Software for quality evaluation of a PS plate edge

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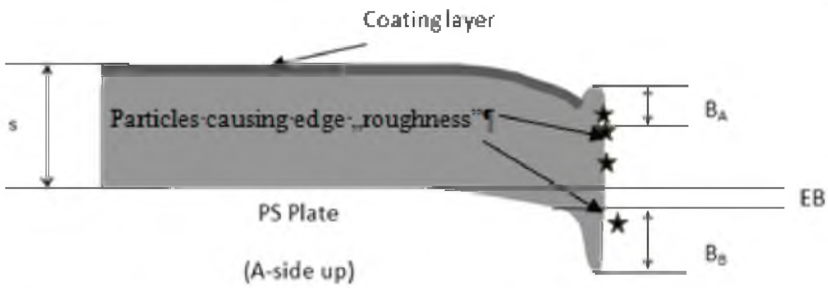
Pre-sensitized (PS) plates are specially treated and coated aluminium sheets, widely used for offset printing. PS plates used in the Computer to Plate technology require strict quality control of the plate's edges, disturbed during various finishing processes like cutting on guillotines or slitting. For this purpose a special tests stand had been built by the Silesian University of Technology, in cooperation with one of the largest PS plates manufacturer in the world – FUJIFILM. The paper describes the software, written for the purpose of evaluation of various defects caused during finishing processes.

1. Introduction

Pre-sensitized (PS) plates are approximately 0.15 – 0.4 mm thick aluminium sheets, covered by several layers of a light- or heat- sensitive coating. Hundreds of millions square meters of these materials are used yearly in the offset printing industry. The State of Art – Computer to Plate (CtP) technology requires from manufacturers adherence to various quality requirements, more strict and demanding than the applicable Standard (1). A very important part of every PS plate are the edges, sometimes severely disturbed during finishing processes, especially during cutting and slitting. Defective products cannot be repaired. Defects to the plate's edges can have detrimental effect on the printing quality (i.e. "edge toning") and can cause damages to the machine parts of the printing press. Excessive cutting burrs can also cause injuries during plate handling. Some typical defects introduced during finishing processes to the PS plate are shown in Fig. 1.

Extend of some defects, like burrs and edge fold can easily be determined by the use of a standard profile measuring apparatus. Other, like plate's "roughness" or so called "edge ripple" have to be estimated organoleptically. To overcome this difficulty a special testing stand had been built and tested at the Silesian University of Technology at the Department of Mechatronics. The PS Plate Edge Scanner allows quality control of the PS plate's edge, during a non-contact, non-destructive measurement of the selected sample area. Major advantage of this apparatus is able to estimate the plate edge "roughness" as no other test method is available.

a)



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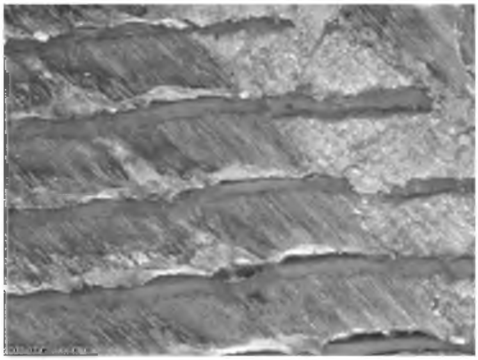

Fig. 1. Typical defects to PS plate after cutting: a) Cutting burrs (B), Edge Bending (EB) and Edge “Roughness”, b) Severe form of a PS plate defect caused by cutting on a guillotine

2. Definition of the PS plate edge “roughness”.

“Roughness” on the plate’s edge might be defined as a rough unevenness of the plates’ surface. It is caused by aluminium and aluminium oxide particles adhering to it. There is no equipment for evaluation of this defect, and consequently it is estimated by the technician during examination of the product’s edge after cutting. Some “rough” particles can be removed easily with a fingernail, causing difficulty to obtain and to preserve reference materials. This defect has, however, serious consequences for plate’s quality. It causes potential risk of jamming and pollution with fine particles during exposure and development of the plate and can have detrimental influence on the quality of the printed image.

