mills have hydraulic gap controls on all stands. The control loops employed are position control; tilt control. The roll forces are measured either indirectly by pressure transducers attached to the hydraulic cylinders or, directly by roll force transducers located in the line of force of the hydraulic cylinders.

It is in action when the gap is open, during threading operation and as a subsystem of the gouge control. The signals from the position transducers on each side of the stand are subtracted to produce the actual value for the tilt controller, which alters the tilt

about the centerline of the stand. This control loop is effective during rolling and is only switched off during calibration after the calibration force has been reached. A typical response time is approx. 30ms.

Roll force control is measured for each roll work. The total tension reference value is calculated in the control system in accordance with the rolling program and the strip dimensions and is sent to the tension controller.

The tension is measured by tensiometers mounted under the bearing blocks of the deflector rolls. As the control system depends very heavily on the speed with respect to the gain and time response, the gain of the tension controller is matched out adaptively to the properties of the controlled system.

The work rolls and the intermediate rolls are equipped with separate cylinders for positive as well as negative bending. The cylinders on the drive and the operator sides are complied in parallel for each bending direction.

The strip tension is kept constant. During work if it is necessary, we must apply a speed correction. The exit thickness of strip must be adjusted like: thickness error measured by the gauge before the stand and compared with the measured exit thickness error. The difference is added to the exit thickness set point and the sum forms the set point for the thickness gauge before sand (experimental mill) fig.1. Also a processor is used to detect if milling process is driven in fixed parameters.
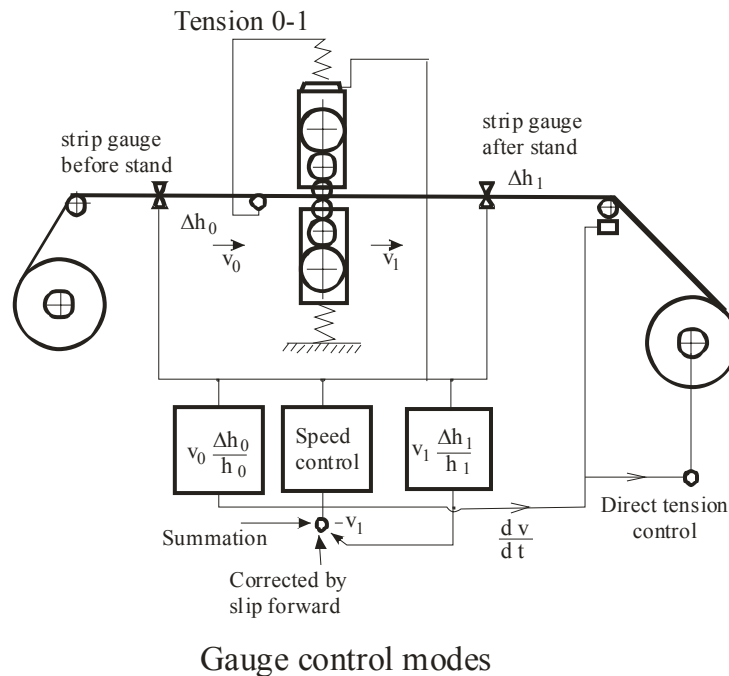

Gauge control modes

Fig.1. Management of rolling mill system.

3. Mill mathematical model

The audible noise is often the only indication to the mill operator that the mill is vibrating. As stated earlier, this type of vibration is self-exciting. There is a feedback mechanism that provides a sustaining force to increase the mill vibration amplitude which is a consequence of the vibration motion itself. This mechanism has its origins in the roll bite and is a consequence of the continuity of mass flow through the stand.

$$H_1 v_1 = H_2 v_2 \qquad (1)$$

where:

H_1 and H_2 are the entry and exit gauges and v_1 and v_2 are the entry and exit strip speeds.

On the basis of continuity of mass flow through the mill stand during rolling, it can be shown that a change of exit gauge will produce a change in entry strip speed, assuming the entry gauge and exit speed remain constant.

$$H\delta v_1 = H_2 \delta v_2 \qquad (2)$$

The change in strip speed at one end of the entry strip compared to the other, v_c, will produce a change in entry strip tension, T_1, as follows

$$\delta T_1 = K_1 \int (\delta v_1 - \delta v_c) dt \qquad (3)$$

where: K_1 is the stiffness of the entry strip given by the following equation

$$K_1 = H_1 l \cdot E / L \qquad (4)$$

where: E Is the elastic modulus of the material being rolled, l is the strip width and L is the length of the entry strip over which the speed difference was applied.

A change in entry tension will produce a change exit gauge thus completing the loop as follows

$$\delta H_2 = \left(\frac{\partial H_1}{\partial Rl} \right) \left(\frac{\partial Rl}{\partial T_1} \right) \partial T_1 \qquad (5)$$

where: Rl is the rolling load.

