Technology Bulletin

By Alan Landers, Product Manager

Gravimetric Extrusion Control Saves Material and Increases Processing Efficiency

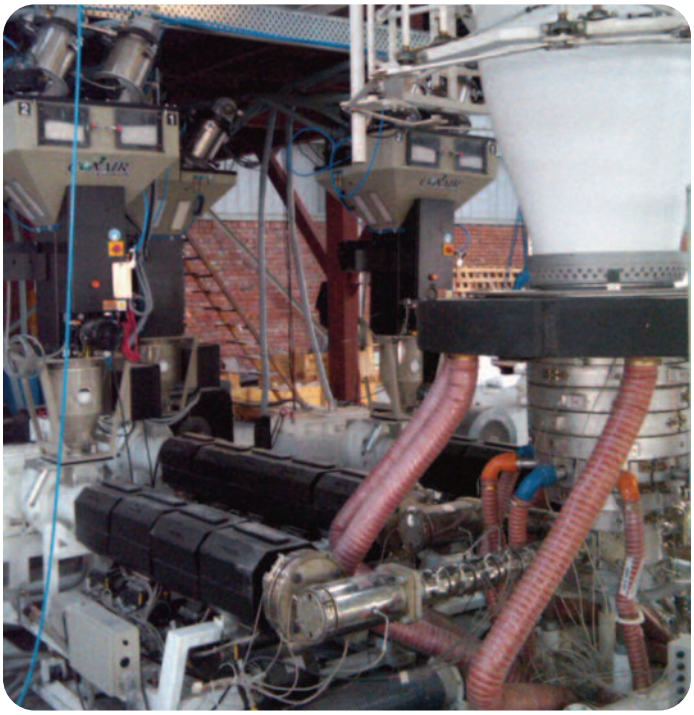
According to resin pricing experts, plastic materials represent the single most costly element in a film and sheet extrusion operation. And while all costs have risen over the last decade, the price of film and sheet feedstock resins has skyrocketed. Polypropylene has increased from about $0.30/lb in 2000 to $0.90/lb or more today. High-impact styrene has doubled in price from around $0.55/lb in 2000 to over $1.00/lb today. The picture for polyethylene is much the same.

To stay competitive, film and sheet extruders have got to squeeze every bit of production out of their operation and do it smarter and better than the competition. Savvy processors know this and have structured their plants to achieve maximum throughput while maintaining quality and minimizing scrap. However, the real challenge lies in the fact that so many variables can affect throughput: screen-pack blockage, melt-temperature variations, screw wear and resulting leakage-flow over the flights, loss of cooling of the screw or feed throat, or changes in material behavior, including normal drifts in bulk density. As if all of these processing and ambient conditions affecting output aren't enough, you also need to contend with the most insidious of them all: operator interference. Whether they have years of experience or are completely green, rarely will two operators run an extrusion line in quite the same way.

Despite all this variability, some things can't change. The film or sheet gauge must adhere to specifications and so must the layer thicknesses if you are running a multilayer structure. These are factors that govern whether or not you are making a saleable product and, if your film or sheet does not meet or exceed specifications, it really doesn't make any difference how much of it you make. In the end, you'll only be losing money.

That's why most extruders give themselves a healthy safety margin.

When an extruder states the thickness of a product, it is expected that the gauge of that film will be at least the thickness specified. A 4-mil film will be at least 0.004 inches thick. Given all the possible variability in an extrusion plant, the processor has to run a gauge that is thick enough so that the thickness at the minus end of the tolerance band will be at or above the specified thickness. So, using a 4-mil film as an example, and assuming the film will be over or under the setpoint by 10%, the extruder needs to target a +10% setpoint so that the film will always be at least 4-mil. That means that



To ensure that finished product meets minimum specification, extruders often build in a healthy safety margin that wastes valuable raw materials and limits profitability.

There is ample opportunity to save by reducing the over-gauge percentage built into extruded film and sheet.

The TrueWeigh hopper is a critical component in the Conair extrusion control system. A highly accurate load cell constantly measures the loss-in-weight of material as it flows out of the hopper and into the extruder.

"normal" thickness is 10% over 4 mils, and some product will be as much as 20% over the specification. That fact should be enough to convince you that there is a lot of resin waste built into your process and into your profitability picture.