Origin of the “roughness” phenomenon has been investigated in detail by the team of scientists led by A. Mężyk and Z. Rdzawski [2 – 4]. A typical view of a plate surface after cutting shows Fig. 2.

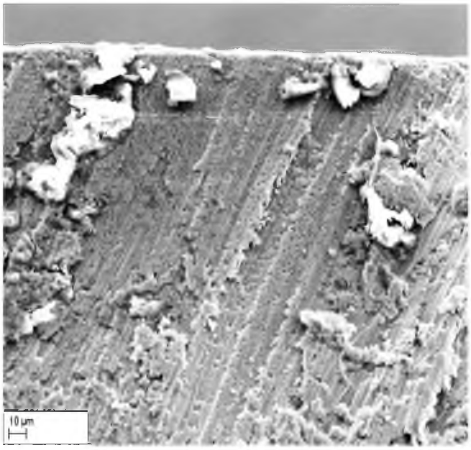

Fig. 2. Particles causing „edge roughness" of the PS plate

In order to overcome the difficulty in evaluation of the severity of this defect, a prototype of a measuring stand has been constructed at the Department of Mechatronics, Faculty of Electrical Engineering of the Silesian University of Technology in Gliwice, Poland [5]. Two laser sensors moving alongside the edge measure the size of particles adhering to the plate. The "roughness" phenomenon can be investigated further, allowing to take proper countermeasures in order to limit the extend of this defect.

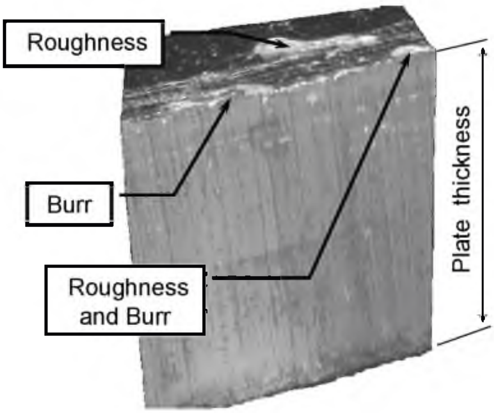

Fig. 3. Exemplary defects of plate edge

The magnified region of PS plates edge area are presented in Fig. 4.

The newly constructed at the Silesian University of Technology apparatus can estimate also severity of various other defects, like cutting burrs, edge folding, edge ripples etc. [6]. Results of organoleptic judgements of the operators and surface profile measurements were combined and integrated, resulting in one, objective judgement regarding the PS plate edge quality.

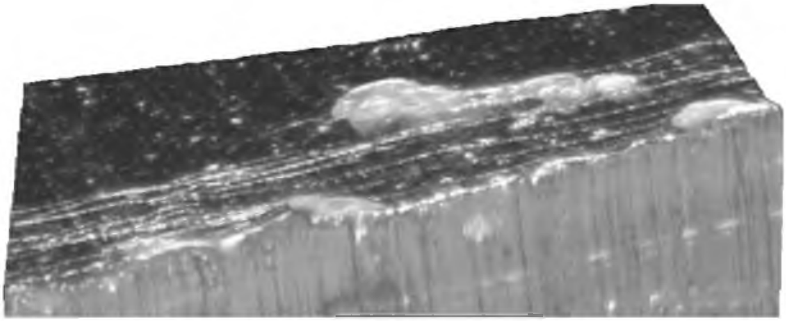

Fig. 4. Magnified region of the PS plate edge area after cutting

3. A Prototype of the PS plate edge scanner

The general view of prototype PS Plates Edge Scanner is presented in Fig. 5. The main components of this device are as follows:

