

Bosch Rexroth Corp.

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Better Gap Controls Bring Better Sheets of Plastic

Engineers at Welex can't tell you the expected life of one their machines. That's because none has ever been retired. Every machine shipped since the company was founded in 1966 is still working productively in the field (except for a couple ruined in natural disasters). A maker of extrusion equipment headquartered in Blue Bell, Pennsylvania, Welex is known worldwide for its sheet extrusion lines that serve the packaging and industrial markets with lines from 30" to over 10 feet wide, with capacities from 300 pounds per hour to over 4 tons per hour. Welex engineers recently developed an improved system for controlling the gap in its sheet take-off system. After the polymer passes through the extrusion dies that give the sheet its basic shape, it passes to the take-off rolls. The rolls cool the output, give the sheet the desired thickness and surface finish, and accumulate the sheets in uniform rolls or flat stacks. Sheet thicknesses range from 0.006" (150 μ m) to 1.5" (38mm).

Welex sheet take-off rolls are computer designed to achieve maximum heat transfer with minimal roll deflection under pressure. The rolls have a double-shell construction, with multiple spiral baffles to assure high cooling fluid velocity for uniform roll temperatures. A heavy rigid inner shell supports the shrunk-fit outer shell. To prevent indentation from high sheet pressure, rolls are constructed with a thick, hard stainless steel overlay. Proper cooling requires the appropriate roll diameter. If the rolls are too small, the line capacity will be limited. If the rolls are too large, the sheet may not lie flat

after cooling or there can be excessive sheet sagging between the die and the roll nip.

The gap between the rolls is also critical. The system uses three rolls. The middle roll is fixed. The upper and lower rolls move to create the proper gap. The top roll must maintain a fixed gap between it and the center roll to achieve the proper sheet thickness. The bottom roll, which provides the final polish and surface finish, is also set to a gap, but is allowed to float based on a force setting. The float is necessary to prevent ripples from forming on the sheet.

Welex engineers wanted to create an improved system for automatically controlling the roll gaps. The existing system, in use since 1991, is an analog system that requires a custom electrical control to interface it to the overall machine controls. Welex built a custom conversion box, with lots of potentiometers requiring adjustment during startup. In addition, the servo valves were sensitive to contamination of the hydraulic oil, creating support headaches.

But the biggest drawback, according to Mike Mitchell, Welex's director of engineering, was that the system could only control the position of the rolls. "We wanted to sense both the position of the roll and the force being exerted on the sheets. While the position of the roll is a good indicator of the gap, being able to also monitor the force and make on-the-fly adjustments gives us even better results in sheet quality." Forces range up to 40,000 pounds at line speeds of 300 feet per minute.

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In a meeting with Gary Jermyn, a fluid power specialist with Airline Hydraulics, a value-added distributor with locations throughout the Northeast, Mitchell explained the drawbacks of the existing system and gave his vision of an improved system. Jermyn offered to come back with some ideas on how to implement an improved system. Jermyn enlisted the aid of Neal Gigliotti, an applications engineer specializing in the plastic industry at Bosch Rexroth. Since Airline Hydraulics is a Bosch Rexroth distributor, Jermyn was familiar with the advanced capabilities of the company's products in providing solutions to tough challenges in hydraulic motion control. The system Jermyn and Gigliotti proposed to Welex was based on the VT-HACD digital hydraulic axis controller which would be used to monitor and control the movement of the two outer rolls. Bosch Rexroth CST4 hydraulic servo cylinders move the rolls. The system provides precise control based on both position and force.

The solution is based on two control loops interacting with one another. The closed-loop position system sets the basic gap required. The closed-loop force controller monitors the hydraulic force and limits the amount of force that is exerted on the roll. This force limiting function allows the roll to float on the surface of the plastic sheet and also protects the roll from damage due to obstructions. Since each roll is a high-value, precision-manufactured component, damaging one not only halts production, but also represents a costly repair involving considerable downtime. The closed loop hydraulic force control system will automatically sense an obstruction by the added force it measures. It will open the rolls to allow the obstruction

to pass through and then close them again to the proper gap. Since the operator doesn't have to clear the obstruction manually, this approach has obvious safety benefits.



