Perfect Sealing

The temperature of sealing in-sync with machine motion

SCOPE

"Easy" is the key for the end-user, the packer, the OEM/maintenance and the supplier. In FFS machines, the key is to provide the perfect seal each time and right from the start. For this, OMRON provides a solution to integrate temperature control, seal-jaw timing, and pressure.

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WHITEPAPER

Executive Summary

The need for speed in sealing packages.

Companies who pack goods, machine builders and automation suppliers are all working towards one goal: the best way to move vulnerable goods from producer to consumer. To extend the shelf life and to protect products is the main essence of packaging. We all want products to arrive at the consumer in a perfect state.

Form, Fill and Seal (FFS) machines are often used to pack large quantities of goods at high speed. Often these goods are food items, like nuts, chocolate bars and candy. There are different factors which can limit the speed of this type of primary packaging machine. They are: product feed, packaging material feed and seal-time. The flexible packaging material (e.g. foil) used in FFS machines is formed and sealed on the fly, often around the product while in motion.

Apart from *variation and quality*, producing *more packs per time* are the 3 fundamentals of an FFS packaging machine. With more consumers and the target to reduce cost, the need for more output is obvious. This can be reached not only by faster machines, but also with better quality sealing right from the first pack you produce.

In this paper the solutions provided are for seal quality, higher throughput and less waste at start-up. Conclusion, the sealing of packaging needs to be fast, but most of all, good in all stages of machine transition.

Constant seal jaw temperature; at start-up and during production.

The packaging material requires an exact temperature at a given pressure to ensure a good seal. In the sealing process, the temperature, pressure and time are equally important as you can see in figure 1. The motion control is responsible for the timing and pressure of the sealing jaw. This is important, but not a subject discussed in this paper.

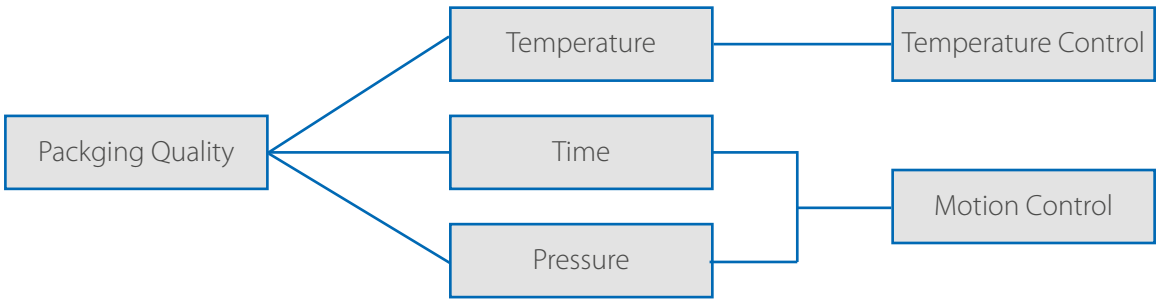

Figure 1. Packaging quality depends on 3 parameters.

Packaging seal quality is affected not only by the sealing temperature, but also the room temperature, packaging material temperature and the product temperature.
In many cases it comes down to only the sealing jaw to compensate for all of these factors. Pre-heating the foil can be an option, but is not always allowed or possible.

During operation, at each seal, the film absorbs heat from the seal-jaw causing it to drop in temperature. Before the next seal can be done, the seal-jaw needs to be at the right temperature again. Omron's 2-PID algorithm and auto tuning (AT) is fully developed to recover fast when temperature drops after each seal. Control is normally good when the machine is in production stage, but what when the production needs to start or stop? When moving from the idle stage to production stage, the balance in the PID control loop is disturbed heavily. The big drop in temperature at startup results often in a few or even many bad packages (fig.2). When the machine is paused the Seal jaw temperature is rising unnecessary high.

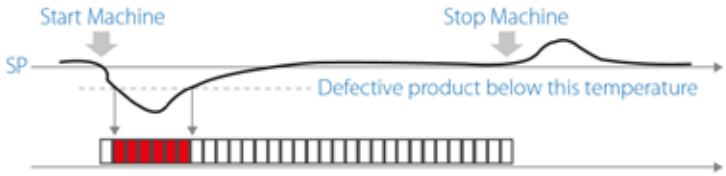

Figure 2. bad seal at startup

Especially with fast running machines like Flow Wrappers, you want to run at full speed from the start, packing all products with an equally good seal.

Here is the solution; we know that the operator gives a signal when the machine is going to start! With the indication of this start moment, we can "prepare" the seal-jaw temperature for the soon-coming-drop, and "pre-compensate" for that.

OMRON has two approaches:

1. PLC-based function block called Direct Power Control (DPC) to be used together with OMRON's unique 2-PID algorithm.
2. Pre-boost function included into in-panel temperature controller NX-TC.

