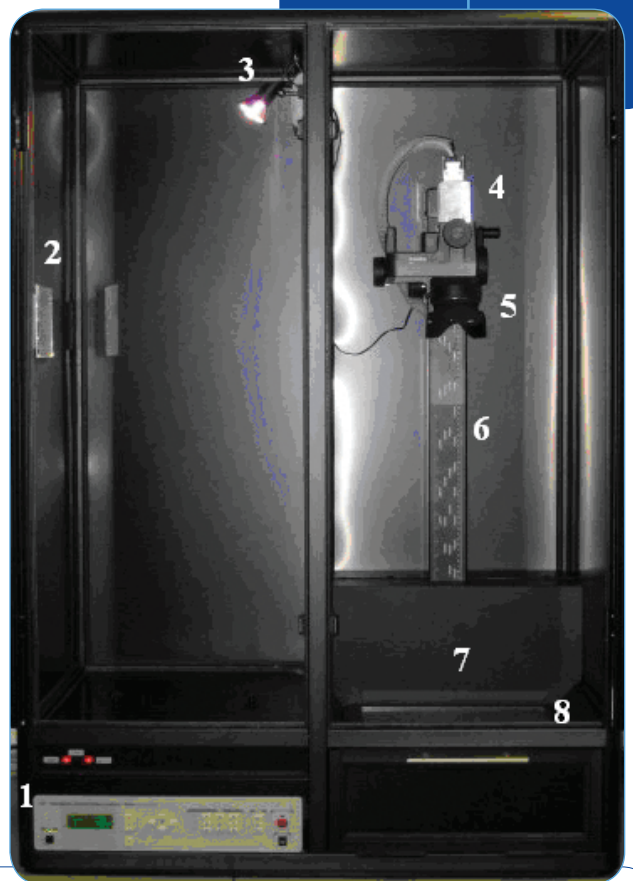


MEASUREMENT OF PAPER SURFACE TOPOGRAPHY USING SHADOW MOIRÉ METHOD

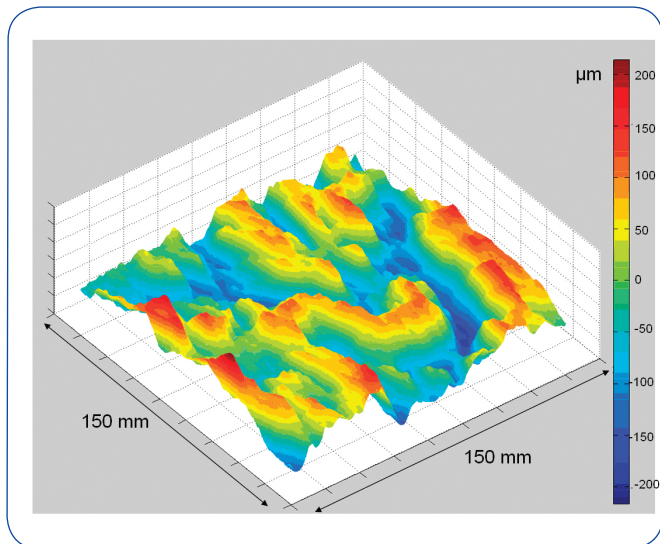
Out-of-plane deformations such as waviness, fluting and cockling are typical defects for printing grades. Due to decreasing basis weights and increasing production speeds many mills are facing these problems. At the moment these defects are typically evaluated visually since there are no standard methods for analyzing whole-field surface topography. The Shadow Moiré method is a whole-field, non-contact and non-destructive methodology to measure the surface topography of printed or non-printed paper samples. In Shadow Moiré, a paper sample is positioned under a grating which is illuminated at known angle. The light projects the shadow of the grating on the surface of the paper sample. The interference of a line grating and its shadow wrapped around the sample produces moiré fringes representing lines of constant out-of-plane depth.

PARAMETERS

- Measurement time of A4 size paper/board sample is less than 30 s.
- Measurement of surface topography of printed sheet is possible.
- When using Ronchi grating of 4 line pairs/mm:
 - The z-resolution is 4.2 μm
 - Max area is 210 mm x 210 mm.
- When using Ronchi Grating of 10 line pairs/mm:
 - The z-resolution is 1.7 μm
 - Max area is 100 mm x 100 mm.
- Xy-resolution depends on the area measured (210 mm x 210 mm area -> 0.2 mm /pixel.)



The Shadow Moiré unit enables determination of the surface topography of A4 size paper or board sample in less than 30 seconds. Main components of the Shadow Moiré unit are:
1) Motion Controller, 2) Mirror, 3) Lamp, 4) CCD-camera, 5) Zoom lens, 6) Camera stand, 7) Linear stage and 8) Grid. Dimensions of the measuring box are 970 mm (W) * 1370 mm (H) * 560 mm (D).



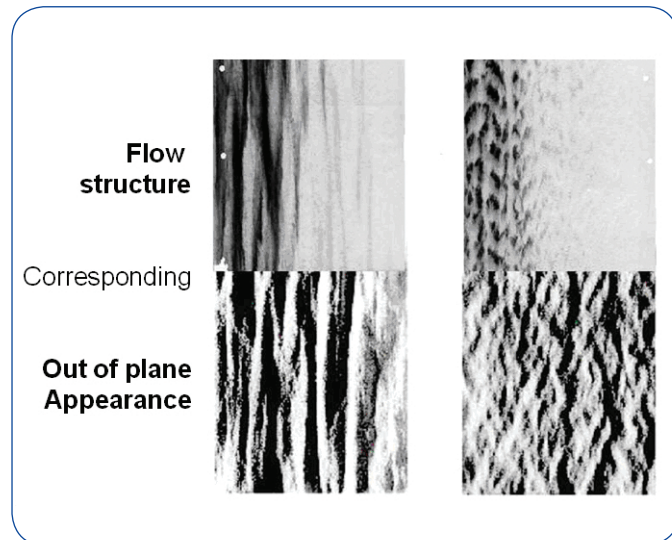
Surface of paper sample measured with VTT's Shadow Moiré unit.

The main components of the Shadow Moiré system constructed at VTT are: a white-light source, a Ronchi grating and a CCD-camera. Camera with optics and light source are installed in a black measuring box in order to eliminate the effect of ambient lighting. The illumination geometry of the VTT's Shadow Moiré unit is suitable for the analysis of cockling and fluting of A4 size paper or board samples. The temporal phase-shifting (TPS) technique has been applied to Shadow Moiré to increase its sensitivity. The z-resolution is 1/60 of the fringe period when using phase-shifting method. Sensibility of 4.2 µm is achieved for a 250 µm grating period (in 45°/0° configuration). Use of grating with 10 line pairs/mm improves the z-resolution of the system, but the max area to be measured is in this case only 100 mm x 100 mm. In our system the CCD-camera has 10-bit video output and the exposure time of the camera can be adjusted from 0.5 to 2000 ms. Therefore measurement of topography of printed surfaces is also possible. The total measurement time of one A4 size paper or board sample is less than 30 seconds. Short measurement time of paper sample

Additional information

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Flow structures vs. surface topographies.

is a necessity, because 5-15 parallel samples has to be measured in order to have a good statistical confidence for a given sample set. Different parameters describing the scale and amplitude of out-of-plane deformations can be calculated from the surface topography maps. In order to calculate the small scale variations, the large scale variations in topography such as curl are removed from the height data. Parameters include first order statistical parameters and scale parameters. Cockle sizes can also be determined.