THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI.
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N^0. 1 – 2007, ISSN 1453 – 083X

VIBRATION DIAGNOSIS SYSTEMS FOR A COLD ROLLING MILL MACHINE

Stefan DRAGOMIR, Silviu MĂCUŢĂ, Constantin SPÂNU
"Dunărea de Jos" University of Galati
email: silviu.macuta@ugal.ro

ABSTRACT

In this work is shown the importance to use a monitoring by vibration system for a cold rolling mill machine. The using of this monitoring vibration system reduce maintenance costs, minimize the impact on operation because is monitoring the rolls, the backup rolls, the coupling shaft, the gears from power system. Another advantage is to preventing damage occurring by detecting signs of abnormalities. The accurate prediction of works parameters is essential for a product quality. Currently, a mathematical model is used. It is important to directly predict the roll force and the other parameters, to compute a corrective coefficient Using a mathematical model, we grove up the possibility to obtain a new quality for laminates strip.

KEYWORDS: Cold rolling mill, Strip, Vibration, Prediction, Undulation

1. Introduction

A rolling mill process for obtain cold thin strip, consists in four stands where the force, the speed and the intermediate thickness tension between each pair of stands is continuous monitoring.

The roll gap is the distance between two working rolls, most important variable to affect the actual output thickness of the strip. The set parameter values are dynamically adjusted as the strip thickness and tension who are measured during milling process.

The initial setting produced by the mathematical model can give errors that can usually be compensated by the real – time controller, but large errors lead to quality decline and cost increase. The installed system produced, the initial settings on the tension roll the strip speed and the force prediction values with the settings from the mathematical model.

Using a mathematical model, the mill settings are determined before a strip enters in the mill, like the work load, the roll gap for each stand is calculated, the speed in each stand (from the first stand to the five stand).

It is known that milling process is a function of many variables, with an exception – the presetting roll force-. It is essential to predict the roll force as accurately as possible. The roll force is calculated using mathematical formula based on the metallurgical and mechanical knowledge like:

$$F_m = f\left(H_i, H_o, T_b, R_{p0,2}, \mu, v_e, n_r\right) \qquad (1)$$

where F_m - the roll force produced by the mathematical model.

The roll forces are influenced by deformation resistance$\left(R_{p0,2}\right)$, thickness (H_i and H_o), backward and forward tension (T_b and T_f), friction coefficient (μ), and other constants. The first four factors (thickness and tension) are constant and impose.

The rolling stands press a strip of steel using upper/lower rolls to a desired thickness.

The gap between upper/ lower rolls determines how much pressure or force is applied. Force, thickness, speed and tension is measured while the strip is processed, and then for real – time control like in the fig. 1.

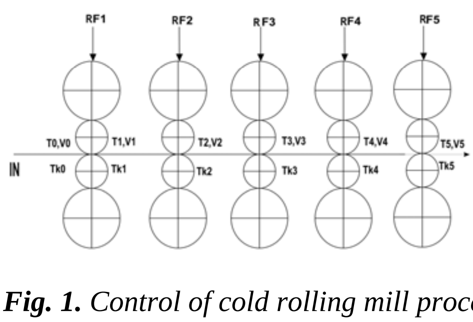

Fig. 1. *Control of cold rolling mill process, with presetting in recalculation, which is related to thickness control.*

The mathematical model does not take all the factors into account. The friction coefficient is known to be affected by working roll parameters such as the rolling speed, the roll surface, the oil used, etc. However, the mathematical model employs only the rolling speed in calculating the friction coefficient. The mathematical model's prediction values (F_m), against the target values (F) are selected in the time of coil processed.

The mathematical model, by definition, can employ only the factors whose exactly physical relations are understood. The parameters predictions involve many other factors whose exact relations are not well understood and the mathematical model is far from perfect.

Recent studies about the roll force tension and coil width prediction were made in two directions, first in improving the mathematical model and second in employing the neural network.

The neural networks were used to calculate the roll force with the improved prediction accuracy in cold rolling process.

- Use of neural networks improves the accuracy of roll force prediction.
- Many factors not considered in the mathematical model can easily be incorporated in neural networks.

The rolls forces, the coil tension, the coil width and the speed sheet were measured with specifically tools and than we draw the next curves by a mathematical model prediction.

The models of roll force prediction are given in fig. 2. The exception was stand (cage) no. 5, where the mathematical model made very good predictions.