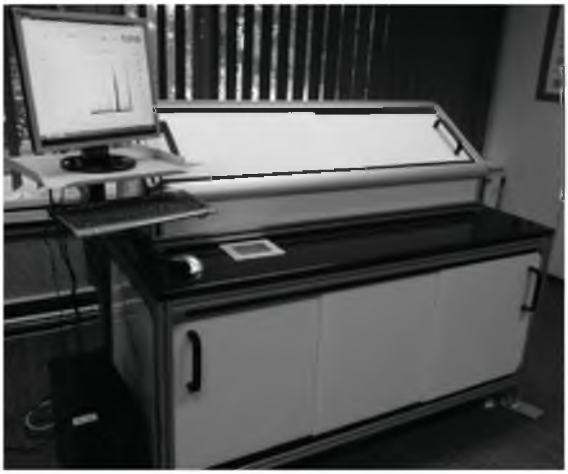

Fig. 5. A general view of the PS Plate Edge Scanner

- Laser scanning heads – two Keyence LJ-G030 laser scanning heads were used. The view of a single laser head is shown in Fig. 6. The two heads work simultaneously and scan top and bottom parts of PS plate with standard vertical resolution of 1 μm. The width of the scanning heads laser beam is 22 mm at a reference distance of 30 mm.

Fig. 6. Exemplary view of the Keyence LJ-G030 laser scanning head used for the Project

The two laser heads create accessible measuring (scanning) area, consisting of two trapezoidal regions. The measuring area and its fundamental dimensions are shown in Fig. 7a. The tested PS plate should be placed close to the central part of measuring area, - it assures high accuracy of the measurement. The way how the PS plate should be placed in the measuring area is shown in Fig. 7b.

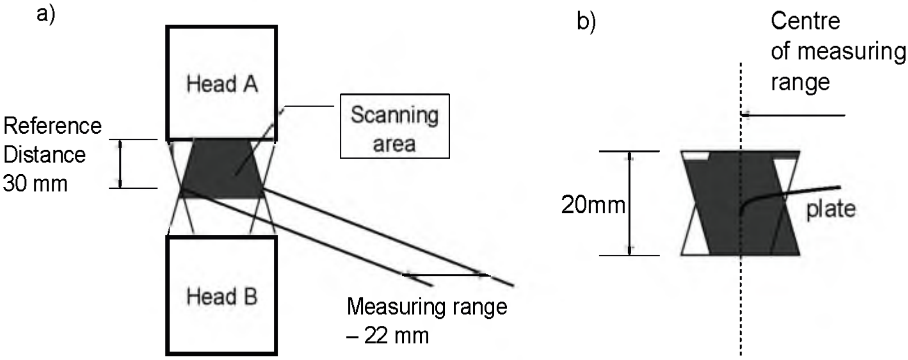

Fig. 7. Basic dimensions of the accessible measuring area of the PS Plate Scanner

- Scanning laser heads controller – this device is responsible for controlling the heads and collecting the temporary measurement data. The LJ-G5001P laser heads controller is able to collect in its internal memory data from 1024 scanning series. Naturally, it is possible to extend the number of storage series by adding an external memory card.

Fig. 8. Scanning head LJ-G50001P controller

- Servo linear module – this device is responsible for transporting the sample plate between the scanning heads in a discreet way. The maximum (stable) discreet resolution of horizontal linear motion is 200 μm,
- PLC controller – it is responsible for controlling the linear servo module and keeps the linear translation of measured sample in the specified region,
- Touch panel – allows operator to control the measurement (scanning) process. It allows to set the test conditions – like number of scans, selected/specified scanning region etc.
- Personal computer – it is used for collecting measurement data and storing them in the data base. Installed software allows evaluation of the data collected during testing. Finally, the quality of the PS plate sample can be estimated.

4. Operation algorithm of the PS plate scanner

The PS plate scanner consists of six main hardware components, which are necessary for proper operations. They include: scanning heads, LJ-G5001P laser heads controller, linear servo module with servo controller, FESTO PLC controller, a touch panel and a personal computer. Mutual interactions between main components and flow signals are shown in Fig. 9.

The touch panel allows for setting position of the table for suitable PS plate sample placed on it. In addition, it allows for choosing the number of desired scans and the scanning region. From the touch panel all mentioned settings are sent to the PLC controller. The PLC controller sets the servo module to the desired home position. After reaching it, the strobe signal is sent to the laser scanning head controller. The controller denotes permission to begin single scan of the PS plate sample. Results of the measurements are sent to the personal computer and are presented by the LJ-Navigator software. The LJ-Navigator software sends the second signal to the laser scanning heads controller, containing information if further storing of the data is required. Exemplary raw data after a single scan are presented in Fig. 10. The top curve corresponds to the shape (single scan from edge to interior part of PS plate) of the coated side of the examined PS plate; the bottom curve corresponds to the uncoated side of the PS plate.