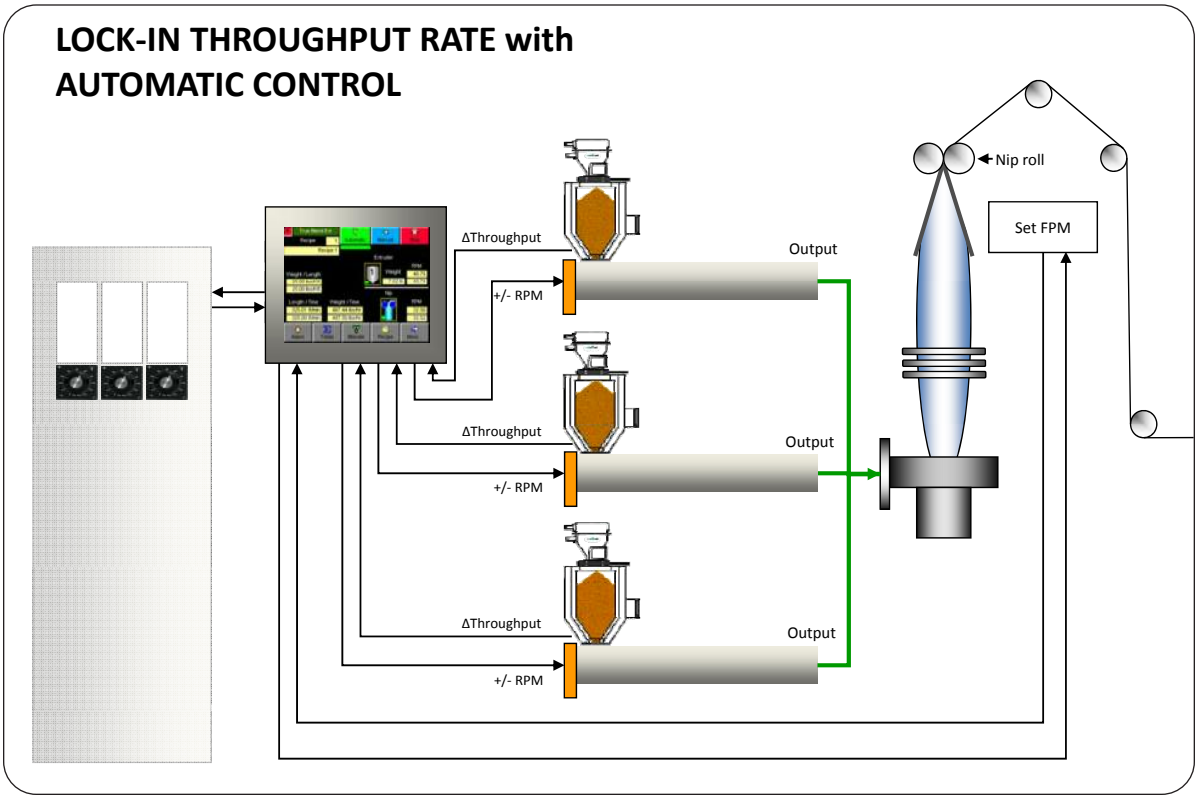
Looking at all this in a more positive light, it is easy to understand that the high cost of raw materials and the relatively large percentage of waste in most plants means there is ample opportunity to save big by reducing the over-gauge percentage built into every foot or meter of material produced.

Is that possible without running an unnecessarily high risk that one or more rolls will need to be scrapped because they don't meet minimum specifications? The answer to these questions is an emphatic "yes," and the key to making it happen is the TrueWeigh™ gravimetric extrusion-line control system. Combining a highly accurate weigh hopper and a PLC-based control, the system tracks material being fed to the extruder and automatically adjusts screw rpm and haul-off devices to maintain a consistent product output – either weight per hour or weight per product length – regardless of changes in raw materials, ambient conditions or processing variables.

The weigh hopper 'floats' within a frame and is supported solely by a load cell. As pellets are loaded into the hopper and then fed to the extruder, the change in weight is measured and the data are sent instantaneously to the TrueWeigh PLC control unit. If a screen begins to blind and throughput begins to fall off, the control recognizes it immediately and can increase extruder screw speed to maintain the desired throughput. Add a line-speed encoder downstream from the die and the TrueWeigh control can adjust haul-off speed to maintain the correct product thickness even as material viscosity and line speeds change.