Welex takeoff machine offers superior roll-gap control using a hydraulic system from Bosch Rexroth.

The VT-HACD controller and CST4 cylinder together can control the gap with impressive 0.0001-inch accuracy over a 5-inch range of travel. As Mitchell explained, "Manual gap control is a tedious trial and error process. The new system gives us control of the gap with greater precision than can be obtained with feeler gauges and hand wheel adjustments."

As Bosch Rexroth's latest generation digital axis controller, the VT-HACD offers a host of features to allow faster startup and better control. The system has four servo axes to control the movement of the rolls. Each end of the two movable rolls forms one axis. Coordination at each end is required to

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ensure that the rolls remain parallel with a consistent gap across the span. Any skew can turn production into scrap. The VT-HACD monitors the four axes and provides on-the-fly adjustment in milliseconds. Setpoints and data are transferred between the axes and machine programmable logic controller (PLC) over a PROFIBUS fieldbus, with the PLC able to command multiple control loops and sequence steps.

The VT-HACD gives the performance required to maintain high-quality production. Even better, it's



The VT-HACD digital hydraulic axis controller is used to monitor and control the two outer rolls and provides on-the-fly adjustment in milliseconds.

fast and easy to commission and setup. Gigliotti explained, "The HACD is user configurable through a intuitive Windows-based graphical interface using pull-down menus, check boxes, and value fields. There is no programming

language to master. A system designer can configure the controller in only a few hours." Indeed, the first Welex system was up and running in less than a day.

The CST4 hydraulic servo cylinders play a critical role in achieving the precision movements required. Airline's Jermyn noted that the cylinders allow the valves to be mounted directly on the cylinder. "The closer you can bring the valve to the

cylinder, the quicker and more accurate the response you can achieve. In addition, the digital position feedback transducer is inside the cylinder, where it is rigidly mounted and protected from damage."



The CST4 Hydraulic Servo Cylinder is used to move the rolls and plays a critical roll in achieving the precision movements required.

The integration of feedback device, valve, and cylinder into one unit offers packaging advantages in terms of faster assembly and minimum space requirements.

Also critical to high accuracy positioning are the low-friction seals in the CST4 cylinders. Standard piston seals create a condition called stick-slip. Because the friction of the piston seal is higher when static than while moving, when the cylinder piston first moves the seal will flex instead of slide. As the piston moves further, the static friction between seal and cylinder is overcome and the seal slides, snapping back to the original shape. If, as is the case with standard lip seal piston rings, the static friction is very high the piston will overshoot the intended position. "Stick-slip presents no problems if you're talking about small errors within the allowable tolerances of an application, but for accuracies of ten-thousandths of an inch you need to absolutely minimize stick-slip by using low-friction seals," explained Gigliotti.

The hydraulic power unit uses the Bosch Rexroth

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A10VSO hydraulic pump. In addition, the structural members of the back-end, where the hydraulic power unit is located and where sheets are fed into the rolls, is built from Bosch structural aluminum framing, which offers easy assembly.

The new system exceeded the requirements of Welex in terms of both performance and logistics. Welex's Mitchell said that the new system gives Welex several advantages in deploying an improved takeoff system. "The new roll-gap control is built entirely from off-the-shelf components, all from a single source. We eliminated any custom components — including the custom electronics we needed for the previous system," said Mitchell. "In addition, having all components from a single supplier gives a single point of accountability. The components integrate easily and flawlessly."

Mitchell also likes the way Airline Hydraulics and Bosch Rexroth engineers work with Welex engineers to find the best solution. "You knew they were pulling together to give us the best solution. Their understanding of the requirements of the plastic industry was impressive. Plus, they were much easier to work with than our previous vendor."

Jim Nissel, Welex's sales manager, believes that the new takeoff can even change the way companies buy sheets. "Traditionally, sheets are bought by the pound. Given the volumes involved, better control of sheet tolerances can significantly reduce the weight and costs of sheets. Because our new takeoffs give better control of tolerances, it becomes practical to buy by the yield rather than weight."