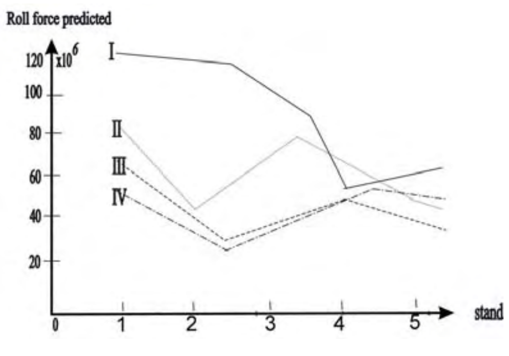

Fig. 2. *The predicted values of roll force.*

Those models that we show are a test pattern and are not likely to make a reliable prediction. The deviant domain approach proposed in [1] tries to identify the part of input space where the prediction accuracy of model is not expected to be good. For each input variable, we analyzed the correlation with the prediction error in order to identify the default domain (force, tension, width, speed, acceleration).

Another way for controlled the good functionary at the cold rolling mill for strip is to do a monitoring by vibration for the moving parts of mill machine.

2. Experiments on monitoring system by vibration

The configuration of the system used for measuring and recording of vibration parameter (displacement, velocity, acceleration, and frequency) is shown in fig. 3.

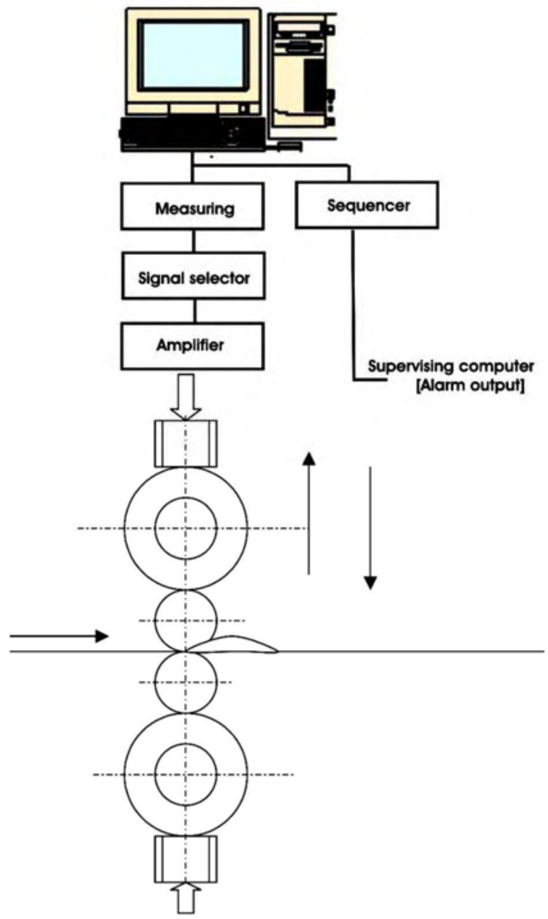

Fig. 3. *The configuration of vibration monitoring system.*

This system work like an alarm which automatically determines the incident who has occurred on basis of measured values and notifies the operator accordingly, a diagnostic function to estimate check times from past measurement data, and a database of apparatus repair times.

The system, displays this information graphically on a screen. Example of screens recording are shown in fig. 4.

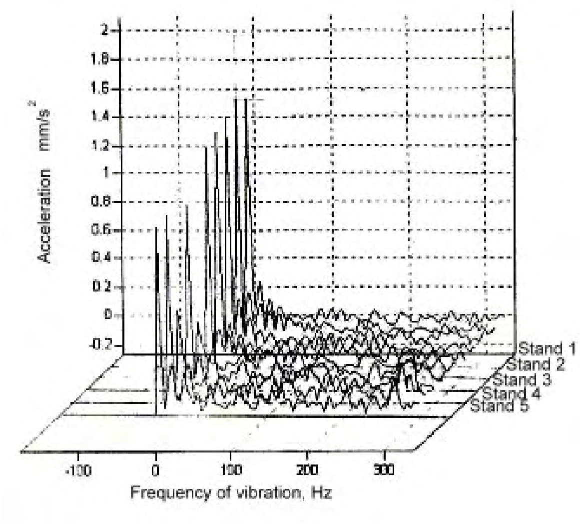

Fig. 4. *Running time transition and power spectrum for five stand cold rolling mill.*

In fig. 5, 6 we show (partially) the recordings by comparing the parameters of vibrations at the beginning of work period and after six month in function. Because the wear who appears in bearings, box gear, bar of coupling, the amplitude of vibration increase and determine the “out” of initially work parameters for the cold rolling mill machine. The model directly predicts all work parameters, while the corrective model produces a correct coefficient, which is then multiplied to the mathematical models prediction. Additional variables which were not used in the mathematical model were found to be necessary for the substitutive model only. The networks of parameters (forces, tensions between stands (cages), speed, can be easily retrained if necessary as all the data from the processed coils are automatically saved in a workstation located next to the process computer. The retraining period does not have to be fixed such as monthly or yearly. It will be more proper to determine it dynamically by monitoring the trend of prediction error [2].

