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PC Programmed Automatic Level Control for Quality Casting Using the Precimeter Control System

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Constant feeding of a material both in quantity and quality is the key criteria for improved production performance for almost all industrial processes. Specifically, when casting aluminum alloys, it is necessary to accurately control the feed flow of the metal out of the furnace. Precimeter Control AB has developed intelligent and affordable solutions to safely make these operations automatic for quality assurance processes. This paper provides an overview of the different components in an MLC and the varieties of available MLC-systems.
The Precimeter Automatic Metal Level Control (MLC) Systems consist of the following three functional components:
(1) Precimeter digital camera sensor based on laser triangulation using digital CCD camera technology. It features a high measuring accuracy of ~0.1 mm and reliable functions in difficult cast house environments.
(2) MLC console consisting of control systems, microprocessors, control software and operator interface.
(3) Actuators equipped with a tap-out rod, stopper/pin and/or gate-valve. It may also use electrical interfaces for controlling the furnace hydraulics or molten metal pumps.

Keywords: *Level, flow, control, system, quality.*

1. Introduction

Briefly explained, the Precimeter MLC-system uses the Precimeter sensor to measure the level or height displacement. This measured signal is transmitted to the MLC console. The console computes the control signal for output to the actuators.

Thus, the Precimeter Control System guarantees maintaining the desired level within a fluctuation of 1 mm that is better than what any operator can achieve, and is absolutely safe for the employees. This constant feeding of the metal improves the quality casting with increased product uniformity and less scrap production. [1]

2. System configuration

As shown in Fig. 1, Precimeter MLC-systems are based on the "closed loop" control theory.

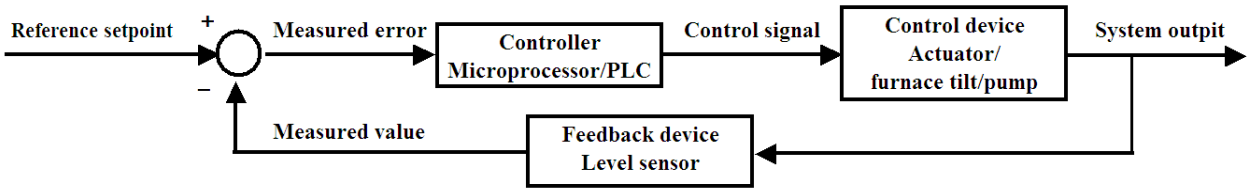

Fig. 1 – Basic "closed loop" feedback controller

To achieve a closed loop, a minimum three types of devices are required. With Precimeter technology for foundry automation, all three of the following components are available as shown in Fig. 2:[2[

(1) Precimeter actuators for adjusting the metal level/flow, (2) Precimeter Digital Camera Laser sensors for indicating metal level/flow, and (3) integrated microprocessors or programmable logic controllers inside the powerful Precimeter MLC-systems that produces the control signals and monitors the casting process.

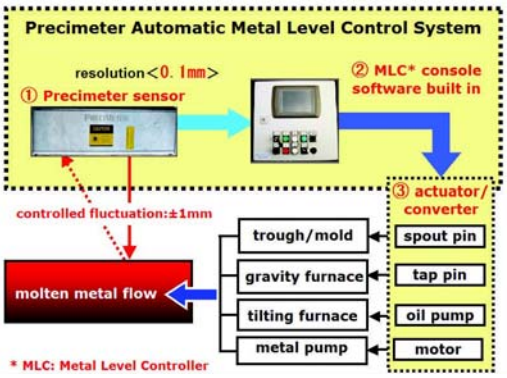

Fig. 2 – MLC configuration flowchart

Fig.3 – Example of a "closed loop" stand alone control system for furnace tap out control

