SYSTEM OF GEOMETRIC PARAMETERS MONITORING DURING CUTTING OF STEEL PLATES PROCESS

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Summary

The steel plate cutting is performed on a special pro-duction lines to enable longitudinal and lateral cut. Input material is usually a metal ring of weight about 32 tons. The cutting process is preceded by an operation of straightening the cutting section. So far, during this operation parameters such as wave cut off sheets, the thickness of the material were not monitored. This paper presents a system of continuous monitoring of sheets parameters constructed by the authors. It was mounted on the process line-cutting and slitting of one of the companies cutting sheet metal. Such approach allows to improve quality control.

Keywords: diagnostics, steel plate cutting.

SYSTEM MONITOROWANIA PARAMETRÓW GEOMETRYCZNYCH PODCZAS CIĘCIA BLACH STALOWYCH

Streszczenie

Proces rozkroju blach stalowych wykonywany jest na specjalnych liniach technologicznych umożliwiających cięcie poprzeczne oraz wzdłużne. Materiałem wejściowym jest zwykle krąg blachy o wadze ok. 32 ton. Operacja cięcia poprzedzona jest procesem prostowania przy rozkroju poprzecznym. Dotychczas przy wykonaniu tej operacji nie monitorowano parametrów rozkroju takich jak falistość uciętych arkuszy, grubość materiału. W pracy przedstawiono wykonany przez autorów system ciągłej kontroli parametrów blachy. Został on zamontowany na linii technologicznej cięcia poprzecznego oraz cięcia wzdłużnego w jednym z przedsiębiorstw rozkroju blach. Zastosowanie powyższego rozwiązania umożliwiło poprawę kontroli jakości produkcji.

Słowa kluczowe: diagnostyka, cięcie blach stalowych.

1. INTRODUCTION

The process of cutting steel sheets takes place on the special process lines in order to enable longitudinal and transverse shearing. Usually, the process starts with introducing a coil of 32 tons. The cutting process is proceeded by straightening, especially in case of transverse shearing. At this point, parameters of cuttings, sheets corrugation, metal thickness and its level of crescent shape were not examined. Presented in this paper, the system of constant monitoring of sheets parameters was installed on transverse and longitudinal cutting lines. Measurements of thickness, corrugation and the level of crescent shape of a sheet, performed by laser transducers is linked to the system of production process monitoring.

2. ANALYSIS OF METAL ROLLING DEFECTS

Minor defects of surface which result directly from rolling, but do not influence parameters of the final product are accepted. It refers to the top side of sheets or the outside of coils. Physical and technological properties should suit requirements given in the PN-EN 10025:2002.

Sheet surface defects include:

- surface defects – the surface of the rolled metal should contain no cracks, blisters nor tears, remains of the shrinkage cavity, delamination and cracks which are visible to the naked eye are not acceptable,

- surface defects such as cracks, minor scales and overlapping, non-metallic inclusions, corrosion pits, bulging, dents, mill scales and roughness are acceptable on condition that:

- they do not exceed deviation limits,

• they do not exceed 0,5 mm for 25 mm thick coils, 0,7 mm for thicker coils.

Moreover, it is important to determine the longitudinal and transverse corrugation of the initial material and cut sheets.

Rolling defects always result from differences of sheet thickness and its width. This difference defines zones of tension which seem flat and zones of bumps which resemble a kind of 'pocket' folds. Through constructing rollers it is possible to form working rolls in order to press their longitudinally fibre-pulled parts so that they are pushed to the free zones.

Depending on the place in which 'pockets' are, rollers are precisely set in

a specific way. It must be always checked whether the end line does not have a double tail. Entering material into the straightening machine may damage straightening rolls. Figure 1 shows the screen of the system which controls the rollers power and allows removing sheet waves. Figures 2-5 illustrates forms of transverse waviness.

