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BYTEWISE

Embossing Depth Measurement for Profile Extrusion Processes

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OVERVIEW

Embossing quality is a leading aesthetic value that differentiates construction products such as siding, trim boards, and deck boards. Embossing imparts a wood-like characteristic to the appearance of the board surface that buyers find attractive.

Many building profiles are manufactured by extrusion processes that apply a weather -resistant capstock over the extruded profile. The profile is then passed through a roll stand that embosses a pattern into the material. Several problems can lead to non-uniform embossing depth.

- Poor roll setup
- Roll wear
- Roll contamination due to transfer of capstock onto the rollers
- Elastic behavior of the compound (die-swell and springback)

Several problems can result:

- Boards with different embossing depths can appear to be different in color due to differences in shadowing, thus causing customer complaints.
- Excessively deep embossing can weaken the capstock and lead to premature ageing.

Shallow embossing is a serious concern that creates scrap in the production shop, product returns by the distributor, and even returns from the decking contractor. In the worst case, complaints come from home owners who report inconsistent appearance after a deck installation is complete.

There are no industry-wide measurement solutions in use for measuring embossing depth. Some shops make periodic checks off-line using standard lab instruments such as Coordinate Measurement Machines (CMM). Others use hand tools or simple visual checks.

This paper introduces laser triangulation profile sensors as a solution suitable for on-line and off-line checking for embossing depth.

LASER TRIANGULATION

Laser triangulation is a method of distance measurement. As shown in figure 1, a laser light source projects a point of light onto the measurement surface at distance D1. The laser light is reflected at angle α through a lens and onto a detector at position d1. When the measurement surface is positioned closer to the laser source at D0, the reflected light falls on the detector at position d0. When the measurement surface is positioned farther from the source at D2, the reflected light falls on the detector at position d2. The range of the D2-D0 can be scaled to the range across the detector d2-d0 so that the detector output correlates to the actual distance between the sensor and the measured surface.

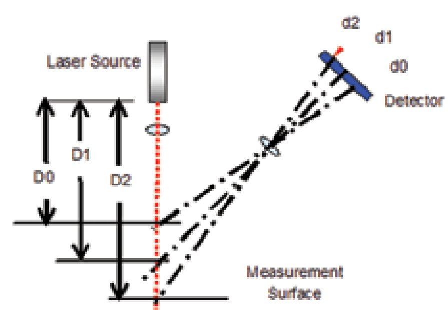

Figure 1 – Laser Triangulation Method

Early laser triangulation sensors used analog devices such as gallium arsenide to detect the change in position of the reflected laser light. These came to market in the 1970's and are referred to a Position Sensitive Detectors (PSD). PSD's output a varying voltage or current proportional to the position of the light on the detector. Charge Coupled Devices (CCD) are now in wide use as detectors. CCD's are light sensitive microchips of the type used in digital cameras. A CCD detector may contain, for example, 1024 pixels that result in a detector resolution of 1024 parts across the measurement range.

PROFILE TRIANGULATION

In the mid-1990's, Starrett-Bytewise Measurement Systems and others developed profile triangulation sensors that substituted a laser line source for the laser point source, and substituted a 2-dimensional CCD array in place of the single-axis pixel array. This is illustrated in Figure 2. A profile triangulation sensor using a one mega pixel detector (1024 x 1024) could now acquire data comparable to 1024 fixed-point laser triangulation sensors. These were marketed as "sheet of light" laser sensors. These sensors could acquire a single profile of 1024 points at frequencies up to 15 samples per second, which is suitable for on-line rubber extrusion measurement. Note that Complimentary Metal-Oxide Semiconductor (CMOS) detectors are used in place of CCD detectors where higher frequencies are required. CMOS detectors achieve frequencies of 2,000 to 8,000 Hz in similar applications.

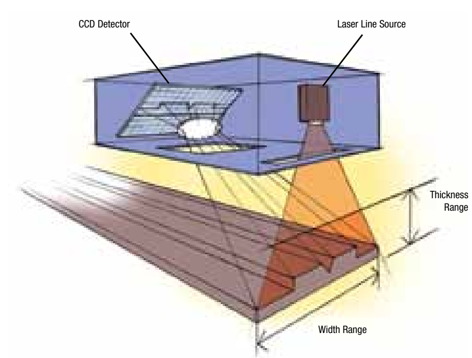

Figure 2 – Profile Triangulation Method

SOFTWARE CONSIDERATIONS

Sensor systems consist of the sensor, power supply, cable, data acquisition card, PC, and software. Software can be divided into several functions including real-time data acquisition, calibration transform, parameter calculation, visualization, test-plan management, data history management, reports, and external communications, as shown in Figure 5.

Real-Time Applications take a single profile, perform a calculation to extract measurement values, and output the measurement values for visualization, grading decisions, and automatic feedback. This is done at the sensor frequency.

