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Fast jacking system for zinc pots to minimize downtime of continuous galvanizing lines

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At continuous galvanizing lines (CGLs), it is particularly important to be able to switch the line to a different type of coating alloy without causing long production delays. Such a capability enables efficient application of different types of surface coatings. For jobs of this kind, the German company Pfaff-silberblau has developed a reliable and precise changeover system for switching melting pots that weigh hundreds of tons. This special solution "Made in Germany" integrates seamlessly into the production process and is being used in CGLs around the world.

Changing melting pots flexibly and efficiently

Changeover equipment makes it possible to choose between two alloys that offer different technical properties within the same continuous galvanizing line. A jacking system with closed-circuit oil cooling was designed by Pfaff-silberblau in cooperation with a leading plant manufacturer active in steelmaking and heavy industry. Depending on the task at hand, the system lifts one of two melting pots with the required coating material into the production line **(figure 1)**.

Two melting pots filled with molten zinc are located one story below the production line. These pots are positioned on rails and motorized to enable travel. In their basic position, the two melting pots are parked to the left and right of the jacking system **(figure 2)**. Depending on the specific need, one of the melting pots is then moved out of its park position and onto the jacking system, where it is then secured. Locking is accomplished automatically with the aid of a lifting element from Pfaff-silberblau's HSE series. After locking, the 500 t pot is lifted about two meters high until it is even with the production line floor. This jacking process takes around 20 to 30 minutes. Once the upper position is reached, the jacking system stops and the rotary actuators (SHE 5.1-series) unfold four swivel supports. As soon as these supports are completely folded out, the pot is lowered by about 200 mm and set on top of the swivel supports. As a result, the lifting elements only bear the load during the lifting and lowering process. This has the advantage that servicing and maintenance work can be performed on the jacking system during ongoing production operations.

In each case, the melting pots are raised and lowered with the aid of at least four heavy duty worm-gear screw jacks with special threading. These jacks are based on extremely precise lifting elements (SHE 200). The individual spindle lifting elements – with a worm gear pair and a gear ratio of 17.5:1 – are connected together and synchronized mechanically using worm drives and connecting shafts, and they are driven by a central motor.

The small twisting angle for the drive and connecting shafts of just one-quarter degree per running meter, combined with the gear reduction within the worm drive, permit extremely precise synchronization, even when there are offset loads within the jacking system: the deviation is less than 0.1 mm. Absolute synchronization of all lifting elements is ensured by a mechanical synchronization solution that renders it unnecessary to employ the kind of forced synchronization approaches that are required with hydraulic solutions, or the electronic synchronous run control approaches that involve the use of sen-

Figure 1. The melting pots in their operating position one story below the production line

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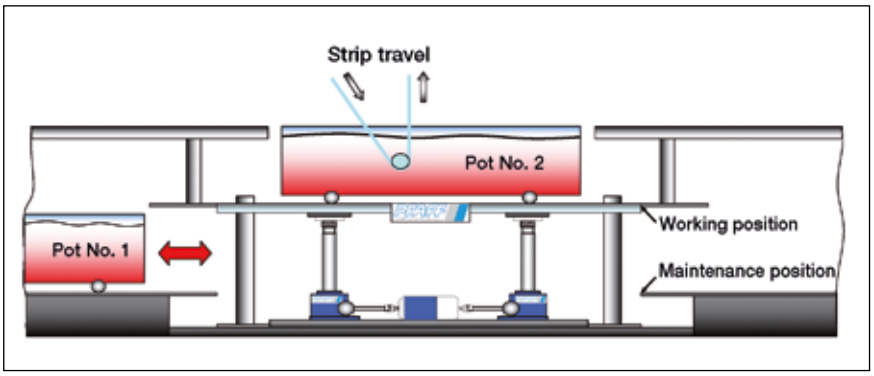

Figure 2. **Scheme of the pot lifting device for the melting pot changeover system**

sors, frequency converters and complex programmable logic controllers.

The outstanding special feature associated with this purely mechanical lifting device is that is goes completely without the use of fault-prone hydraulic cylinders. Should disturbances arise during operation, the self-locking, buttress-thread spindles of the SHE elements ensure that the load is secured at its current height, which means that load is not lowered when system malfunctions arise.

Overall, operating the jacking system produces little vibration and shaking, which helps to prevent damage to the pot insulation. The worm drive's oil lubrication ensures that the lifting elements achieve a particularly long life span. The spindle itself is lubricated with a special grease.

