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Machine vision application for cold plate width measurement

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The paper presents results of the laboratory scale development results of the machine vision gauge to be installed in the newly built plate manufacturing line. The gauge measures the head and tail of steel plates after the milling. The gauge will be installed after the cooling bed. The plates are hot leveled but they can also be wavy. The gauge projects a laser line over the width of the steel plate. Several cameras are mounted in line with the lasers in a thermal isolated cabinet. The cameras are connected via a camera link interface to the PC. The evaluation software captures the picture of each camera and calculates the actual width value of the plate.

1. INTRODUCTION

Assessment of the actual cold plate shape and dimensions in real time, as the plate is travelling with a mill speed of 2.5 m/sec along the production line, is essential for its optimum utilisation. The conventional non-contact systems used for plate width measurement are not sufficient, as they cannot detect the shapes of the front and back ends of the plate, that have to be taken into account while optimising the productive output from the input material. The matrix cameras detect the diffuse reflex of the laser line on the surface of plate. Four 1024 x 1280 CMOS array cameras with 35 mm focal length lens were used for tests. Broadband requirements of interface and PC make it necessary to set a region of interest (ROI) at each camera to reduce the data collected every 5 mm along the plate. To realize a synchronous measurement it is necessary to trigger the measurement by an external ”start exposure” binary signal. The ROI patches of 50 x 1280 pixels for each camera are enough to evaluate the reflected laser line. The PC includes two frame grabbers to capture the pictures from the cameras at the required rate of 500 images/sec from each camera. At first, the software detects the laser line in the image, the next step is the correction of the optical system errors like distortion, etc. in the image. The software detects finally the plate edges and calculates its actual width. If the plates are wavy, it is necessary to make the parallax compensation. In the industrial grade system version (Fig.1) the width values will be sent via Ethernet to a separate visualization PC.