You no longer need to rely on operator judgment and off-line QC analysis that may uncover product quality changes only after rolls of off-spec film or sheet have been extruded. And you don't need to set thickness setpoints unnecessarily high in anticipation of process variability. The system reads and reacts to changes as they occur so the processing window can be narrowed as much as possible.

In co-extrusion applications, each extruder can be fitted with a TrueWeigh hopper and a single PLC integrates and synchronizes control of all. Not only is the total throughput of the line maintained, but each component material that makes up the multilayer structure is present in the correct ratio to the total. This can be especially important when thin barrier or adhesive layers are critical to the function of the finished film or sheet.



The TrueWeigh gravimetric extrusion-line control system can synchronize material throughput, screw RPM and haul-off speed automatically to maintain maximum throughput and sheet dimensions despite changes in materials or operating conditions.

Let's look at a hypothetical five-layer film that is being produced at a rate of 1500 lb per hour, 20 hours per day and 250 days per year. (See chart on next page) The two outer layers are composed of virgin material costing $1 per lb and it represents 80% of the total structure. The middle layer is a barrier material representing 10% of the total structure and costing $5 per pound. Between the virgin layers and the barrier layer are two adhesive layers made up of resin costing $2 per pound and representing 5% each of the total structure.

If you are accustomed to running 10% over gauge to ensure consistent product regardless of process and material variations, you can see that your annual cost for the additional material will amount to $1,125,000.

Now, what if you could run at 5% over gauge instead of 10%? You would save half of that amount or $562,500. And, if you could run confidently at just 1% over gauge, your cost for wasted material drops to just $112,500 per year. Until now, few extruders would attempt to run at a mere 5% over gauge, much less at just 1% over. However, with the additional control provided by the TrueWeigh gravimetric extrusion-line control system, it is not only possible, but easily cost justified.

If you cut your amount-over-gauge in half, from 10% to 5%, you save half of the additional material cost – $562,500 per year or $46,875 per month – that we identified above. A TrueWeigh system configured to control this 5-layer extrusion line is nominally priced at $52,677 so it will more than pay for itself in about 33 days. After that, savings go right to your bottom line or they give you some pricing leverage without impacting profitability. If you are able to reduce your amount-over-gauge to something less than half of what you are accustomed to – perhaps even as much as 90% – the system pays for itself and feeds your profitability in less than 3 weeks.

Process Improvements

Company management will appreciate the material savings and improved profitability offered by the gravimetric control system, and purchasing will welcome the quick payback, but a TrueWeigh system still has more to offer. A production manager will appreciate the value of process efficiencies the system also delivers.

During start-up for instance, the TrueWeigh control is able to automate many of the time-consuming trial-and-error steps

Gravimetric Extrusion Control

Resin Savings Calculator

Pounds per hour	1500
Processing hours per day	20
Processing days per year	250

Ratio of blend (%)	
Virgin	40
Adhesive	5
Barrier	10
Adhesive	5
Virgin	40

Cost per pound ($)	
$	1
$	2
$	5
$	2
$	1

Resin Cost

% over gauge	10
$	300,000
$	75,000
$	375,000
$	75,000
$	300,000

Annual over gauge cost $ 1,125,000

Over-gauge	10%	5%	1%
Annual cost of over-gauge material	$1,125,000	$ 562,500	$ 112,500
Annual TrueWeigh savings vs 10% over-gauge	$ -	$ 562,500	$1,012,500
Budgetary cost for the TrueWeigh system		$ 52,677	$ 52,677
Saving per month	$ -	$ 46,875	$ 84,375
Months payback		1.1	0.6

Download a copy of the TrueWeigh Savings Calculator as a Microsoft Excel file.

involved in synchronizing the extruders in a multi-layer film or sheet line. The conventional approach begins as production personnel periodically collect and weigh samples of each material being run on a given extruder in order to correlate screw rpm to throughput. The data are charted to be used as reference during start up. In a multilayer line, the same information needs to be collected and maintained for each extruder and the charts need to be updated periodically as screws wear, and as ambient conditions and material characteristics change over time.

