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On-line moisture content estimation of saw dust via machine vision

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1 Background

One of the research directions currently present seeks to find methods to utilize sawdust in biofuel production. A significant challenge in the use of sawdust is its deviating flowability properties from the more common used raw materials. Furthermore, the biological nature of sawdust brings about significant variations of pertinent physical properties. The flowability of sawdust is affected by granular properties like size and shape but also moisture content. Furthermore, the moisture content is important factor when processing is concerned. Variation in moisture content brings up disturbances during the processing and needs to be controlled to achieve uniform operating conditions. Most of the pre-existing methods of moisture content measuring have too long procedural times with respect to the variation of the moisture content in the feed scales of industrial plant. For this reason, an on-line monitoring method with low capital costs and easy interpretability and generalizability with respect to monitored raw material would be of great use.

It is known that moisture contributes cohesively between objects. When particle size reaches the scales of millimeters or less, the dominant source of liquids' cohesive contribution is due to liquid bridging. Because the cohesion gives rise to deviations in the heap formations it is then logical to ask if these deviations contain some useful information about its source. In this work the angle of repose and the deviations the heap exhibit from it were used as data to infer moisture content in the sample. The aim was to find the computational features, which would manage to explain the moisture levels in adequate manner.

2 Materials & Methods

The effect of moisture content and feasibility of its estimation in granular material was investigated via machine vision. The test scheme consisted of sawdust samples derived from Norway spruce with moisture content adjusted to three distinct levels. The effect of moisture when present as ice or water was compared. The experimental procedure consisted of pouring the sawdust under video camera recording. The equipment setup consisted of a vibrator feeder and custom-built pouring frame. Still images were extracted with fixed sample time from the recording done during the pouring procedure. From the extracted frames the dynamic behavior of cone profile was investigated via statistical means. A schematic illustration of the apparatus is presented in Figure 1. The funnel was fed by sawdust from above via vibrator feeder. The pouring plate was circular so that the poured heap assumes roughly a shape of a circular cone.

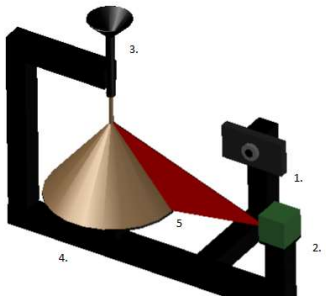

Figure 1. Test environment: 1. Video recorder, 2. Laser source, 3. Funnel, 4. Pouring plate, 5. feature marker.

The still images were extracted from the recorded video material. This corresponded to sampling to time of approx. 0.3 seconds. Any footage which involved arching at the funnel was deleted. After this, to ensure steady state assumption of the material, only last 1813 frames were used for analysis which corresponded to roughly 10 minutes of footage.

3 Results and Conclusions

Figure 3 shows an example of an extracted image from the footage with the feature marker clearly visible.

Figure 3. Example of an extracted image from the recorded footage.

It was observed during the experimental campaigns that 2nd and 4th standardized moments correlate with moisture content when present as water. When water in the material was present as ice the correlation with 2nd moment was significantly diminished and correlation with 4th disappeared. Corroborated by optical microscopy, this correlation was deduced to be due to liquid bridging in the bulk. Moisture content when present as ice was, however, observed to have a drastic effect on the overall cone shape. Based on these findings, a machine vision application could be feasible way to estimate moisture content on-line in thawed saw dust by using statistical parameters in classification decision making. This would enable cost-effective on-line monitoring of moisture content and a control system to be designed.