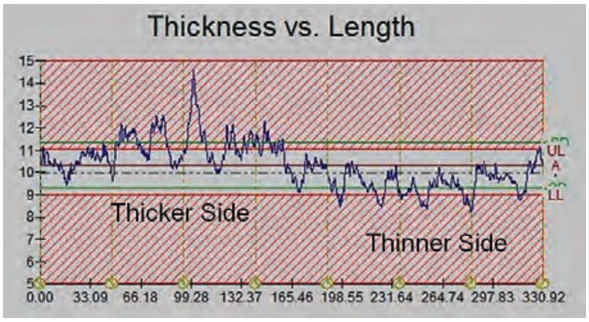
Troubleshooting gauge variation:

Why you should have paid attention in math class

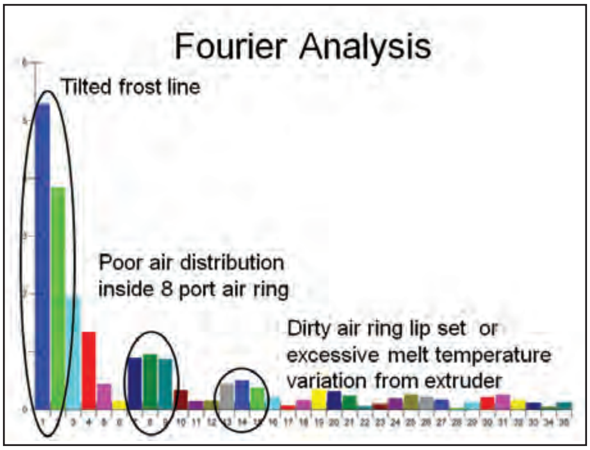
By Paul Waller, Plastics Touchpoint Group Inc.

Thickness or gauge is one of the most important quality control parameters in film or sheet manufacturing. Disturbances in this steady state manufacturing process are the root causes of gauge variation. Some of these disturbances are random, while others appear and disappear at regular intervals. Cyclical disturbances can often be eliminated if they can be identified, but many rapid frequency disturbances are difficult to detect.

Fourier series analysis can be used to decompose complex disturbances into a sum of simpler trigonometric functions, such as oscillating waves or sine waves. The technique can be used to identify which frequency of disturbances affect gauge variation the most. Even with this information, identifying the root causes requires experience and skill.



Graph 1



Graph 2

The gauge profile described in this article was measured using an indirect measurement capacitance technique that provides the best combination of resolution (accuracy), speed, and cost. All plastics are electrical insulators, with change in this insulating characteristic (dielectric strength) being directly proportional to thickness change. This principle can be used to correlate the subtle changes in electrical resistance to gauge variation. All indirect measurement techniques require that the sample be measured using a micrometer or other contact device as a reference first. The Oakland Instrument Corporation model CX-1020 was selected because it has a patented calibration mechanism (AutoCal™) that minimizes calibration errors and is capable of detecting variations as small as 0.025 microns (0.001 mils).

Graph 1 shows the results of measuring transverse direction gauge variation profiled for a blown film sample exhibiting thin and thick regions on opposite sides of the bubble. The large variations can be easily identified, but the smaller contributors are almost undetectable by just inspecting the graph. The target gauge for this blown film product was 250 ± 25 microns (10 ±1 mil). Gauge varied from a maximum of 371 microns (14.6 mils) to a minimum of 162 microns (6.38 mils), which is unusually large for most film applications. The Fourier series analysis shown in Graph 2 displays three clusters of peaks, indicating that three fixed disturbances contributed to the majority of gauge variation measured in this sample. The strongest set of peaks was "1" and "2", clearly indicating that the frost line was higher on one side and lower on the other side of the bubble. This pattern can be the result of a misaligned or tilted die or air ring.

The second set of higher peaks was "7" to "9" times around the bubble. This variation is much more difficult to detect by looking at the gauge variation plot (Graph 1). Air pressure distribution within the air ring chamber was unequal because the air distribution manifold did not deliver the same amount of air to each of the eight air ring ports. There was a smaller cluster of peaks between "13" to "15" times around the bubble, which would be almost impossible to detect by inspecting the gauge variation plot (Graph 1). The most likely causes for this were dirt in the air ring or port line effects caused by excessive melt temperature variation entering the die block. The problem was confirmed to be dirt inside the air ring lip set. In this case, the root causes of the non-random contributors to gauge variation were below the frost line. The same technique can be used to detect problems all the way to the winder.

This example demonstrates how the intelligent use of mathematical tools such as Fourier series analysis can be used to identify and eliminate causes of gauge variation. Some high-end profilers such as the Oakland CX-1020 have these tools built into the software. It's important to realize that only high resolution sensors can detect many of these subtle cyclical patterns, and most require indirect measurement techniques to collect the quantity of data required. Lastly, there's still no substitute for a skilled person who can interpret the data. **CPL**

Paul Waller consults on extrusion and packaging and heads Plastics Touchpoint Group Inc., which offers engineering services and operator training. He is the author of the recently published book "A Practical Guide to Blown Film Troubleshooting." Plastics Touchpoint Group is the Canadian distributor for Oakland Instrument Corporation. He can be reached by e-mail at paul@plastics-touchpoint.com, website www.plasticstouchpoint.com, or phone at 416-788-9742.