Fig.1. Screen of the system which controls the rollers power enabling the removal of sheet waviness

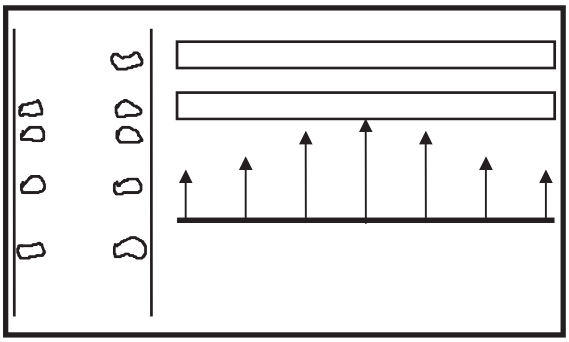

Fig.2. Outline of side wave formation process

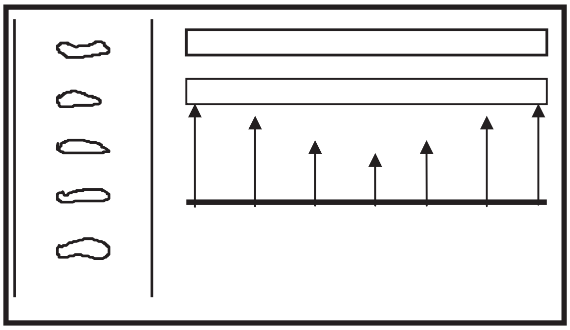

Fig.3. Outline of central wave formation process

The above-mentioned wavy parts of sheets are removed through pressing them by rollers set in so-called negative parabola.

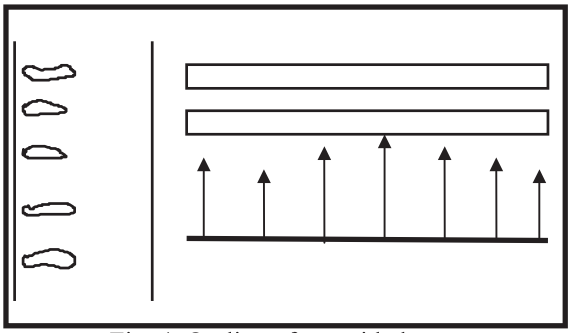

Fig. 4. Outline of one-sided wave formation process

Straightening of this wave is possible by lowering down rollers in the deformed areas

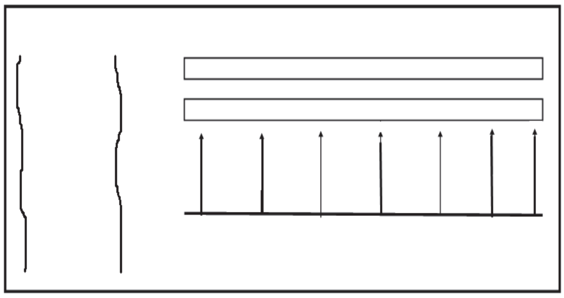

Fig. 5. Outline of the longitudinal waviness

3. MEASUREMENTS OF SHEET PARAMETERS ON THE TRANSVERSE CUTTING LINE

Within this process of monitoring sheet parameters system, measurements of sheet thickness and waviness of its surface had to be separated. Measuring devices were installed in two different places.

Waviness measurement of the sheet 1 which was from 250 to 2050mm wide is performed on the transporting table 2 (fig. 6). Measurement is recorded by two detectors 5 located around 50 mm from the edge of the sheet. Detectors are automatically spaced according to the set sheet thickness with the aid of the drive 6. Detectors 5 are located on trucks 4 moving on the lead 3. The sheet waviness is examined with reference to the laid down criterion of a given sheet thickness. The sheet which does not fulfill the criterion is classified as the one of lower quality.

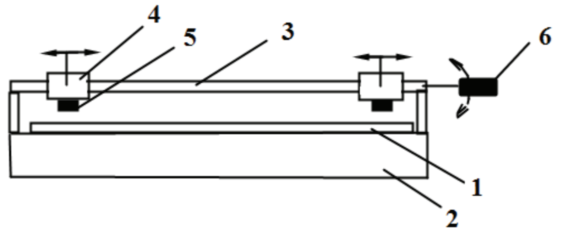

Fig.6. Outline of the sheet waviness measuring machine

Waviness measuring is constantly recorded and accompanied by its simultaneous graphic and sign presentation. Thickness measuring is recorded by detectors located in the differential gear in the place the most convenient because of the risk of unexpected transverse vibrations of the sheet (especially at the end of the unrolling sheet). Figure 7 illustrates the measuring system installed on the transverse cutting line.