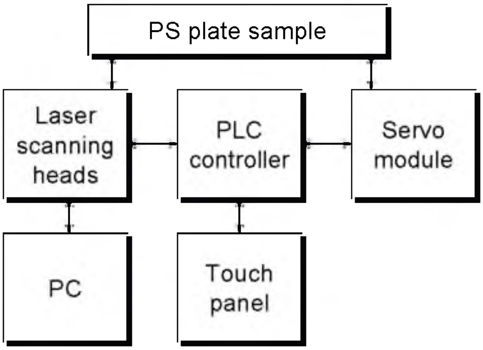

Fig. 9. Block structure and mutual interactions between the hardware components of the PS Plate Scanner

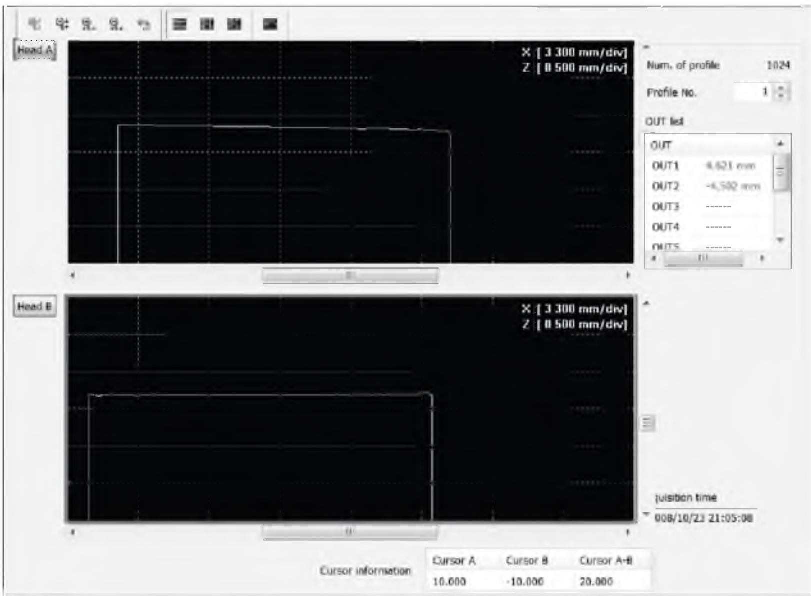

Fig. 10. Exemplary data representing single scan of both sides of a PS plate

5. Algorithm of operation of PS plate quality evaluation software

The Algorithm of operation of a PS plate quality evaluation software consists of twelve steps, shown in Fig. 11.