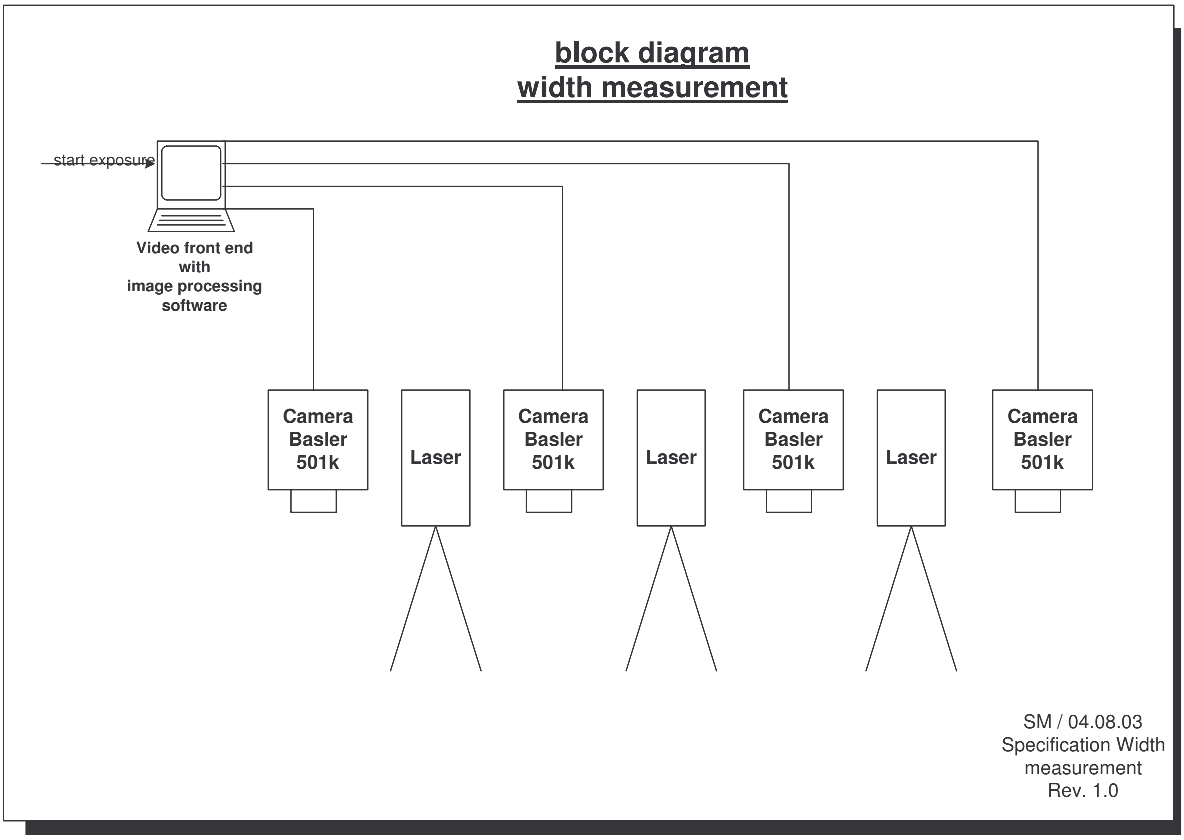

Fig. 1 Layout of plate width gauge system elements

Table 1 Main specifications of plate width gauge

Plate and gauge parameters		Values
Plate	Width Thickness Temperature Speed Width	1300 – 5000 mm 5 – 50 mm < 100° C < 3m/s 5650 mm
Gauge	Camera-Plate Distance Range at 3800 mm Interface	3800 mm 1600 mm Camera link

2. MODEL SETUP DESCRIPTION

The static system model was made in the 1:2.5 scale to test the camera - frame grabber – PC system. The PC software was developed on the QNX real time operating system platform. The steel specimen was used with the surface optical properties similar to those of the plate surface in the real production conditions (Fig. 2). The exposure time was less than 2 ms.

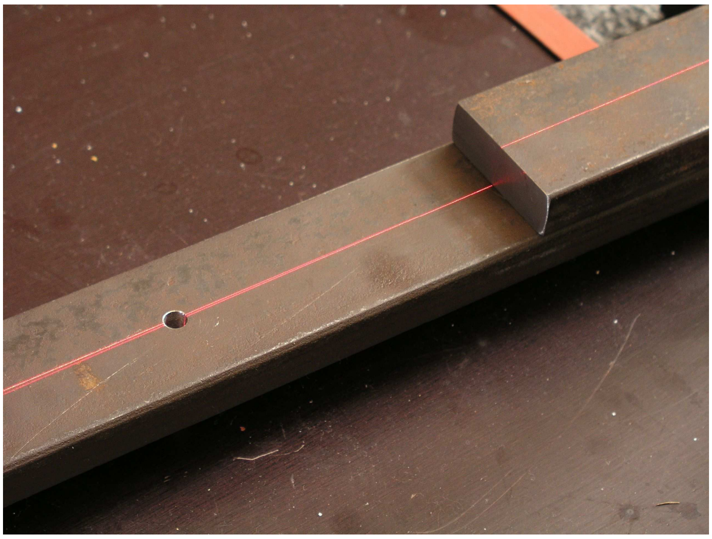

Fig. 2 Layout and shapes of specimen edges

The images were transferred between the acquisition and analysis tasks using the PC RAM buffers, whose sizes will be further tuned during the dynamic system tests. The camera software calibration tool window screen shots (Fig.3) illustrate the images collected by the system and analysed further to restore the plate wedge location. The thin red line represents specimen surface; whereas, the coloured square points mark the specimen edges found by the proprietary line analysis algorithm. Because of required operation rate and high rate of image acquisition – line detection was carried out basing on analysis of brightness and brightness gradient between pixels without any additional transformations like filtering, edge detection, etc. In order to adjust the image analysis parameters to real lighting conditions, the following parameters were defined for each camera:

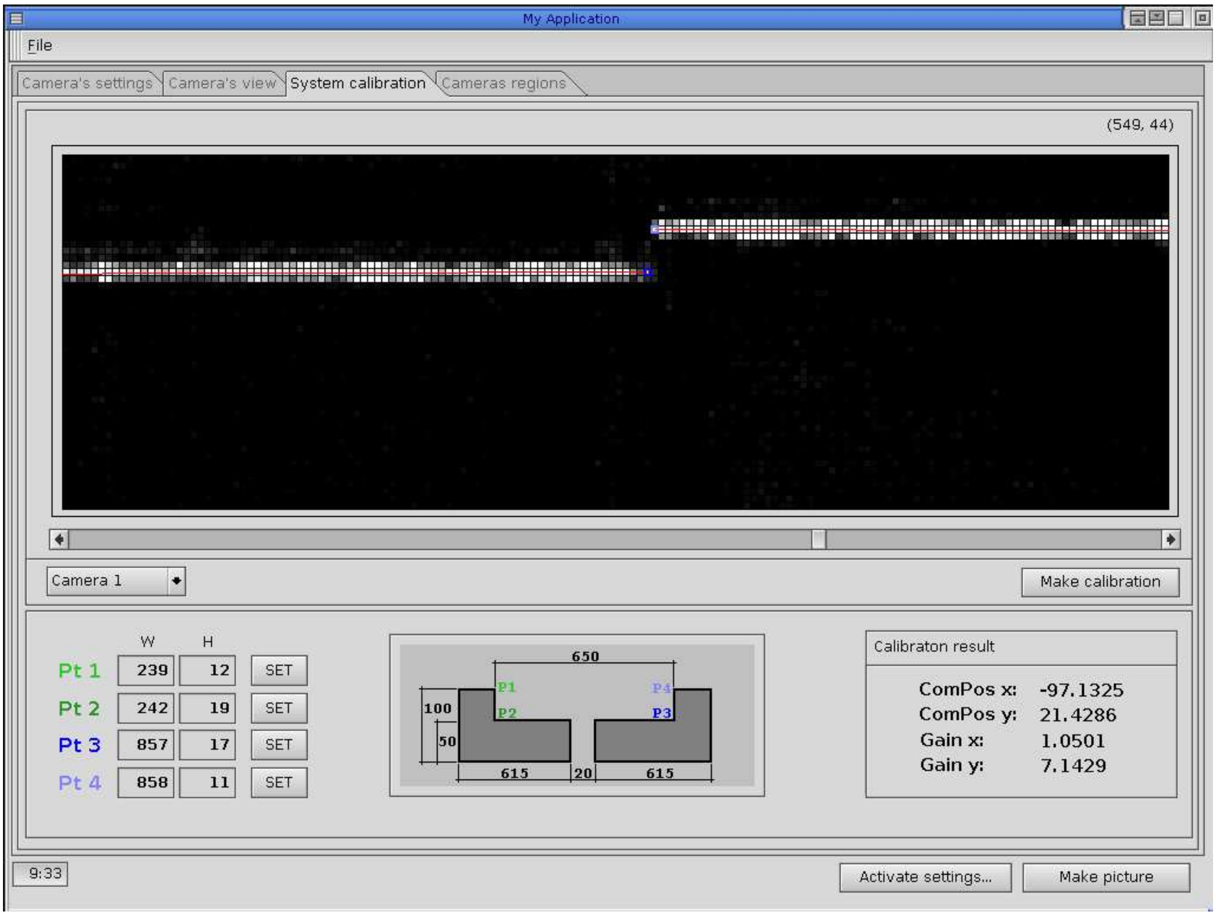

Fig. 3 Specimen surface and detected wedge

- Rejection threshold determining the minimum brightness of pixels representing the laser line image;
- The limit threshold of brightness gradient (first derivative) determining the minimum steepness of line edges was determined experimentally.
- The minimum and maximum laser line widths were specified that allow the preliminary filtering of interferences.

3. CONCLUSIONS

The static model setup made it possible to carry out series of experiments, which proved that it was possible to meet all design requirements imposed by plate manufacturing process. The required 1.25mm/pixel resolution was achieved in measurements made at the required image rate acquisition. Development of the plate width gauge module included the following tasks:

- Handling the frame grabbers boards and cameras:
    - Programming the cameras operation mode
    - Programming the frame grabber boards operation mode;
    - Image acquisition from frame grabbers and transferring them to PC
- Image processing:
    - Finding lines and points in an image acquired by a single camera;
    - Correction of geometric errors;
    - Calculation of edge coordinates
- Calibration of the static model stand:
    - Displaying of images coming from the particular cameras;
    - Calculation of parameters and calibration coefficients that are required for calculation and correction of measurement results;
    - Calculation and displaying the data required for calibration process and to set the positions of cameras
- Communication with master computer:
    - Sending messages with measurement results and module status;
    - Receiving the messages with commands and parameters

The next experiments will be carried out on a 1:1 model setup with measurement capability in dynamic conditions. Their results will make it possible to fine tune finally the parametric algorithms developed for the initial static system.

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