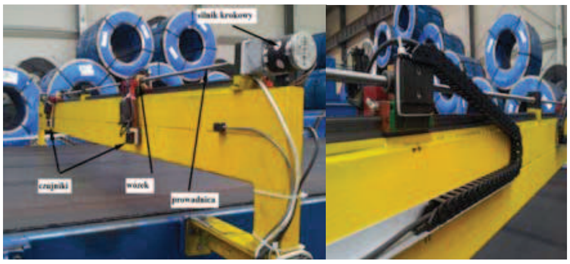

Fig. 7. Waviness measuring system on the transverse cutting line, on the right carriage from the wired side

A special rail protecting detectors against bumps of the end of cut sheet was installed on the line. The monitoring system of sheet transverse cutting is based on the independent measuring system with the parameters presentation seen on a separate screen. The screen shown on the figure 8 presents digital information of the thickness parameter and under it the waviness parameter of the left side, then the one of the right side. Measurement of waviness is performed at the individual programmed distance for sheets, usually it is 50 mm. Differences between measurement points of waviness and thickness cause a delay of thickness parameters comparing to the waviness ones resulting from the distance between detectors. On the right side of the screen (fig. 8) operators' identifiers and parameters of the working material. When the programmed tolerance threshold are exceeded, numbers become red and a red column signaling device is activated (optionally with the sound information).

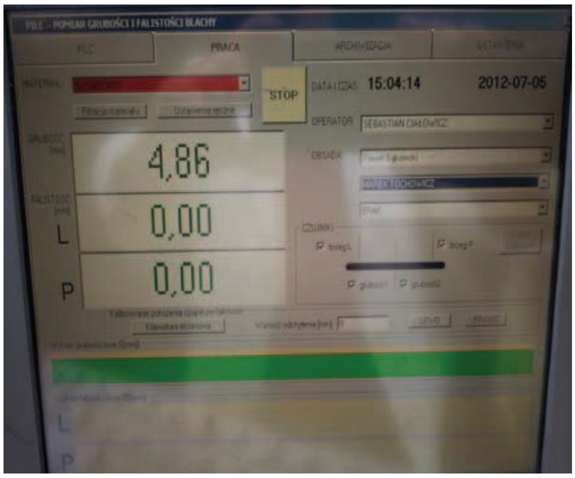

Fig.8. Screen of the thickness and waviness measuring system

Figure 9 shows the location of transducers for the differential measurement of sheet thickness.

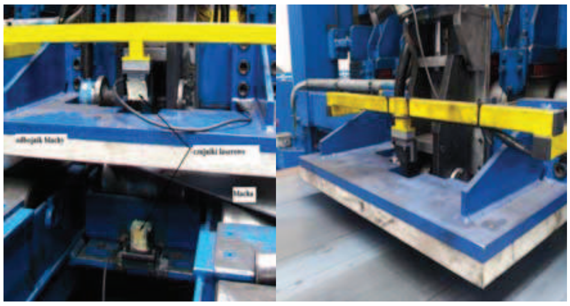

Fig.9. Measuring system of sheet thickness

Laser transducers of LD type OMRON company, starting signals of which are initially processed by a single-integrated circuit microcomputer. Within waviness measuring system, the same computer is responsible for the control of trucks locating laser transducers. Computer data are transferred through the interface RS485 to the controlling computer storing data and monitoring sheet cutting process. On the touchscreen (fig. 10), important changes of initial parameters may be done as well as they can be observed while being measured.

Fig. 10. Location of the measuring system screen (in the middle)

4. MEASURING SHEET PARAMETERS ON THE LONGITUDINAL CUTTING LINE

Straightness measurement (the sheet is longitudinally wavy which needs to be specified before longitudinal cutting) is performed after straightening unrolling line. A technical system in accordance with the patent 185472 entitled „Device measuring straightness of moving and/or fixed" was implemented on this line; it uses a projection device and a slider with a measuring detector moving along the object 1 (of a cut sheet) where straightness of the latter is measured.

Within the implementation of the above-mentioned technical system described in the patent, the projection device which constitutes a straightness model (fig.11) consists of a fixed axis 2 with a ball screw; on the axis there are sliders 3 with measuring detectors 5 moving along the cut sheet 1. A step motor was used as a drive. The location of sliders depends on the width of the sheet, and detectors measure the straightness of the sheet thanks to the implementation of an appropriate measuring system. As detectors, measuring strips 5 can be used, they consist of magnetic circuit, a keeper of which is fixed and connected with the slider 3 and active elements (magnetic field detectors) are located above the projection device 2 in the air slit 6 situated between permanent magnets and connected to the keeper. The measuring strips connected with the slider through elastic elements protecting against possible vibrations which occur during sheet cutting process.