Fig. 4 – Precimeter ProH sensor comlete with heat shield and metal hose

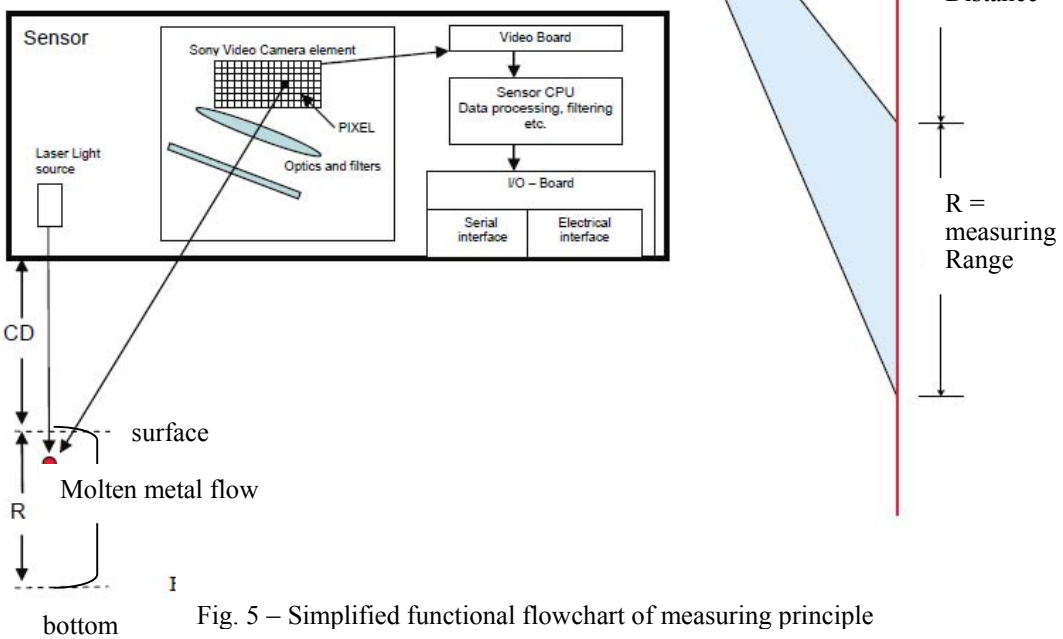

Fig. 5 – Simplified functional flowchart of measuring principle

3. Sensors

The Precimeter digital camera laser sensor has been exclusively developed to measure molten metal surfaces. The Precimeter ProH series is specifically designed for high performance in different aluminum (and other nonferrous metals) applications. Its stability and accuracy of measuring (typically 0.1mm) any alloy makes it one of the best performing sensors for mold level control. The Precimeter ProH sensors are being used worldwide by most major aluminum producers and are also being integrated by many casting equipment manufacturers into their casting lines and machines.

The working principle behind the sensor is the use of a laser light to create a reference point on the measuring surface. A specially designed camera focuses on the light spot, and depending on the light spot location on the CCD, the exact distance to the measuring point can be calculated using a triangulation method.

4. Actuators

To control the metal flow in a casting process, different types of actuators are used to adjust the metal flow. Adjustment is very precise using stepper motors in order to control the movement in steps as small as 0.01mm. Different types of actuators provide complete metal transfer and flo
Table 1 shows a summary of these actators with photos and applications in a cast house.

Table 1 Summary of Actuators

actuator	Photo	Application on cast house
Pin position actuator for down spout PXP-2 E	 Fig. 6 – Pin position actuator, PXP-2E	 Fig. 7 – PXP-2E in a level drop application with a pin and spout combination
Funace tap out actuator TXP-6E	 Fig. 8 – Tapout actuator, TXP-6E	 Fig. 9 – TXP actuator in a stationary furnace tap out application
Starter Dam actuator SDX and Gate valve actuator GXP	 Fig. 10 – Starter Dam actuator, SDX	 Fig. 11 – Gate valve GXP actuator in a launder level control

5. Metal Level Controll System (MLC)

MLC stands for Metal (M) Level (L) Control (C) and is also referred to as MMLC (Molten Metal Level Control). The MLC-system is easily integrated and combined with existing control systems for casting machines and various pit utility systems. An MLC is a control system that controls the metal level and the metal flow in a casting process using a combination of measuring equipment, intelligent controllers and control devices.

In order to meet the different requirements of foundry automation, the Precimeter MLC-system family has four levels as shown in Table 1.

Table 1 Summary of Precimeter MLC-system cabinet

1. MLC - M1	2. MLC - A1	3. MLC - Flexible (FLEX)
		
Entry level for single point application。 Easy installation and setup	Powerful alternative for single point applications for any type of control device (actuator, pump, tilting furnace, VFD*, etc.)	Flexible and customized platform for multiple control point applications with any type of control device (actuators, pumps, tilting furnaces, VFDs*, etc.)

4. MLC – Advanced	
	State of the art system for unlimited control point applications with any type of control device (actuators, pumps, tilting furnaces, VFDs*, etc.) The application is 100% customized to fit the requirements of the customer (actuator, pump, tilting furnace, VFD*, etc.) High-performance PLC-controller Panel PC with touch display for complete control of parameter adjustments, recipes, trends and alarms. Integrated SCADA* system with historical datalogging. *(VFD = Variable Frequency Drive) *(SCADA = Supervisory Control And Data Acquisition)

Table 2 discribes the detailed function of the Precimeter MLC-system cabinet. PC software of “Level Pilot” is integrated with the hardware of the MLC-system to inprove the system performance for quality casting.