When it is time to start the line, the charts are used to initially set the extruder screw speeds to establish the total throughput per hour and the specific percentages of various materials in a multilayer structure. Once the line is up to speed, operators take a sample of the film or sheet to the QC lab for analysis and then manually adjust extruder speeds and haul-off speeds accordingly to achieve a finished product that meets specifications. This process may need to be repeated several times before all the weights and ratios are right, and periodically thereafter to adjust for inevitable changes in processing conditions. It's little wonder then that most processors build in such a large over-gauge allowance into the set-up.

When the TrueWeigh gravimetric control system is used, there are no charts to be filled in, except perhaps to provide a starting point for a product that has never run before. Instead, the operator enters the total throughput rate (weight per hour) for the film or sheet, and the percentage for each layer, and then instructs the system to "start at 5%." All components ramp up to this initial speed and material is strung through the take-off equipment. The speed of the line can then be increased incrementally to run at 25%, 50%, 75% and finally 100%. At each stage, the control adjusts speeds on all the extruders and the haul-off unit to ensure the overall throughput, layer ratios and gauge readings are correct. The operator may take a sample to the QC lab, but testing will only confirm what is already known: the film being produced is within spec.

How much time TrueWeigh can save during start-up depends on a host of factors specific to the application. However, with lines that are designed to operate at 1000 lbs/hr (455 kg/hr) or more, it is easy to see that even 30 minutes of downtime or 500 lbs of off-spec product being produced can very quickly justify having such a system. If you do an average of three start-ups per week for an average of 45 weeks per year, that's 135 start-ups per year. If you avoid the need to scrap 500 lb of product by using TrueWeigh control to cut start-up times in half, you will save 67,500 lb of material per year. At, for instance, $0.90 per lb, that translates to $60,750 – more than enough to pay for a TrueWeigh system in less than a year on start-up savings alone.

Long-term trends can be reviewed and analyzed with a data logging function built into the TrueWeigh system. It continuously records all process readings, including total weight/hour throughput, throughput of each extruder, screw and haul-off speeds … even thickness gauge readings if the line is so equipped. This information can be invaluable for inventory control or to demonstrate the stability of the process and the quality of the film or sheet produced. Processors that may have needed to submit actual product samples to customers for verification can use process-trending reports instead. And, if there is any question about product that has already shipped, it is easy to research the exact conditions under which it was made.

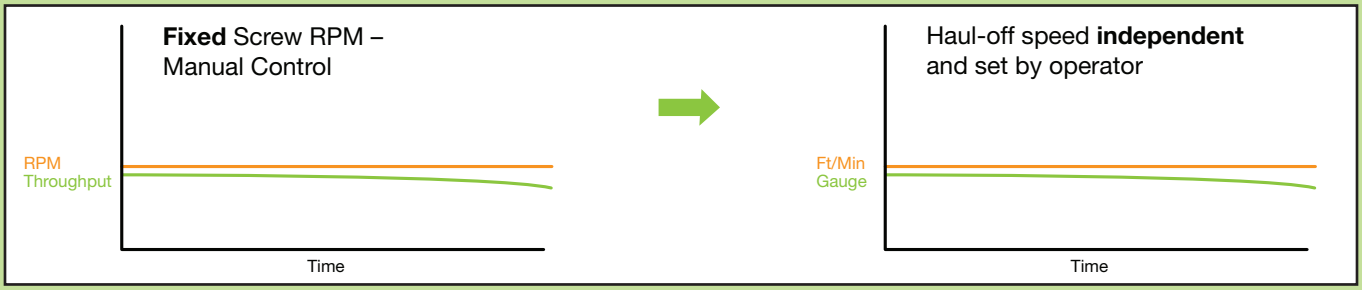
The TrueWeigh system should compensate for most of the process variables that can affect throughput and quality over time, and the trend lines for weight per hour or layer ratios should show very little variability. As screws wear or a screen pack becomes blinded, the data will record the increase in screw speed needed to maintain throughput, providing an early indication that maintenance may be required.

An **alarm function** is included to alert operators in case a temperature-control failure or some other unforeseen problem arises to force the extruder to operate at an unsafe condition. Other alarms are programmable.