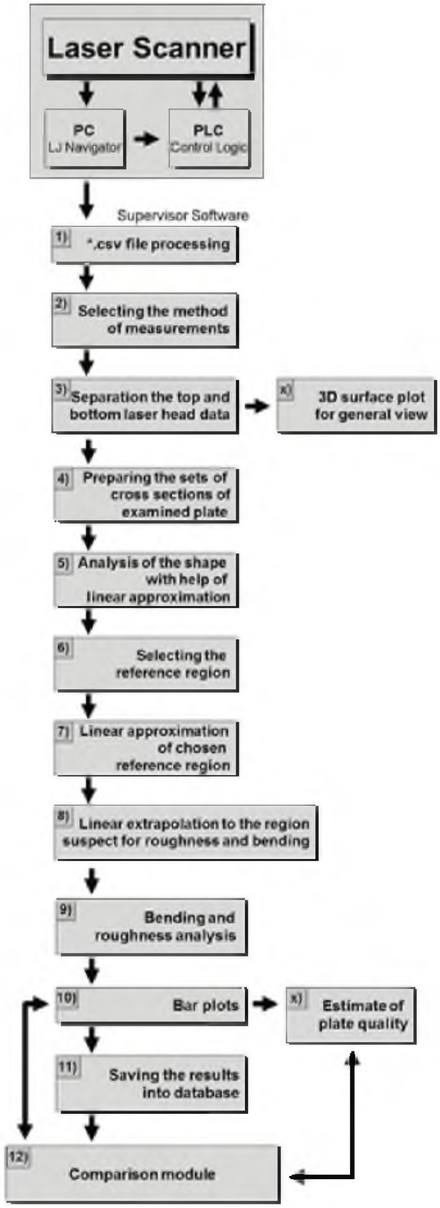

Fig. 11. The Algorithm of operation for a PS plate quality evaluation

There are following steps of the Algorithm:

1. ***.csv file processing** - all scanning data are stored into the internal memory of LJ-G5001P laser heads controller. This data should be finally saved in the desired folder, using the LJ-Navigator software with "csv" extension. The "*.csv" file contains the data representing the shape of the top and the bottom of the PS plate surface (recorded with the desired resolution, put-in by the user through the touch panel).
2. **Selecting the method of measurements** – the measurements method is based on collecting data from the upper and the lower laser head in the measurement range (tested area) for an adequate number of scanning points.
3. **Separation of top and bottom data** - at this step the data are split into two sets, representing only the data related to the top and the bottom surface of the PS plate. Furthermore, the data are cut into 200 points in the direction towards the interior part of PS plate. It limits the data for further analysis to a stripe of an average width about 5.4 mm and the standard length defined and set by user from touch panel. Exemplary data representing the shape of the top and the bottom side of a single scan after data clipping are shown in Fig. 12.

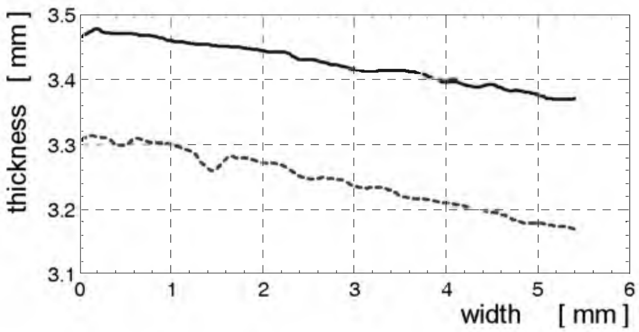

Fig. 12. Exemplary shape of the top and the bottom fragment of a PS plate after single scan

4. **3D surface plot** - in this step the processed data from the top and the bottom side of a PS plate are prepared for three-dimensional plot presentation. Exemplary 3D plot of the scanned plate is shown in Fig. 13. A severe deformation between point 60 and point 70 on the plate edge is clearly visible.
5. **Preparing the set of cross sections of the examined plate** - at this step the reference area for the base is selected and the angle between the reference area and the rest of the plate is calculated.
6. **Linear approximation** - at this step the reference area for the base is selected. From all the data set of each individual scan (for every side of the plate), thirty samples near the edge of the base region are omitted. The remaining results are used for linear approximation and for the calculation of the empirical

"Roughness Coefficient". The reference regions used the in data from Fig. 10 are shown in Fig. 14.

