HAMMER-IMS

Application note

Material variations in the non-woven industry

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Introduction

Measuring and controlling the basis-weight of non-wovens during the production process is essential for the quality of the non-woven and the economics of the production line. This application note focuses on how variations in the basis-weight of non-woven materials occur. There is a non-uniform distribution of density which is intrinsically present in the fiber bales. In a non-woven production line, several production steps are inserted to improve this large variation in distribution. A setup commonly used for longer and/or larger fibers is a carder followed by a cross-lapper. Although this reduces the non-uniform distribution of density, there still remains a residual variation. As a result, non-woven products show similar variations in both the machine and the cross-machine direction. Figure 1 shows an inline basis-weight measurement system of Hammer-IMS in a non-woven production line, with indication of machine and cross-machine direction.

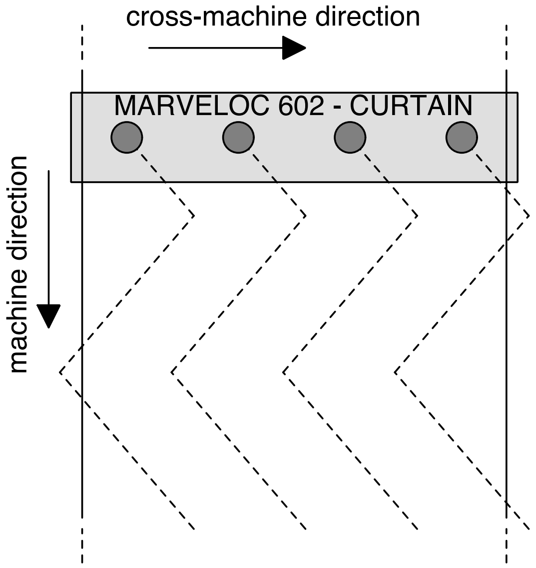

Figure 1

To conclude, in a typical non-woven production line, variations are omnidirectional and fluctuate equally in both dimensions. Figure 2 visualizes this, as, starting from a point with nominal basis-weight Wnom, the machine direction variation ΔWmd at a certain distance will be in the same order of magnitude as the cross machine direction variation ΔWcmd at the same distance.

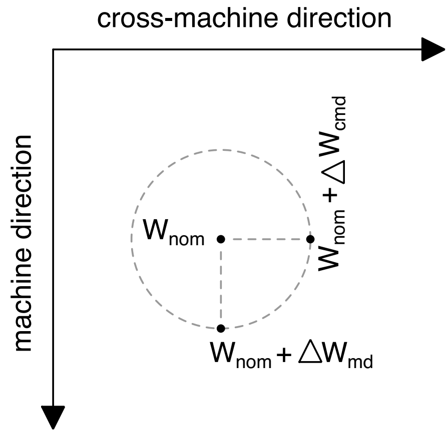

Figure 2

This can be empirically verified in two manners:

1. By cutting out a significant amount (N or M) of small identically sized samples with a dedicated sample cutter, in both the machine and cross-machine direction (see Figure 3). By then weighing the identically sized samples with a very accurate scale, it can be confirmed that similar variations are present in both directions.
2. By means of an inline scanning basis-weight measurement system:

    a. The variation in cross-machine direction can be isolated by performing a measurement when the production line is paused and the measurement system is scanning, thereby measuring the profile solely in the cross-machine direction.
    b. The variation in machine direction can be isolated by performing a measurement when the production line is running, but the measurement system is stationary measuring, thereby measuring the profile solely in the machine direction.

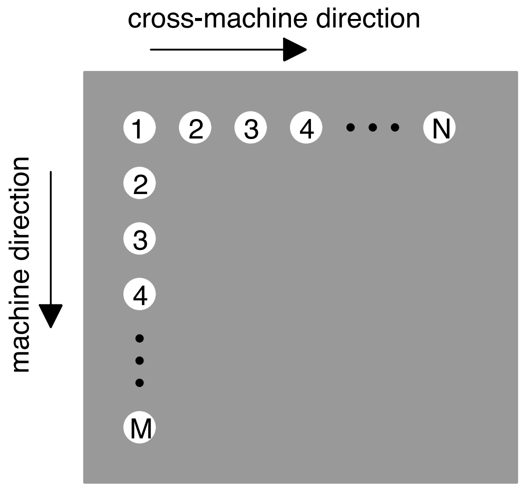

Figure 3

Influence of variation in cross-machine direction

Figure 4 shows a typical profile scan of a non-woven material. The basis-weight of the material is plotted as function of the position in cross-machine direction. The nominal weight Wnom is indicated, as well as the maximum weight W+ and minimum weight W- as defined by the allowed tolerance. As can be seen, the variation