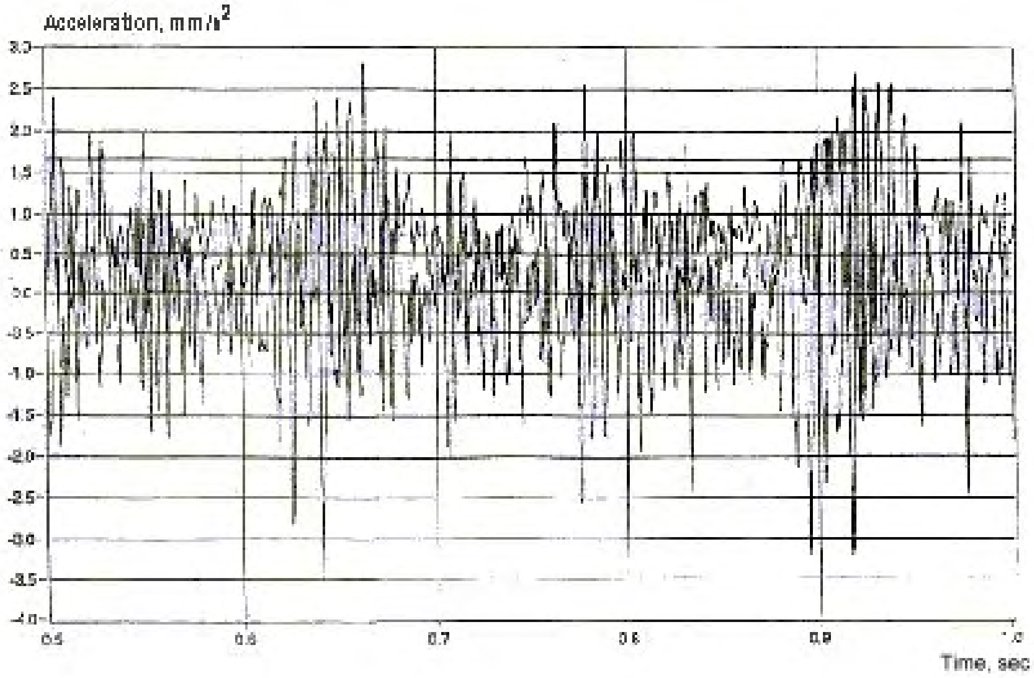

Fig. 5. *The acceleration spectrum measured on the backup roll support in while of vibration (side machine).*

The-network models are planned to be used in daily operation. One difficulty is to estimate the monetary savings resulting from the improved quality and decreased off-gauge [7].

Using the network of parameters-based roll force – prediction models show that the prediction errors of the currently used mathematical model reduced by 30-50%. The substitutive model directly predicts the roll force, while the corrective model produces a correct coefficient, which is then multiplied to the mathematical models prediction.

The networks can be easily retrained if necessary as all the data from the processed coils are automatically saved in a workstation located next to the process computer. The retraining period does not have to be fixed such as monthly or yearly .It will be more proper to determine it dynamically by monitoring the trend of prediction error.

The -network of parameters models are planned to be used in daily operation. One difficulty is to estimate the monetary savings resulting from the improved quality and decreased off-gauge.

The networks of parameters (milling process force, tension between cages (stands) have a potential to improve the accuracy of the computation be substituting or correcting the mathematical model [8].

From the effectuated experiments it can conclude the fact that, the highest values for displacement, velocity, acceleration and power spectrum (on the direction of the action system) have been recorded at the3, 4 and 5th cages of the rolling mill machine (the causes that determinate these important values for the measured made are great tension into the strip between mill cages ;high speed of strip while the milling process or the variation of those; abrupt change for the rolling mill work parameters; types or different quality for the emulsions used in work; the decrease of reduced number when the strip pass between the work rolls; unpredictability for one of work parameters.