During the measurement, measuring magnetic circuit which consists of permanent magnets, keepers and the air split goes along the examined edge of the sheet and simultaneously moves along the projection device. The magnetic field detector functions as a measuring element; it measures transverse movement of the magnetic circuit depending on the sheet waviness.

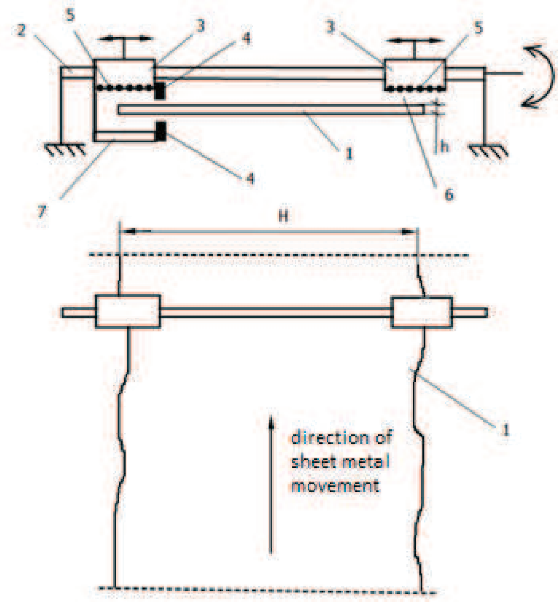

Fig.11. Outline of the adopted technical system

The use of this device will enable to eliminate segments of sheet strips of undesired thickness and the ones which do not satisfy longitudinal waviness edge requirements.

5. PROGRAM SOLUTIONS APPLIED IN PARAMETER MEASUREMENTS IN THE ASSEMBLY LINE

Software enabling permanent measurement of both the thickness and waviness is used in the parameter measurements in the assembly line. Data shown on the screen of the controlling computer are presented in the alphanumeric form as well as diagrams of the thickness and two waviness detectors (fig. 12).

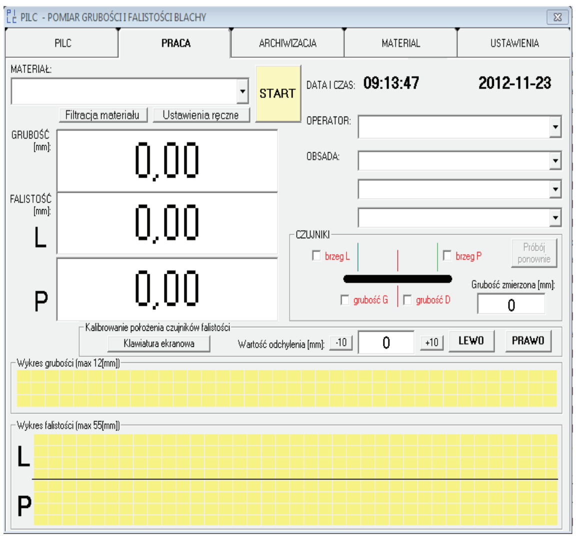

Fig. 12. Main window of the measuring program on the transverse cutting line

In order to quickly space measuring devices, the program uses the data base about sheet metal. The data may be changed and extended by workers responsible for the process. In order to enter data more quickly, the automatic generation of tolerance values calculated on the basis of entered sheet parameters can be applied (fig. 13).

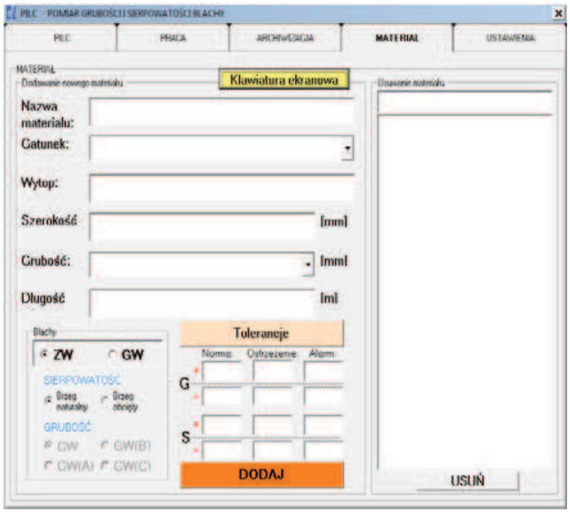

Fig. 13. Tab enabling the material base management

Moreover, workers team responsible for the process is also recorded. All information registered by detectors, including data of the working material and workers responsible for the process is stored on the controlling computer. The archive is saved in *.xls files which allows to see quickly data, and with the use of MS Office scripts it is possible to generate immediately diagrams of both the waviness (fig. 14) and the thickness of a given sheet.