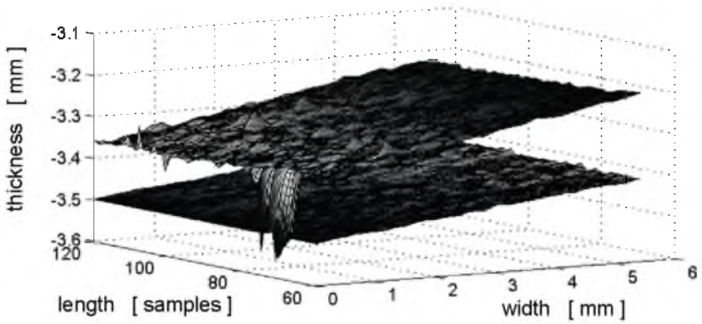

Fig. 13. The view of a reconstructed fragment of the scanned PS plate

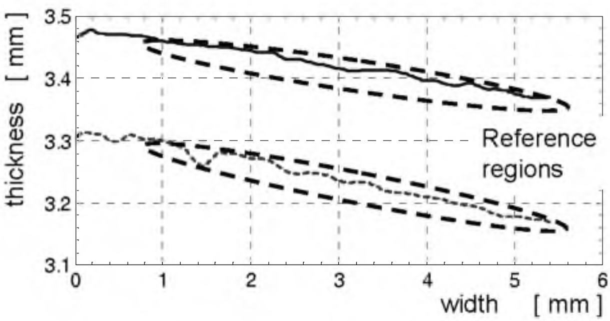

Fig. 14. Regions used for linear approximation, necessary for establishing artificial reference region

7. **Linear extrapolation to the suspected "roughness" and the "edge bending" regions** - at this step the interpolation line from step 4 is extrapolated to the region suspected for "roughness" and "bending" defects. The distance between the extrapolating line and the line where measured data are collected is calculated.
8. **Linear approximation to the "roughness" region** - at this step the samples close to the plate's edge are approximated by a line, however every first measurement result is omitted from approximation (because it may be influenced by a single roughness particle). Once again the distances between samples and the approximation line are calculated.
9. **Calculation of the "Roughness Classification Factor"** - at this step, based on a calculated distance between the measured distances from the approximation line at the roughness region an empirical so-called "Roughness Classification Factor" is calculated according to the following formula:

$$RF = \frac{\sum_k S_{Ak} + \sum_k S_{Bk}}{Z - k} k \cdot 100, \quad (1)$$

where: RF – „Roughness Factor", S_{Ak} and S_{Bk} – height of the single bar from the lower and the upper side, Z – total number of scans (i.e. 200), k – number of measurements with bars higher than 9 μm.

10. **Calculation of the "Edge Bending (Edge Folding) Classification Factor"** - calculating the bending factor is based on the value of the angle between data from linear approximation at bending region and the data from linear approximation from the remaining measurement points beyond the reference area.
11. **Saving the measurement results** - at this step all measured and analyzed data are saved on the hard disk of the server of the PC unit.
12. **Comparison of the data from "Roughness" and the "Bending" analysis** - at this step the saved results are compared with the historical data for statistical analysis.

6. PS plate quality evaluation software

The program for quality evaluation of PS plates was created in the Matlab environment, with the use of the GUI (Graphical User Interface) module. Finally it was compiled to an executable version. The program is dedicated to users with two different access levels – the "Basic" and the "Advanced" level (Fig. 16).

Fig. 15. Starting window of the program for quality evaluation of PS plates

The Basic Level version is dedicated to all machine operators. It enables obtaining quick information about the Roughness Factor and can be used directly at the workstation in the factory. The graphical interface of basic level is divided into four main parts, as shown in Fig. 17. In the area marked "A" the users observe the final results of the analysis. General information about the outcome: actual date of measurement, numeric value of the "Roughness Factor" (between 0 and 200) and the classification symbol which represents the quality of the plate are displayed. There are four classes describing the quality of the plate's edge: *A* (very good), *B* (good), *C* (questionable) and *D* (bad). Classes *C* and *D* require further analysis of the origin of the defect and proper countermeasures must be taken.

The area "B" contains a fields dedicated for inputting personal data of the operator – like his name or nick name and the symbol or a number of the working team. In the area "C" the user has a possibility to choose the device (i.e. guillotine) number. All the data in B and C areas are typed by operator. The D area is a control panel for opening the source directory file, for starting analysis of the process, for saving data or for printing results of the measurements.

Fig. 16. Main window of the "Basic Level" mode

The most sophisticated tools are included in the Advanced Access Level mode. In this case the software is dedicated to specially trained operators and engineers, interested in much more detailed analysis. The general view of the Advanced Level window is shown in Fig. 18.

The main window displayed on the computer screen for the advanced user can be divided into five areas. Window marked as area "E", placed in the central part of the screen, enables visualization of the measurement results. In allows free choice between the 2D and 3D view of the displayed data. This tool is very useful when more detailed analysis (i.e. trouble shooting) of a PS plate is required. The visualization includes the form of the 3D plots: top and bottom surface plot (Fig. 19) and the deformation bar plots of the edge area (Fig. 21).