At rolling mill’s speed between 600 – 1250 m/ min and frequencies of vibration measured that do not excel hadn’t recorded of marks, undulations and abrupt variations of the strip thickness after milling process.

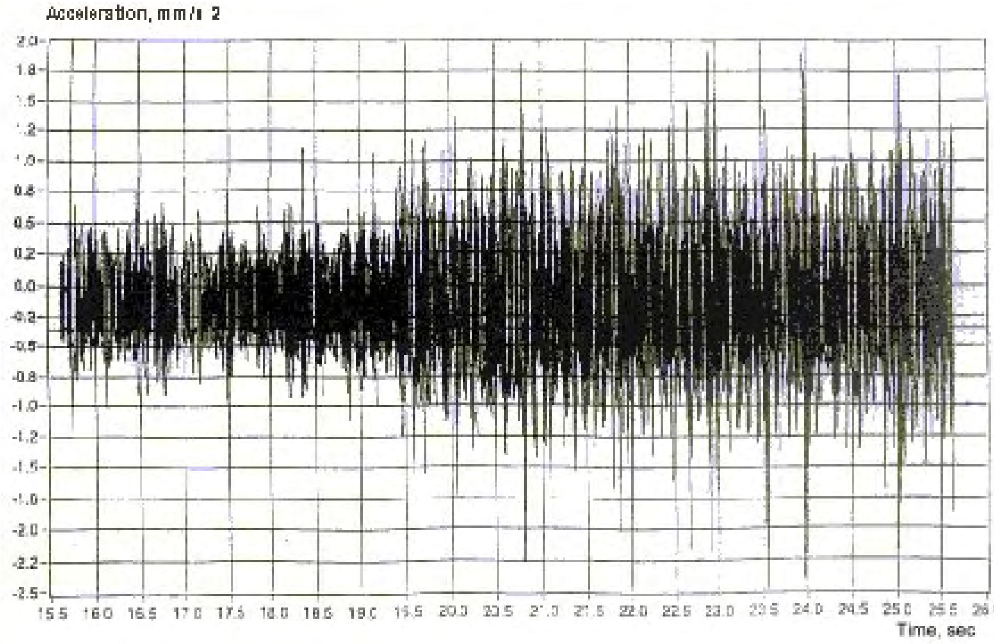

Fig. 6. *Accelerations spectrum (side operator) measured in function of rolling mill.*

At vibration’s frequencies between 450 – 1150 Hz, we observed undulation at strip’s surface with the gap between 2- 40 mm, big wear of shell of work rolls and into the bearings of work rolls.

4. Conclusions and results

The problem studied is very important for:

- the quality of surface and geometry of cold rolling strip;

- the correct command of milling process ;

- the prominence of causes and the oscillation’s effects, vibrations, shocks etc. – owing the own system of rolling mill cages and the parts of kinematics action fluxes;

- the fix measures for control, decreasing, command ;

- the increase of productivity, the reduce of costs;

The vibrations are present in equipments and installations of cold rolling mill by different type. By an ample study and perform experiments – with modern gear – it result a series of aspects.

From the effectuated experiments between 2004-2005 at a number of over 200 coils of cold milling strip, which in fact were measures and vibration’s analyses, the have been established the following series of characteristics frequencies:

- vibrations in series of frequency between 5-90 Hz, for coupling, couplings bars, gear boxes with defects into their bearings;

- vibrations in series of frequency between 125-300 Hz for the strip which is being milling, for the gaps of positioning system, the wears into the backup and work roll bearings, lubricant used;

- vibrations in series of frequency between 500-980 Hz, wear’s afferents accentuated backup and work rolls shell of these encampments, determination the appearance of hallmark and undulation on the surface of strip.

The experiments in the functionality for rolling mill machine show the tendency of vibrations amplitude at the increase of milling speed. We record a increase of milling speed with 50% at each cages of the rolling mill, the vibration’s amplitude record a increase 35 % at each cage) by the other way, at strip with small breadth and with high toughness is manifested the same tendency of increasing of vibrations amplitude, but on the other hand the strip with a big breadth and thickness, where the effect of amortization of vibration is considerable highest.

From the all experiments done it results haw actual is at the problem of science analyze by functional conditions of rolling mill machine, the identification and the quantification of disturb factors and, finally, the modern projection, in the scope of resistance and reliability increase and diminutions of consumptions, insurance of continuing technological process and the quality of the final product.

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