Table 2 Detailed function of Precimeter MLC-system cabinet [3]

No.	Type: measuring and control	Single point		Multiple points	
1	system objects				
	1.1 MLC model	MLC-M1	MLC-A1	MLA-Flex	MLC-Advanced
	1.2 level sensor	1	1	1~4	1~20
	1.3 control point	1	1	1~3	1~20
	actuator	YES	YES	YES	YES
	tilting furnace	-----	YES	YES	YES
	metal pump	YES	YES	YES	YES
	tilt-angle feedback	-----	YES	YES	YES
	over flow guard	-----	YES	YES	YES
2	operation				
	2.1 manual start	YES	YES	YES	YES
	2.2 manual level control	YES	YES	YES	YES
	2.3 automatic start	-----	YES-set point	YES	YES
	2.4 automatic control PID	YES	YES	YES	YES
	2.5 emergency shutdown button	TXP-6E, PXP-2E	YES	YES	YES
	2.6 auto emergency close (option)	-----	high level	customized	customized
3	miscellaneous function				
	3.1 mounting angle compensation	-----	YES	YES	YES
	3.2 setpoint ramp	-----	YES	YES	YES
	3.3 enhanced measurment resolution	-----	-----	YES	YES
	3.4 smart sensor filter	-----	YES	YES	YES
4	control cabinet				
	4.1 enclosure-cabinet	wall maountted		wall/floor	wall/floor
	4.2 standard customer signal	-----	YES	YES	YES
	4.3 cutomized signal interface	-----	-----	YES	YES
	4.4 alarm indication	sensor OK indication	LED	LED/light/sound	LED/light/sound
5	display				
	5.1 type(inch) *bw=black & white	-----	touch 3.5bw*	touch 8.5 color	touch 10.5 color
	5.2 PID parameter: touch input	by PC	YES	YES	YES
	5.3 process level: touch input	-----	YES	YES	YES
	5.4 alarm management	-----	YES	YES	YES
	5.5 recipe: touch input	-----	------	YES	YES
	5.6 trend: 65k point/line	-----	YES	YES	YES
	5.7 data-logging	with PC	automatic data-logging=USB stick		

6. Plant Performace of Precimeter Metal Level Control System

Actual performance of the Precimeter Metal Level Control System is shown in the following figures.

Fig. 6 is a result of the Precimeter control for 6-strand slab casting operation. The metal level fluctuation is less than 1 mm, almost 0.5 mm. With a tilting furnace, comparision between manual operation and the Precimeter automatic operation is shown in Fig. 7. The former has a 35 mm fluctuation level, while the latter has less than a 5 mm fluctuation. [2, 3]

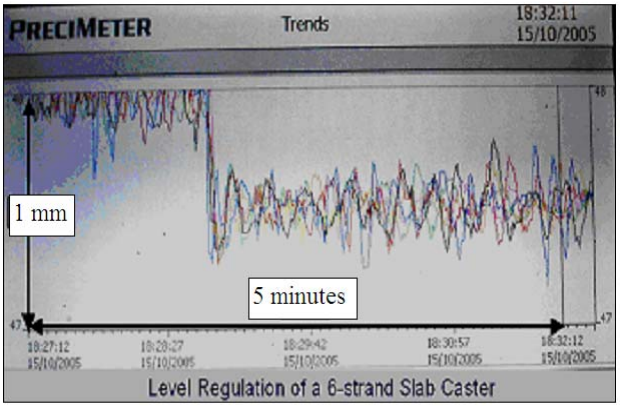

Fig. 6 – Precimeter control for 6-strand slab casting operation

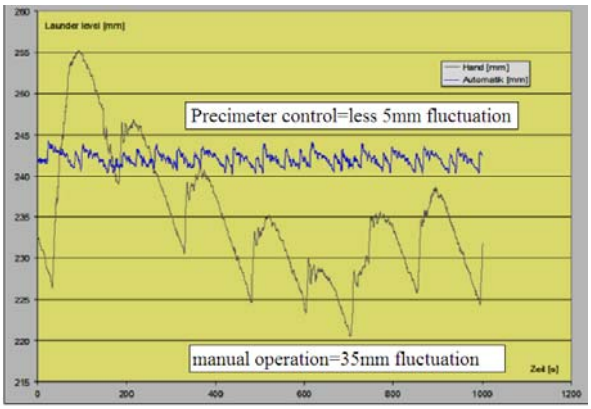

Fig. 7 – Comparision between manual operation and Precimeter automatic control for a tilting furnace

7. Conclusion

Using the Precimeter Control technology, any metal level or flow application can be controlled by the MLC-system range. Foundry application experience and control engineering expertise is included with the design and software logics.

Accurate control and measuring will make sure that the level and flow fluctuations are kept to a minimum (typically less than 1mm) at all times. By automation and receptiveness, there will be improvements like increased productivity, documentation of the process, raw material savings, energy savings and better use of manpower.

Also, the most important of all, by making the casting process fully automatic, the operators do not have to be in the machine area during casting. By monitoring the process from a designated and safe area, operator injuries can be avoided. The failsafe design and automatic shutdown in event of any abnormal situation also minimizes the risk of injuries as well as equipment damage.

8. Acknowledgement

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References

[1] H. F. van den Haak, and H. J. Meyerl: ALUMINIUM. 79 (2003),

[2] M. Suzuki and J.Strombeck: Proceedings, No. 111 Fall Meeting, Japan Institute of Light Metals, 209-210.

[3] M. Suzuki and J. Strombeck: Proceedings, No. 112 Spring Meeting, Japan Institute of Light Metals, 269-270.