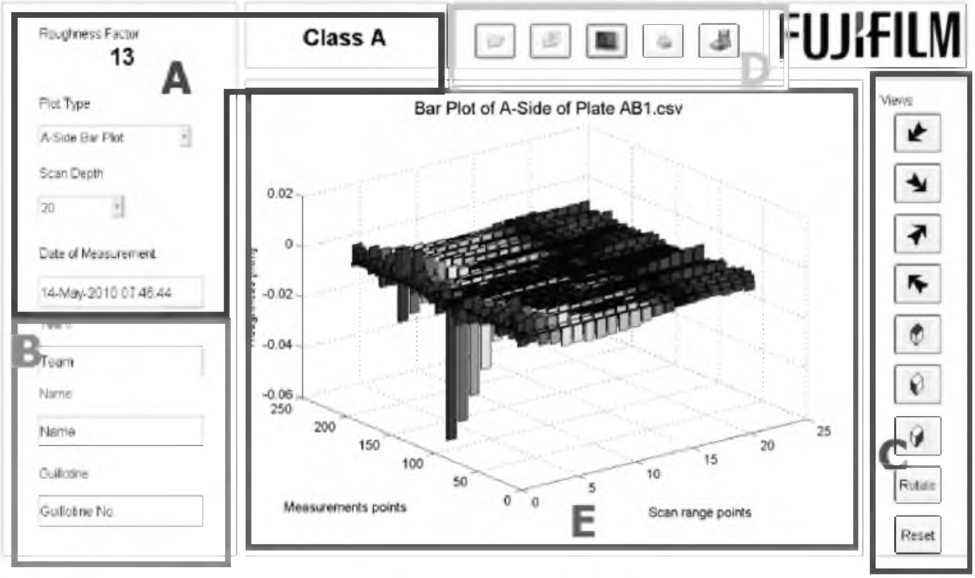

Fig. 17. A view of the main window of the "Advanced Level" mode

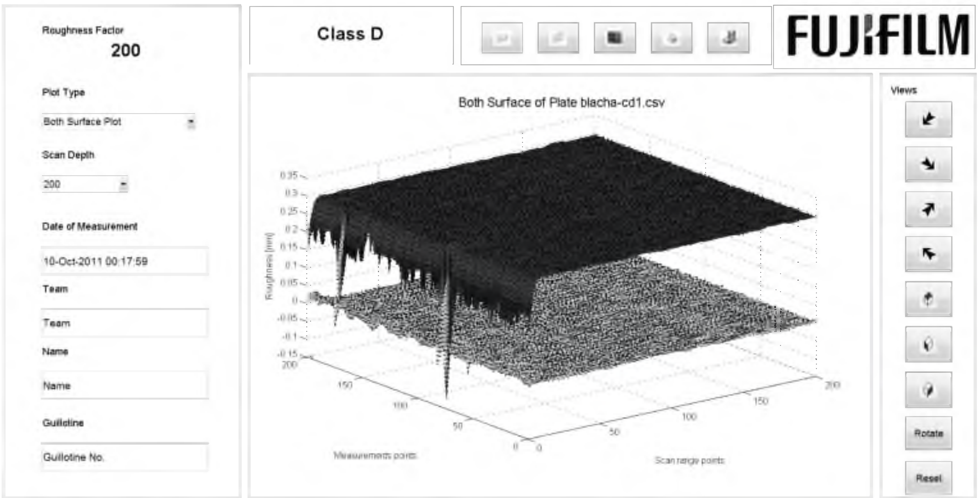

Fig. 18. A view of the main window of the "Advanced Level" – top and bottom surface plot

Also 2D plots are enabled, such as: line plots of edge area (Fig. 20) and the bar plot of local Roughness Factor distribution (Fig. 21).

