Preliminary Proposal for Camber Problem Solution

Benjamin Li, May 1, 2007

Introduction

Control of plate camber (edgewise curvature) in rolling is one of the largest technical problems yet to be solved in the field of rolling [1]. Temperature is one of the main factors influencing camber formation and characteristics [2], though the camber can also be caused by other irregularities with material (input thickness, slab temperature) or with the equipment (roll eccentricity, roll thermal deformation, backup roll lubrication).

This preliminary proposal contains three sections:

1. Temperature reading system for the both side of the plate
2. A camber measurement system with cameras
3. Camber prevention with roll gap compensation through AGC

Section (1) is an immediate, temporarily solution, and it is optional (not required if not urgent). In Company A case, the two sides of the plate are in different environment: one side is with the big door and the other is near furnace. If the temperature in the two sides is notably different, a simple solution (such as a fan) could help quite a bit.

The camber prevention with roll gap compensation through AGC needs integration with current Level 1, to provide set point for AGC system. A mathematical model is to be provided to calculate roll gap adjustment value based on camber value. The camber measurement system requires a set of cameras, image processing software and a PC. The system will display and measure the camber value.

The two systems can be developed independently and are to be eventually integrated together and installed in the same PC.

Proposal for a camber measurement system with cameras

This proposal describes the design and implementation of a computer vision system for real-time measurement of camber in a hot rolling mill. The goal is to provide valuable feedback information to improve AGC operation. Similar systems used in other steel mills have proved to be robust, and at the same time there is a strong relationship between known problems in the mill and system readings [2].

The optical system developed for the on-line, non contact measuring of strip camber makes use of mathematical algorithms based on image processing techniques. Similar systems offer very interesting performances: it is quite accurate (in the order of +/- 5mm), fast, robust (require almost no calibration as far as the cameras position do not change) and cheap [2].

System Overview

Fig. 1: The cameras are to be placed over the run-out tables, on a measuring cabin after the roughing mill exit. They are looking downwards the line with a given angle. The fields of view are slightly overlapped to ensure that entire strip is analyzed.

Fig. 2: Schematic view of the developed camber measurement system. Three CCD cameras are connected to a PC through a RGB frame grabber. The PC schedules image acquisition using information provided by the mill automation system through a data acquisition board. The results are sent to the process through a serial link and an Ethernet TCP/IP connection. There is also a terminal in the control cabin to provide visual information to the operators.

Fig. 3: Mill operators are in charge of introducing offsets in the leveling stands in order to reduce camber. They have an user terminal which shows the shape of the drive side strip edge, camber value for each strip, a trend display and snapshots of the image of the strip.

Fig. 4: All the information gathered by the camber measurement system is stored in a database. This information is used by technicians to elaborate strip quality reports or trend analysis.

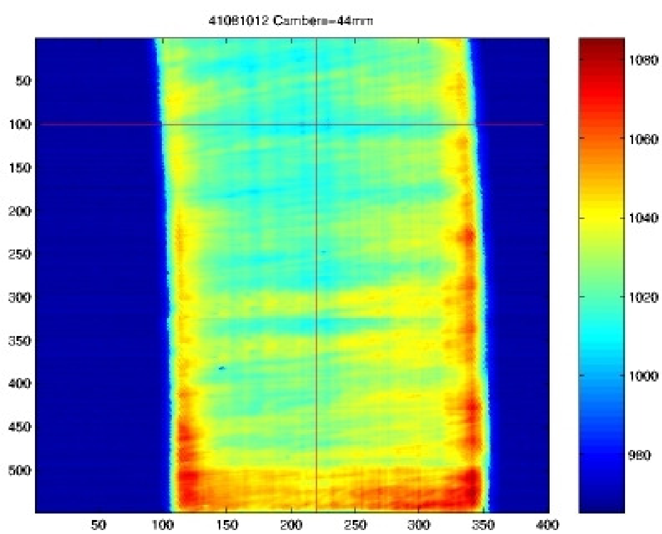
Measuring Principle

Fig. 5: The figure shows different stages of the processing. (a) Original intensity image. (b) Detected edges in the image. (c) Edge map after non-maximal suppression. (d) Detected strip edge. (e) Detected strip edge overlapped with the original intensity image

Fig. 6: Examples of different camber shapes

Application example of similar systems

(a) Measured camber: -26mm



(b) Measured camber: -44mm

(c) Measured camber: -104mm

Fig. 7: Images of the head of 3 different strips obtained with a thermographic camera. Each row in the image provides information about the temperature at that point. Each sample presents a different camber value.

Proposal for the camber prevention with roll gap compensation through AGC

Fig. 8: Current handling of camber: manual steering by operator

The Concept

This proposal is to design and implement a supervisory system for the real-time compensation of thickness on the two sides of a rolled plate. The design is based on a multivariable process model, whose parameters are estimated on-line using measurement data from the mill. As a result, a computer system is to be developed that automatically corrects the AGC output from on-line acquired mill operation data. This system performs computer-based real-time control for the tilting signal.

In this approach, a multivariable model will considers the coupling between north and south sides. It can be used to compute rolling forces as a function of the hydraulic actuators position. As a camber is identified, the system will calculate an estimated thickness adjustment considering the rolls geometry, the slab geometry, the rolling forces, and the hydraulic actuators position.

By applying relation between forces and hydraulic positions given by the multivariable model, the controller can compute the tilting signal which must be sent to the AGC through the Level 1 system in order to replace the human operator (Ztilting in Fig. 9). The AGC reference Zr feeds both hydraulic positioning systems (north and south) with the added compensation Ztiltiing. The stand controller tracks this reference by means of a servo valve.

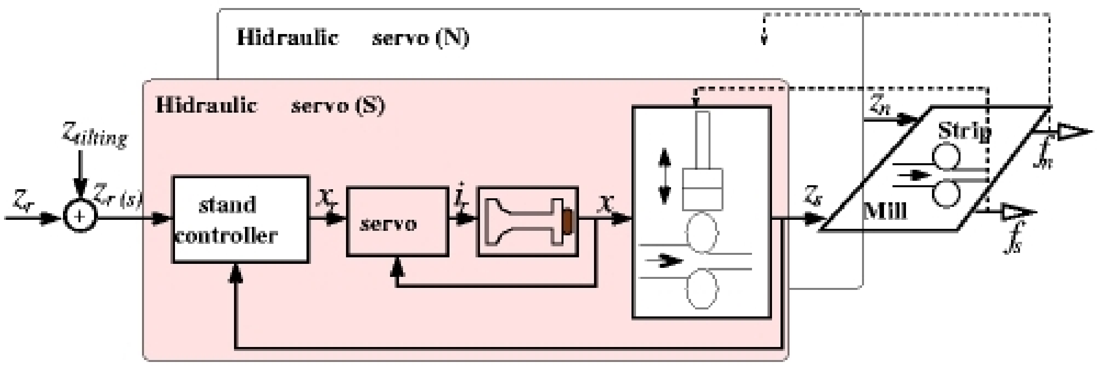


Fig. 9: The hydraulic AGC actuator

The Rolling Model

A multivariable model allows making a real independent control in each side of the rolling sides. That model should take into account:

- the mill and rolls deformation,
- the hydraulic positioning systems (without the servo systems which has an autonomous control) and
- the mechanical properties of the plate.

Fig. 10: The rolling process, side view. The gage between rolls defines the output thickness of the plate

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