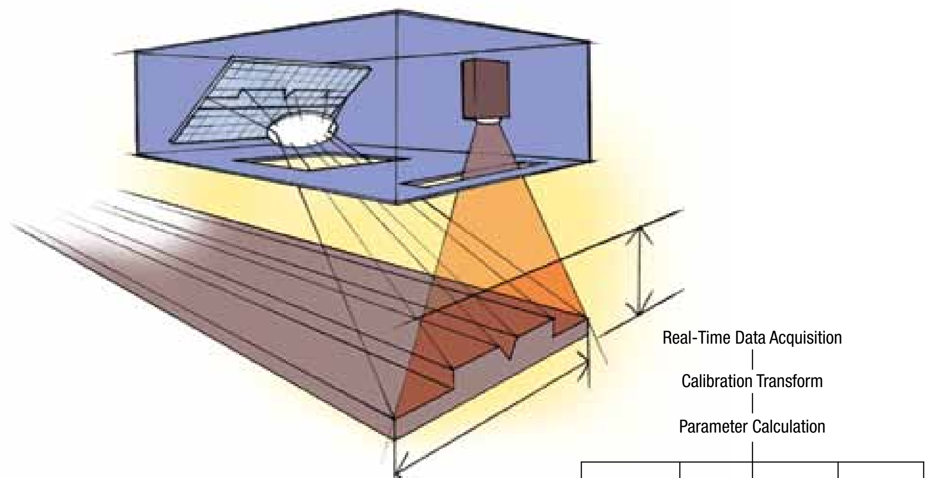

Figure 5 – Profile Sensor Software Functions

RESOLUTION

Resolution is defined as the smallest dimensional change that can be recognized. Resolution for the Starrett-Bytewise profile sensors is 0.001mm (0.00004") in the thickness axis. In the width axis points are spaced at 0.001" intervals.

EXAMPLES

Figure 6 shows the raw point data from an embossed deck board. The line width is 1". The bottom scale (width) has major division of 0.25" and minor divisions of 0.125", as does the vertical (thickness) scale. The embossing depth caliper indicates a maximum embossing depth of 0.008".

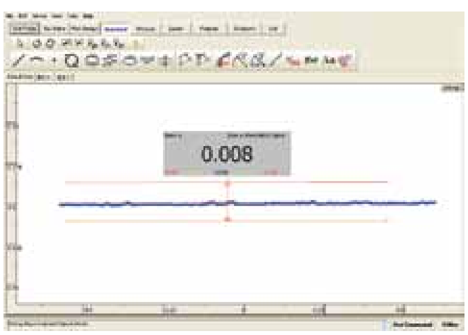

Figure 6 – Embossing Depth Profile over a 1" Wide Area

Figure 7 is a zoom view of the same sample. The embossing depth caliper has divided the 1" width into seventeen 0.060" wide subdivisions. Each subdivision of the caliper closes to the highest and lowest peak points, and returns the peak-to-peak thickness value. The embossing depth caliper returns the highest of the seventeen values. The subdivision width is indicated for the left subdivision below, along with the peak point locations for the right subdivision.

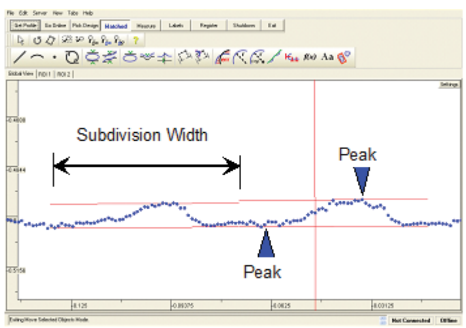

Figure 7 – Zoom View Showing Caliper Subdivisions and Peak Points

In Figure 8 below the profile has been divided into three individual Region-of-Interest (ROI) Windows. Each ROI has a maximum embossing depth caliper that returns the depth for that ROI. The upper left window shows the complete profile with three thickness values. The remaining three windows show the ROI profiles segments. The vertical scale on the ROI windows has been expanded vertically to better visualize the embossing texture.

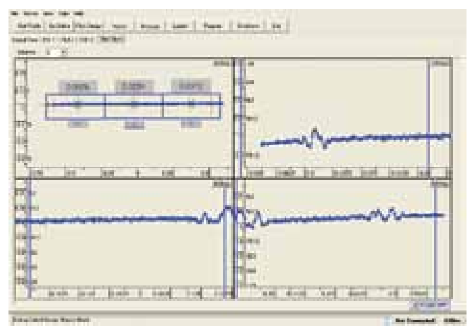

Figure 8 – Tiled View Showing Profile Divided into Three Regions of Interest and Resized to Increase the Vertical Scale

CONCLUSIONS

Starrett-Bytewise Profile Triangulation sensors have been successfully utilized to measure embossing depth in PVC deck and trim boards; WPC deck boards, and vinyl siding. Several advantages have been realized:

1. Embossing depth values are automatically measured, calculated, displayed, and recorded.
2. Measurements are objective and not operator dependent.
3. Complete embossing profiles can be saved for audit.
4. On-line measurement can be used to continuously monitor the embossing depth, and alarm the operator when any problem occurs. This can identify problems not possible with periodic off-line checking.

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