The DPC function block

The benefit of this approach is that the temperature control in-sync with motion is completely integrated into OMRON's Sysmac machine controller NJ series that also manages the full machine functionality. Three steps are needed to apply DPC to an FFS packaging machine. First, set-up and tune the PID control loop, then a few parameters need to be derived from the PID values and finally, load all these parameters into the matrix which is used by the DPC function block in the controller.

Set up the PID loop

Omron's unique 2-PID temperature control is a big advantage over standard PID control.
The build-in Auto-Tune will optimize the system for fast-disturbance-response. Sealing is such a fastdisturbance process. Set value (SV) is fixed, but each sealing makes the temperature of the sealing jaw (PV) drop. The faster the controller recovers the PV to SV, the faster the next seal can be made. Omron 2PID and AT available in on-panel and in-panel stand-alone TC and in PLC and Machine controller FB's

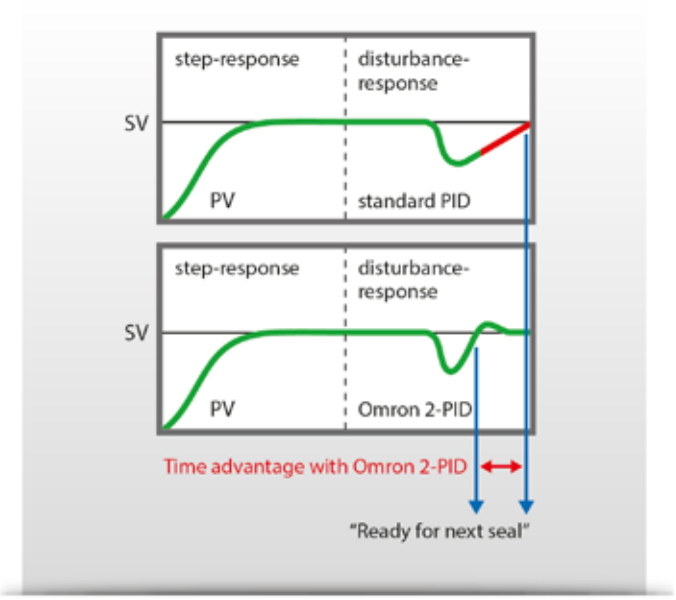

Figure 3.

Calculate the parameters for DPC

From the PID parameters that the Auto Tuning (AT) found, the dead time can be calculated. The DPC function block also need to be fed with information which easily can be found from the temperature trend chart or with a simple manual test.
Mainly this values are power levels of the temperature controller output when the jaw is open and when it is closed with the foil clamped. From these calculations a seal temperature profile and a seal timing profile can be composted. The DPC function block comes with a easy to use instruction, divided in clear steps, to perform this fine tuning calculation task.

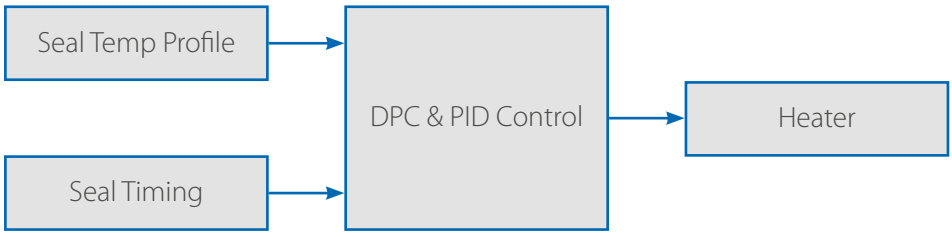

Figure 4. Functional diagram of DPC interaction with PID

The Pre-Boost function

This feature is built-in NX-TC temperature controllers from firmware version 1.2 and, no additional software is required for PLC. The pre-boost function adds or subtracts the pre-set manipulated variable to/from the manipulated variable calculated by the Temperature Control Unit before temperature variations occur due to a disturbance. NX-TC needs to receive machine starts signal via communication.