The all settings: the type of plot and the range of presented data are placed in the A area. The remaining information, like the date of measurement, Roughness Factor and the quality of plate is basically the same as described previously. In the down left corner (area B) the operator puts in his personal data. On the right hand side of the main window (area C), the graph the navigation icons are placed. This panel contains tools for choosing isometric view, for rotating the view and for resetting the view settings. The Area D is the same as described previously – it allows the operator to select the file folders, type of charts to be displayed, print out formats and contains file saving options. The software does not require re-entry of data after working with the basic level or advanced level, because the procedure analyses saves the data in text files which are stored in a folder on the hard disk drive. If necessary, the old files can be analyzed again and compared with the more recent ones.

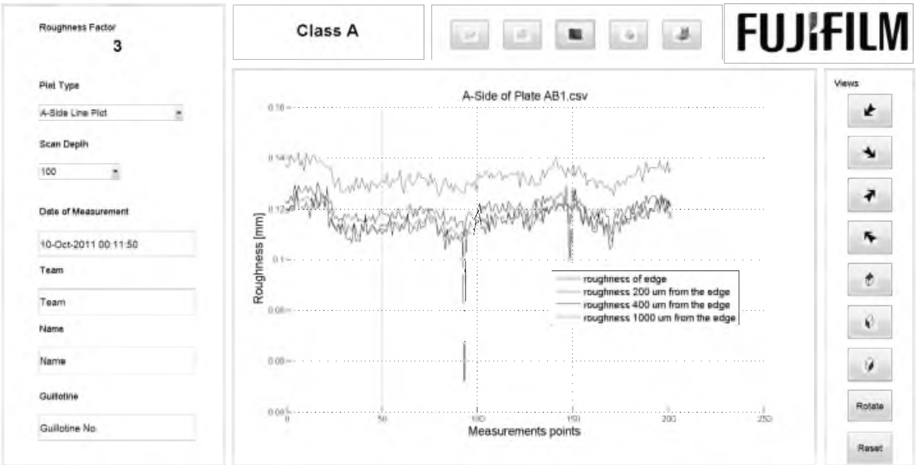

Fig. 19. A view of the main window of the "Advanced Level" – line plot

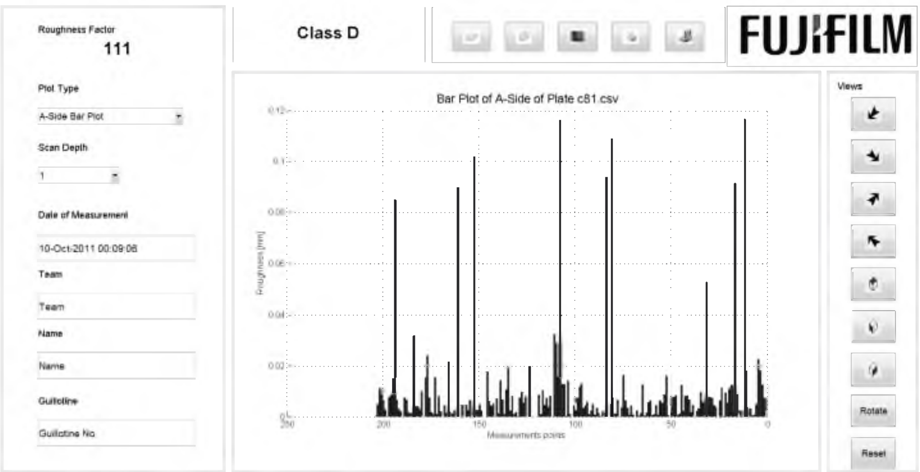

Fig. 20. A view of the main window of the "Advanced Level" – 2D bar plot

7. Conclusions

After a period of an extensive research and repeatedly carried out scanning of over 500 PS plate samples, a very good correlation had been reached between the organoleptic, human judgment of PS plates edge quality and the test result obtained by the PS Plate Edge Scanner. The program will be extended for all other useful modules, like estimation of edge bending and burrs alongside the plates edge. In addition, some recently observed phenomenon like – the “edge ripple”, related to newest generation of the PS plates used in CtP technology, will be measured and classified, adding a new dimension to the quality control in the PS plate industry.

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