Defining the Problem

Flatness in metal Rolling

Sheet flatness, normally measured in I-Units, can be detrimentally affected at many various points in the production process. It can be affected by improper tensions between transfer rolls while loading or unloading the mill or finishing process, or any heating or cooling operations such as cleaning lines or coating operations. **If the end use of the material being produced requires that the material be substantially "flat", how can you monitor and control this sheet flatness prior to final inspection?** Measuring sheet flatness using equipment sensitive and rugged enough for 100% inspection can be cumbersome and expensive.

A Method for low-cost evaluation of surface flatness of reflective surfaces.

This article describes a method that I've developed for evaluating the surface flatness of semi-smooth reflective surfaces. It utilizes off-the-shelf components, making it very inexpensive. I've used it in multiple web applications at various locations throughout the world and although it utilizes a simple principle, I've not seen any commercially available implementations of it to date and I welcome any ideas aimed at developing it commercially.

I'm publishing this article knowing that this method will be beneficial to others and offering my experience using and applying this method in various applications to anyone who might be able to benefit from it. If you would like more information, please contact me during regular business hours (in Colorado, USA) at (720) 530-6290 or by email at jack@surfacequality.com

Flatness measuring systems are expensive

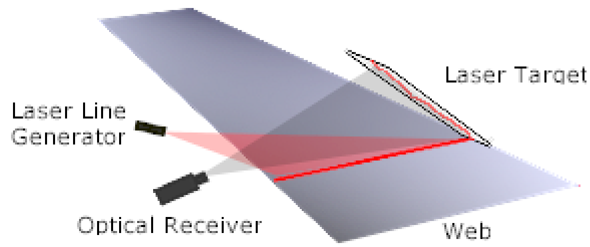
Measuring sheet flatness is generally performed off-line on custom designed flatness tables. A section of the web is cut from the head or tail of the coil and laid on a flat table where it is then scanned by some optical measuring system using 2 or 3 dimensional scanning and that signal is then processed to produce a statistical report about the material. The problem inherent in this method is **that the head or the tail of a coil is usually not representative of the bulk of the material contained in that coil**, either in thickness or flatness. Acceleration or deceleration of the rolling mill causes large shape deviations in these portions of the coil that are not present in most of the coil. Measuring here will tend to skew results making your production process look more or less capable than it actually is.

By employing a low-cost Laser generator, and any one of several forms of a target receiver, based upon the application, a suitable go/no-go production test for sheet flatness is available. By adding a personal computer to this sensor arrangement, precise measurements are possible using software to interpret the target waveform.

The linear laser reflective method

General Description

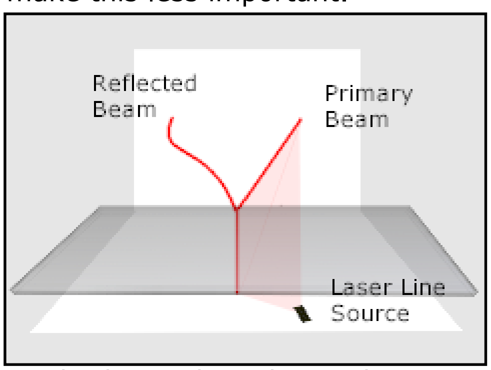
A laser line (usually a visible Helium-Neon) is cast across the surface to be inspected at a low angle of incidence and rotated approximately 10 degrees from the vertical plane so that the resulting reflection forms a "V" shape on the target material. One leg of this "V" is formed by the original laser and is usually eliminated in a commercial device by a suitable mask. The other leg is formed by the reflection of the laser off of the material under inspection. If the material is perfectly flat, then this leg will also be perfectly straight. The deviation from flat is amplified by the geometry of the laser in relation to the position of the target and the material under inspection. Very large levels of magnification can be obtained with this method depending on the space available and the width of the material under inspection.



- **A laser line is cast across the material to be measured using the proper illumination geometry and the resultant reflection is optically collected and statistically evaluated.**
- **Can measure material flatness during the production process.**

Specifics

The laser generator can be any one of several commonly available line generators or standard He-Ne lasers with a line generator lens attached. This principal can be easily demonstrated using an 8x10 inch sheet of glass and a laser hand scanner to generate the line source (those ubiquitous devices used for reading bar codes). The brightness of the laser is important for received signal strength, but good target selection will make this less important.



Very large surfaces may be scanned using this technique. An 80" web of finished aluminum or steel can be easily characterized while the material is on the production line. The primary drawback inherent in this technique is that the amount of deflection in the reflection of the beam for a fixed change in flatness varies across the web. The farther from the beam origination point, the less the amplification of the reflected beam, however, this variation is predicable and can be mathematically factored out by appropriate computer software.

Surface roughness of the material tends to scatter the laser beam in different directions, making the target line less distinct, therefore when scanning metals or other rolled materials, this method works better while scanning across the web rather than in the rolling direction.

Laser Selection

An important consideration in selecting the laser is the line width generated and the transition intensity or sharpness of the line gradient. **A sharp line provides the best-reflected signal for the receiver**, but a good signal can be built using various image processing transforms to condition the final image.

The target material is suitable if it provides the adequate contrast between itself and the laser color. An appropriate Helium-Neon laser target (red line) would be a white, non-reflective surface.

Receiver Selection

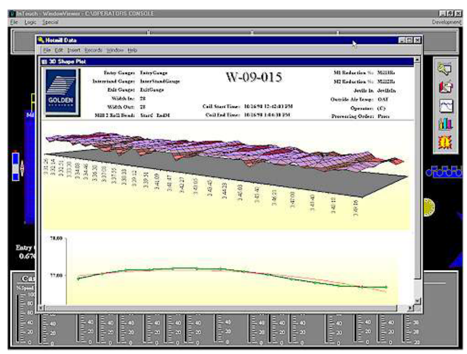
Shape measurement requires a different target receiver than dent detection. **A dent detection system uses an analog detection system due to the high rates of inspection needed and the need for 100% inspection.** An analog detection system consists of a specially designed fiber-optic target that will sense very small movements of the laser caused by dents passing through the beam. I've made practical application of this method in detecting dents as small as 5mm on a web moving up to 2000 feet/minute.

Benefits

- Large amount of material can be inspected
- 100% inspection available at low cost
- Can detect small dents online in high speed web

Lāflis *(Laser Flatness Inspection System)*

I've called this application ***Lāflis***. And it's been used in various applications on a small scale, but I would like to see it used to a greater extent, as I believe it offers a tremendous cost savings for those whose applications could benefit from it. The process works on any smooth surface but finished metals, such as aluminum work particularly well.



Flatness being measured on a rolling mill

I'm currently developing this system commercially and seeking interested partners to help fund the project. If you have an application that would benefit from this technique and would like to speak further about developing it for your own use, please contact me.

Additional Applications

The sensitivity and simplicity of this technique make it a promising method for **measuring the actual thermal crown of the work or back-up rolls in a rolling mill** application. With the proper receiver, scratches may also be detected in a moving web.

If you are interested in learning more about applying laser reflective technology, please contact me at **SurfaceQuality.com** or call me during regular business hours (in Colorado, USA) at (720) 530-6290 or by email at jack@surfacequality.com.