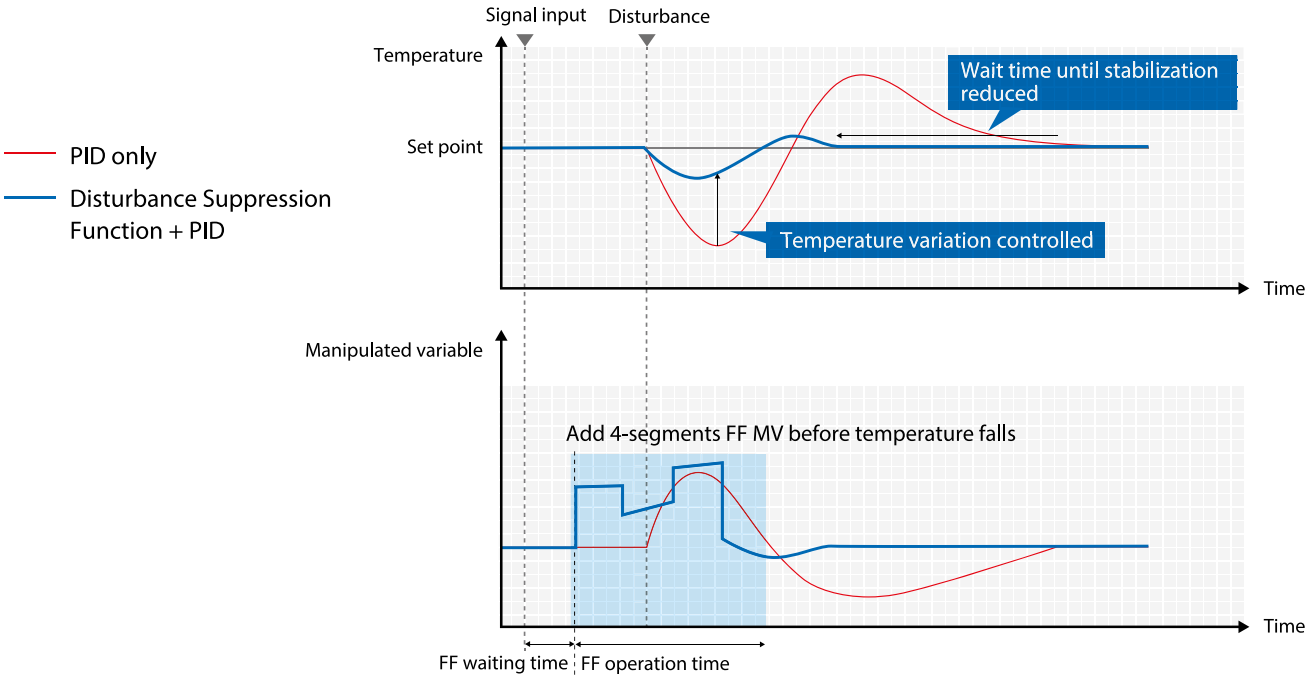

Figure 4.

Key values

- 4 segments feed-forward MV performed for a more accurate disturbance suppression (same as DPC function block)
- All required parameter settings are adjusted automatically by a dedicated auto-tuning procedure (DPC require more manual adjustments than the operator)

How to enable

The main steps to consider enabling the pre-boost function are:

1- Calculate PID values executing AT procedure

2- Execute auto-tuning for pre-boost (D-AT)

3- Execute pre-boost function

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We are now ready to produce with the parameters found, the DPC operation matrix filled, or pre-boost function set and activated. The result is that the seal-jaw temperature will show less deviation from the setpoint (SP) than before, especially during machine transitions from idle to production.

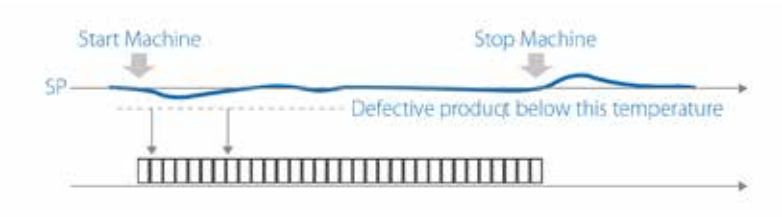

Figure 5. result when using DPC, no bad sealing so good packs right from the start.

Business benefits

The benefits of using such technology are mainly for FFS machines such as flow wrappers, HFFS and, VFFS machines. Slow(er) moving intermitted (stroke) machines such as tray sealers of bulk-bag-sealers are less likely to benefit from this technology.

The temperature is crucial for most of the flexible/thin material. Especially when they exist of laminated layers of barrier and contain foils. 2'C too high could lead to a burned seal and 2'C too low may lead to packages that are badly-sealed or not-sealed at all. For example, easy-to-open packaging is made of foil with a complex layer structure and is very sensitive to heat deviation. The goods which are packed could also influence the sealing. For example, the product could cool down the film and sealing can fail if the product is wet, frozen or very cold. Tight control is the only way to automatically compensate.

Another application area is pharmaceuticals. Temperature is a sensitive matter when it comes to packing medication. OMRON provides a solution to apply the optimum heat to seal. The heat loss compensation is done by the controller. Therefore, there is no need for a bigger sealing jaw that causes more heat inertia. The machine can operate with lighter and cheaper jaws. Smaller sealing jaws also mean less energy use. Feed-forward and pre-compensate tricks sound logical for the OEM/SI, but who is the expert to implement it? OMRON's innovative approach enables a fully-integrated implementation to OMRON's PLC or other PLC brands that has a standalone temperature controller solution (Profinet, EthernetIP, EherCAT).

SUMMARY

"Easy" is the key for the end-user, the packer, the OEM/maintenance and the supplier. In FFS machines, the key is to provide the perfect seal each time and right from the start. OMRON provides a solution to integrate temperature control, seal-jaw timing, and pressure. Sysmac machine controllers integrate logic and motion with some clever analogue and application-specific function blocks. The DPC function and block/pre-boost function integrate the temperature control with the flow of the machine motion.

OMRON has almost 40 years of experience in producing temperature controllers and our algorithms have been developed and evolved into one of the best disturbance-based processes like sealing. The OMRON staff can always help you further.