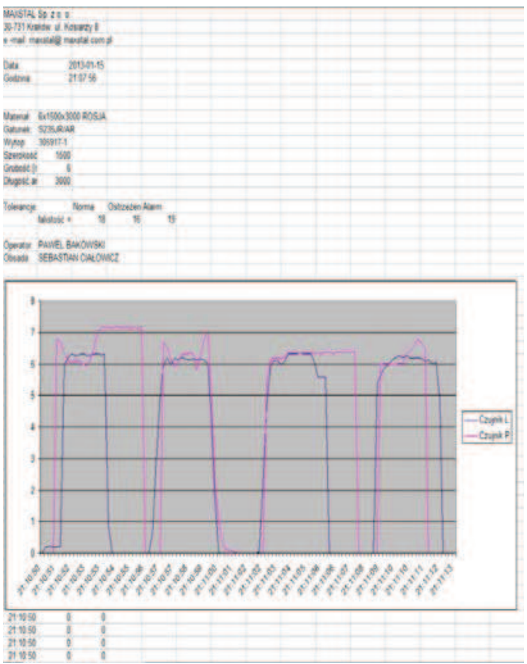

Fig. 14. Example excerpt from the waviness diagram

The access to saved data can be direct on the computer responsible for the process, through the user's interface (fig.15) or indirect through the LAN network.

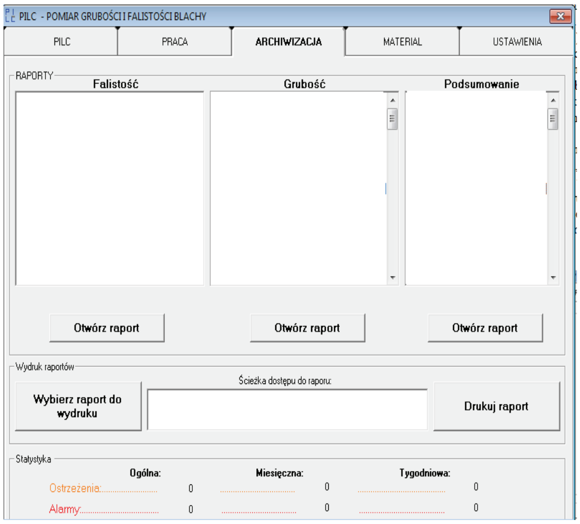

Fig. 15. User's interface enabling archive checking

The quick access from any computer connected with the network is possible thanks to the program attached which additionally renders the management of the working sheet base possible (fig. 16).

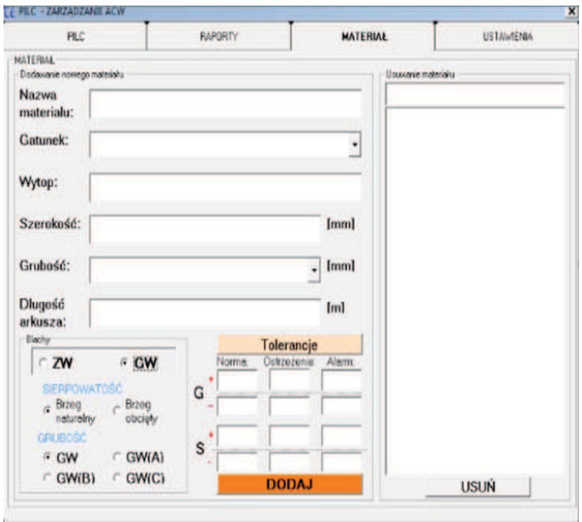

Fig. 16. Tab to manage the material base from computers connected to the LAN network

6. CONCLUSION

The measuring system of sheet parameters on the transverse and longitudinal cutting that has been designed and constructed functions as an independent product quality control system. The implementation of the automatic control and reporting is the basis for the introduction of the quality management. At the stage of improving metrological characteristics of the system, it was indispensable to use the system of program filters adjusted specially to the confounders. Recursive filters with selectable factors which include: material type, vibration level and sampling frequency were used as basic filters. The acquisition of greater knowledge thanks to the examined process will enable further improvement of the program tools.

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