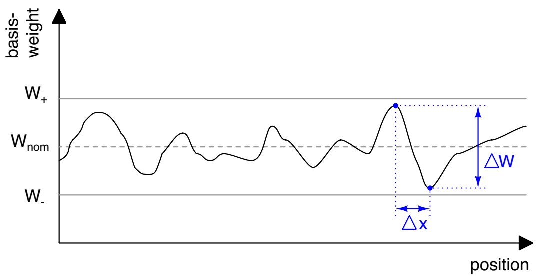

Figure 4

ΔW can be significant over a short distance Δx. This implies that when cutting a single sample out of the material, the position in the cross-machine direction of where that sample has been taken has a large influence on the weight of that specific sample. That single sample might be considerably heavier or lighter than the mean weight of the overall material.

Therefore, great care must be taken when selecting samples to use as calibration samples. Moreover, the exact positioning of the used calibration sample can have great influence. If several calibration samples are used (e.g. for different products), it is essential that samples are always placed back in the exact same position to ensure reproducible results and to avoid having large variations in basis-weight. An error of 10gsm or more is quickly introduced by inaccurate positioning of samples.

Influence of variation on selecting and positioning of samples

Figure 5 shows the probability density function of how the basis-weight of a non-woven is typically distributed when measured by a correctly set measurement system. The weight is distributed symmetrically around the nominal weight Wnom. The farther you deviate from the nominal weight, the lower the probability of a basis-weight value. The probability density function is constructed assuming that all values fall within the allowed tolerance.
As an example, let's take a non-woven being produced with a nominal weight of 1000gsm and an allowed tolerance of 10%. The production line is producing well within the minimum allowed basis-weight of 900gsm and the maximum allowed basis-weight of 1100gsm.
In the figure below, the probability of making an error of less than 10gsm is indicated. If the distribution would be uniform, this probability would be 1/10th or 10%. This is a worst-case assumption, as the distribution in

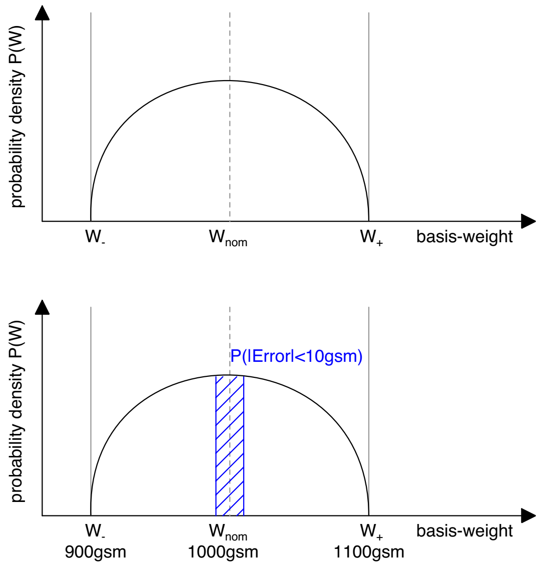

Figure 5

this case is not uniform, but rather concentrated around Wnom. Therefore, 10% can be regarded as the minimal probability of an error less than 10gsm. Nonetheless, it shows that when taking a sample from the non-woven at a random position, the probability of making an error more than 10gsm is quite high.
This error probability can be improved by selecting samples from a well-known position determined with the help of the profile graph of the measurement system (figure discussed earlier). However, this is easier said than done. Say the variation ΔW is 10gsm over a distance Δx of 5cm. Then the position of the sample has to be meticulously determined with an accuracy of less than 5cm to make an error less than 10gsm. Since most non-woven production lines have a larger variation than 10gsm over 5cm, taking a single sample out of the production line for calibration purposes will have very little meaning.

Conclusion

Due to the omnidirectional variations in non-woven products, determining the performance of the production line or benchmarking an inline basis-weight measurement system relative to an offline reference (e.g. a balance) needs to be performed with the necessary care. The recommended strategy is to take an average over a set of measured samples. It is paramount that this set is statistically relevant, i.e. the samples should be taken from different positions in both machine direction and cross-machine direction, and the amount of samples should be sufficiently high.

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