Absolute safety, even in the heavy duty range

One crucial advantage that Pfaff-silberblau's mechanical jacking solution offers over hydraulically operated systems is the high level of safety, especially for heavy duty tasks. The worm-gear screw jacks comply with the national and international safety regulations in accordance with the EN 280 standard. This is achieved through the use of safety nuts and monitoring of the rotational speed. Each individual heavy duty lifting element is equipped with a safety nut that is located at the top of the lifting element beneath a protective dome that guards against dirt and damage. Within the framework of routine checks, maintenance personnel can measure the wear on the load-bearing thread inside the worm gear. Beyond that, the safety nut offers a crucial safety function: In the event that the load-bearing thread should break, inside the worm gear, this nut assumes the load and allows lowering of the melting pot down to its lower park position. If required, it is also possible to monitor breakage of this nut electronically.

A high level of safety is also made possible by synchronization monitoring at each lifting element: An inductive sensor mounted at the safety nut's protective dome acquires data on three holes drilled into the circumference of the rotating safety nut. This sensor sends a corresponding signal to the control unit, which compares the number of impulses per unit of time for all of the lifting elements. When deviations arise in these numbers, a synchronization error is present, and the system switches to "fault" mode. The purpose of this synchronization monitoring is to ensure that all lifting elements extend and retract at the same speed, which ensures that the load distribution remains uniform across the entire stroke.

In the event that one of the transmission elements breaks, there would then only be three or perhaps even two worm screws bearing the load in a system of four SHE-series lifting elements. The integrated monitoring capabilities make it possible for the controller to detect such situations and immediately shut the system down. After that, the system can only be moved again in manual mode following examination of the system.

Customized system solutions

The Pfaff-silberblau engineers adapt the melting-pot lifting system to the requirements of the specific continuous galvanizing line. Even the solution's details reflect individual customer requirements. An extensive system of sensors for process monitoring is one of the optional extras that are available. As an additional variant, Pfaff-silberblau integrates a central lubrication system for reducing the jacking system's maintenance requirements and for ensuring sufficient lubrication of the worm gear screws. This system supplies all relevant lubrication points on the four lifting elements with grease during operation. This lubrication system essentially consists of a central lubricant pump that, with the aid of two progressive distributors, divides up the lubricant among the lifting elements. Depending on the type of travel, the relevant lubrication points are activated during extension or retraction.

Closed-circuit oil cooling for longer duty cycles

Another optional extra is the equipping of the melting-pot lifting system with a special oil cooling function that enables temperature-controlled operation, thus extending system duty cycles. Temperature-controlled lifting systems are advantageous, because their duty cycles are not limited by defined operating and cooling periods, but rather by a maximum temperature limit defined for the lifting system. To make this possible, the temperature is constantly monitored at the critical locations within the lifting element, and the controller only shuts down the lifting plant when a predefined limit is exceeded. The oil temperature is measured constantly via the immersion sensor installed in the vicinity of the worm gears as part of the standard equipment. When a maximum permissible value is reached, either an active cooling circuit reduces the system temperature down to a permissible level, or the system is stopped.

For each lifting element, the cooling circuit consists of a pump unit, supply and return lines, and an oil/air cooler fitted with an electric cooling fan. Furthermore, prior to any movement, an electronic level sensor checks the oil level in the screw jack. The control unit only authorizes use of the jacking system when the oil level has been confirmed to be high enough. The temperature of the worm-gear screw, which absorbs a very large portion of the heat that arises, is constantly monitored via a contactless temperature sensor and measured across the entire stroke.

Quality and service

The reliable and highly precise worm-gear screw jacks used in the modular drive systems provide the basis for the tailored lifting systems. The prerequisites for this precision are provided early on by the high quality standards that are applied during manufacturing of the components. The entire production process for the worm-gear screw jacks is recorded in logs and is 100 percent traceable. After completion of each gear box, a production test is prepared in order to document the relevant dimensions and functional parameters.

Due to its modular design, the jacking system is also well suited for retrofitting tasks that require adaptation to accommodate tight space constraints, for instance when modernizing existing galvanization lines. With its worm-gear screw jacks, the company realizes complete jacking systems with lifting capacities of up to 7,500 kN that can meet both special requirements and unique installation conditions **(figure 3)**. Spare parts and customized service is available worldwide for every system. In fact, the service from Pfaff-silberblau for international customers goes so far as to subject jacking systems of this size to rigorous testing even before they are shipped.