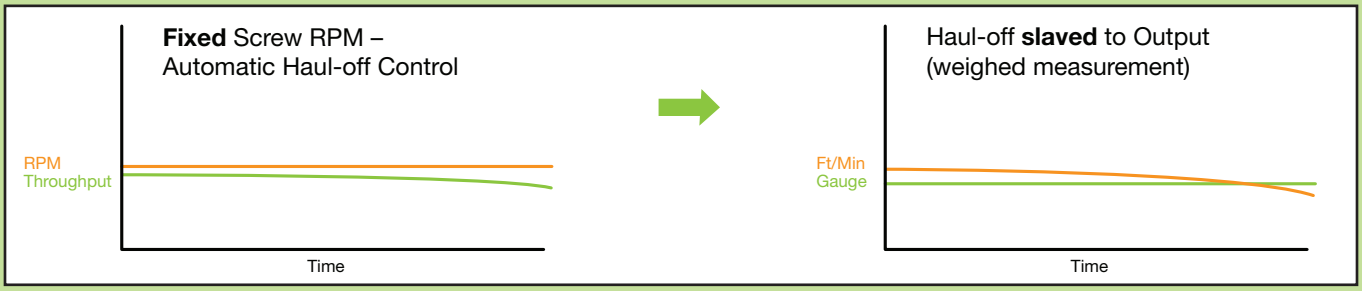
The TrueWeigh system can coordinate the operation of up to twelve extruders, governing total product throughput and dimensions, as well as the relative weight of different layers. It can speed start-up, maintain product quality as process conditions change, and provide detailed production and quality reports. Most significant of all, however, is its ability to help processors confidently reduce the safety margin programmed in to ensure all layer thicknesses and overall product gauge remain within acceptable limits. This material savings alone can justify implanting TrueWeigh control, but the process efficiencies the system offers make it a practical necessity.

Automatic Gravimetric Control vs. Manual Extrusion Line Operation.

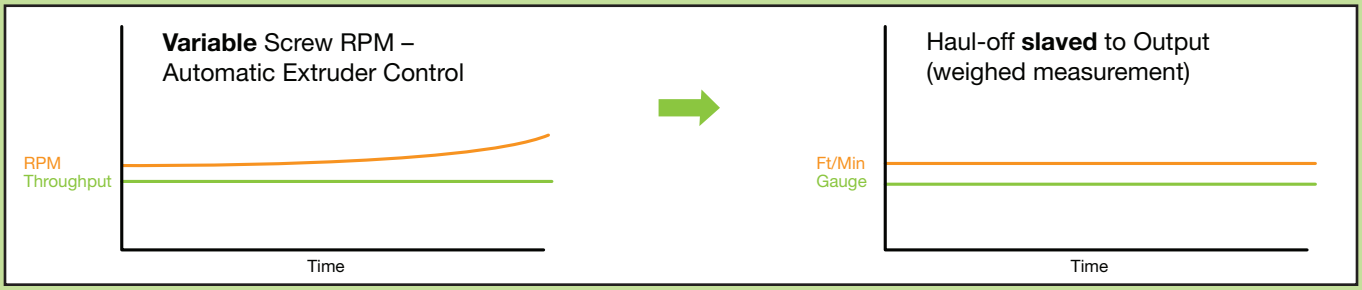
The graphs below compare results using various modes of automatic control available in the Conair TrueWeigh system with more conventional methods.



With manual line control, the extruder operates at as fixed speed and, over time, throughput drops off – as screens blind, for instance. The haul-off operates at a fixed length/time rate and, as throughput drops, gauge goes out of tolerance.



The simplest form of gravimetric control maintains a constant screw speed while monitoring throughput as it declines over time. The haul-off is then slaved to the weight/hour throughput and its speed is reduced to maintain gauge even as throughput drops off.



These graphs illustrate how the TrueWeigh system helps maintain throughput and gauge over time. Extruder rpm is governed according to the measured weight/hour throughput. As process conditions reduce the weight processed per rpm, the control system reacts to increase screw speed and maintain a constant weight per hour throughput. At the same time, the haul-off is slaved to the extruder throughput, changing speed as required to maintain weight/length and gauge.