The ratios in equation (5) are roll gap sensitivities that will depend on rolling variables such as the roll gap friction. There is a 180 degree phase change around the feedback loop in figure 3, 90 degrees coming from the mill vibration mode and 90 degrees from the integration required to convert strip velocity to tension in equation (3).

Analogous to electrical control system instabilities, if there is a 180 degree phase change around the loop then the loop will go unstable as the gain is increased above a certain threshold value. From the above equations coupling each term in the loop it can be seen that gain is proportional to the exit speed of the strip (equation (2). This explains why rolling mills prone to gauge chatter vibration exhibit the problem suddenly as the speed is increased above a threshold value. Other factors such as the material being rolled, the rolling conditions and the natural damping of the mill stand resonance will all affect the threshold rolling speed for vibration. However, these are difficult to change and none vary as significantly as the speed during a particular rolling pass.

The mode involves the two work rolls moving in-phase and vibrating between the two backup rolls. The backup rolls move in anti-phase to the work rolls but their amplitude is significantly less than the work roll amplitude. The evidence linking this mode to roll and strip marking is presented elsewhere [1, 4]. The relative motion between the work roll and the backup roll damages the backup roll surface during the period that the backup roll is in the mill.

The predicted mode involves significant bending of the work roll necks. It should be noted that this type of mode belongs to a family of fifth octave modes, all capable of damaging the backup roll through relative motion between the work roll and backup roll.

Some solutions to this problem may require an on-line monitoring strategy on the grinder and/or the mill to identify the source and then minimize its impact.

This is an effective operational strategy to maximize productivity while maintaining high quality of the strip surface.
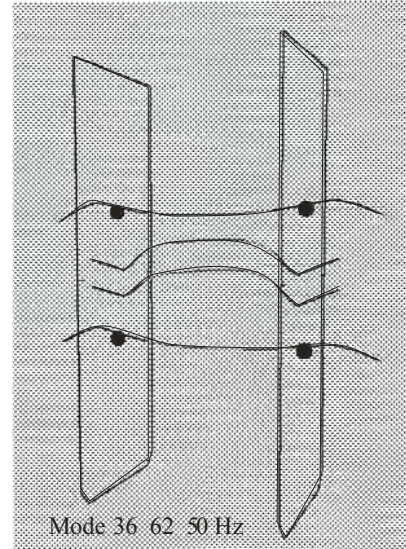

Fig.2. Typical mode shape of rolling mill resonance. The lines represent the central axes of the rolls and housing frames.

Roll eccentricities caused by temperature effects, grinding inaccuracies, wear, cause periodic fluctuation whitch cannot be compensated by the gauge control. The gauge error based eccentricity compensation system analyses the measured strip thickness instead of the roll force. The system works on the principle whereby the roll eccentricities are simulated by means of an error model composed of discrete oscillations whose frequency phase and amplitude can be controlled. The measured thickness error is converted by means of a roll gap model into a corresponding gap position. The value is compared with the asseverated measured gap position, whereby the time delay is taken. The system also has effect of compensating for thermal growth since the amplitudes of the respective frequencies are tracked and compensated automatically.

Chatter is severely influenced by the rolling mill process. For predict the real roll force is necessary to introduce all variables into a corrective neural network. A corrective neural network can eliminate the error in roll force prediction. This network can reduce the prediction errors at 25%. Additional variables, which were not used in the mathematical model, were necessary for the substitutive model only.

The chemical composition of coil and temperature variable were fed to the network.

4. Conclusion

The use of proposed system milling (stand) improves the accuracy of work parameters (in particular rolling force).

Some parameters not considered in the mathematical model can be easily introduced in a mill system.

The management system works on the principle whereby the roll eccentricities are simulated by means of an error model composed of discrete oscillations whose frequency phase and amplitude can be controlled.

A method of preventing roll chatter in a rolling mill stand during the process of directing a strip of material through the stand, the stand having a natural frequency of vibration, the method comprising:

The stand has a rolling gap and hydraulic systems for respectively adjusting the rolling gap and for controlling the force at which backup rolls press against work rolls of the stand, the method including: vibrating one or both of the hydraulic systems at a variable frequency. The method in which the vibrating component is provided with a varying frequency and varying amplitude.

The method of claim 1 wherein the octaval frequency of roll chatter is at third and fifth octaves, whose the frequency ranges from100 to 200 and 500 respectively to 700 Hertz.

A method of controlling the vertical motions of a plurality of vertically disposed rolls in a rolling mill during the process of directing a strip of material through the mill, said vertical motions occurring at a natural frequency of the rolls, the method comprising: introducing into the mill a vibration component having a frequency different from the natural frequency of the vertical motions of the rolls such that said vertical motions become no synchronous with each other.

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