Test passed

In one special case, the Japanese steelmaker Nippon Steel wanted a functional test performed, with its staff on hand, for the main drive elements of its system. For its CGL in Brazil, the company had ordered a 500 t jacking system for a temperature controlled melting pot changeover system with oil cooling. The purpose of the test was to examine the reliability of the lifting elements before they left the premises of the manufacturer, Pfaff-silberblau. This would make it possible to put the jacking system into operation immediately at the rated loads once it arrived on location. With earlier jacking systems from a different vendor, massive problems had arisen; the issues had even caused a complete plant shut down.

Nippon Steel clearly defined the specifications for the test: Operating in the positions in which they would later be installed, each of the four lifting elements had to handle a load of 180 t for a double stroke of 1,900 mm in each direction. In order to fulfill the required test parameters Pfaff-silberblau designed and built a testing set up that was able to withstand a load of 2,000 kN and offer enough space for a 1,900 mm stroke. A series of tests was performed for each individual lifting element across the maximum stroke and with loads between 600 kN and 1,800 kN. The lifting load was increased in multiple steps from 60 to 180 t. This is necessary to break-in the lifting element by enabling it to form an ideal contact pattern in the gear meshing and in the load bearing threading in the worm wheel.

For each of these test series, the motor's power consumption was measured continuously during the stroke travel. Power consumption for the individual stroke movements, compared with the motor's theoretically determined nominal current consumption, is one of the parameters that provide insight into the lifting element's condition. If power consumption is much higher than the motor's theoretically determined nominal current consumption across several strokes, this could indicate manufacturing, assembly or installation issues. Beyond this, after completion of the stroke travel, temperature measurements were taken and recorded on the jack screw and the worm shaft and in the gear box oil at different measurement points.

This test setup up was used without oil cooling. For this reason, on-time was limited to a maximum of 40 percent in order to prevent overheating and damage to the lifting elements. In connection with the oil cooling, however, it is possible to achieve on-times of up to 100 percent.

All four lifting elements were successfully tested under the customer's watchful eye, and the quality was confirmed. In the test, all of the parameters confirmed the values that had been calculated on a theoretical basis. No deviations from the nominal values were determined for any of the jacking elements. In the meantime, Pfaff-silberblau has since installed the melting pot changeover system on-site at its operating location in Brazil and has put it into operation.

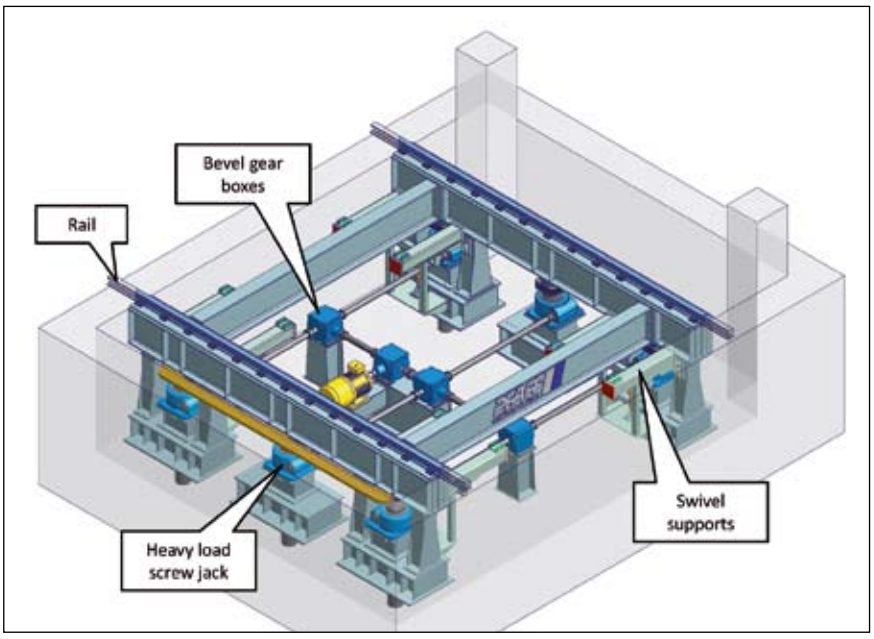

Figure 3. **750 t melting pot jacking system with six SHE 200 elements**

Conclusion

Lifting heavy loads under the harshest of conditions has always been a specialty of the jacking systems from the German company Pfaff-silberblau. With the jacking system described here, which is based on the versatile worm-gear screw jacks from the SHE series and is equipped with closed-circuit oil cooling, the company reduces downtime for the steel industry's galvanizing lines. The tested systems, which are flexibly able to lift melting pots weighing up to 750 t by a height of 2,000 mm into a production line, are in use around the world. ■