INNOVATION OF THE GAS MELTING FURNACE MONITORING SYSTEM

LUBOSLAV STRAKA, SLAVKO PAVLENKO, PETER MICHALIK, MATEJ HRABCAK

Department of Automotive and Manufacturing Technologies
Faculty of Manufacturing Technologies of the Technical University of Kosice with a seat in Presov, Presov, Slovakia

DOI: 10.17973/MMSJ.2019_12_2019034

luboslav.straka@tuke.sk

There are increased demands for safe, reliable and economically efficient operation of modern technical devices nowadays. These technical devices need an appropriate monitoring system in order to fulfil all the requirements. This consequently monitors their activity while providing appropriate information on operating parameters. As a result of them, the control system of a technical device can perform adequate interventions to remove unstable or rather critical condition. Melting furnaces are among devices where the current state of their operation is inevitable to monitor. The monitoring of melt temperature is an inevitable requirement in these devices because of its optimization for casting process, i.e. in order not to degrade its quality due to low or high temperature. Therefore, the aim of the paper is to describe a proposal for a solution of the operating parameters of the gas melting furnace KOV 010/1998, which is in practice used for melting of non-ferrous metals with low melting point. By implementing the proposed solution, its operation should be simplified and more importantly, its operation should be more efficient.

KEYWORDS

monitoring, operating, gas melting furnace, efficiency.

1 INTRODUCTION

In order to achieve reliable, safe and economically efficient operation of a technical device [Al-Jibouri 2003], an appropriate system for monitoring [Čorný 2017] and controlling of its operating parameters is inevitable. Demanded requirements for operating parameters of a technical device are particularly quality indicators [Dhillon 2004], indicators of productivity, overall efficiency [Straka 2017] etc. In order to achieve favourable results [Zhang 2017], its implementation into a technical device needs to be already included when designing a device itself. Based on the data obtained via monitoring system, setting of operating parameters [Krenický 20016] can be controlled in such a way to achieve the highest possible power of a technical device with regard to favourable quality [Knežo 2016] of outputs and overall economy of its operation [Lazic 2005].There are also gas melting furnaces among technical devices, in which the current condition of the operating parameters [Židek 2018] is required to be continuously under control. Those devices represent an important technological unit of pressure casting machine parts. One of the most important monitored operating parameters in these technical devices is the temperature of molten metal in the furnace. Optimum parameters of melt [Wanga 2012], which are necessary for casting process [Miškufová 2013] can be hardly achieved without its control [Mohammed 2016]. In case of melt production with improper temperature, poor-quality cast is incurred or more precisely, deterioration of the whole batch may be incurred because of scorch in some cases. It implies that temperature monitoring is a key factor of the gas melting furnace [Dubják 2016] operation. Many researchers have been engaged in the detailed description of industrial melting furnaces used for Al alloys melting. Among these can be mentioned [Banerjee 2004] who made a detailed research of operating parameters of an industrial melting furnace. [Nieckele 2004] and [Mukhopadhyay 2001] elaborately analysed the control process [Rima 2018] of melting furnace when melting Aluminium. Furthermore, operating parameters are no less important [Panda 2017]. They are related to emissions, gas burners power [Edward 2009] and their air supply. Based on this information, combustion process can be effectively controlled in a way to achieve the highest possible productivity as well as the overall economy of the melting process [Famfulík 2007]. Banerjee et al. have also looked at this problem [Brewster 2001]. They presented a strategy for checking processing procedures in a melting furnace with direct combustion. [Golchert 2006] numerically examined effects of the selected fuels at different level of mixture enrichment with oxygen and nitrogen, where their significant impact on the overall operational performance of a melting furnace for Al melting was proved. Based on the mentioned facts, it is evident that the appropriate monitoring system of a gas melting furnace represents an important systemic [Yan 2017] as well as technological unit [Li 2006]. Therefore, the purpose of an innovation solution of the gas melting furnace KOV 010/1998, that is in practice used for Al and Cu alloys melting, is a solution for monitoring system innovation. This, along with an appropriate connection to the existing control system of the gas melting furnace allows a service simplification, but more importantly, the operation will be more effective.

2 ANALYSIS OF THE CURRENT CONDITION OF THE GAS MELTING FURNACE KOV 010/1998 MONITORING SYSTEM

The gas melting furnace marked as KOV 010/1998 was considered within the framework of the monitoring system innovation. This is a technical device which is used for melting of non-ferrous metals with low melting point, such as Al or Cu alloys. The following Fig. 1 shows the gas melting furnace KOV 010/1998 where monitoring system innovation was made.

Figure 1. Gas melting furnace KOV 010/1998

The construction of the gas melting furnace KOV 010/1998 consists of a supporting frame, which is anchored in the basement plate. The furnace is mounted on two sliding bearings on the front side while on the back it is mounted to a hydraulic cylinder that allows the furnace to tilt (lift) during emptying.

The lining of the melting furnace KOV 010/1998 consists of refractory bricks containing 42% of Al. There is an insulating layer made of ceramic insulation boards on the steel furnace shell. This type of lining provides for the reduction of total heat losses through the steel furnace shell. This ensures that the temperature on the outside of given steel furnace shell is for the given melting furnace below 80 °C. The spout and the exhaust gas opening are protected by refractory concrete. The melting furnace space at the burner place is covered with special refractory material that resists temperatures up to 1600 °C. The movable door of the melting furnace is secured with refractory cast concrete. Tilting of the melting furnace during its emptying is performed by means of a hydraulic cylinder with a maximum stroke height of 1800 mm. The opening of the movable door is solved by pulley transfer and hydraulic cylinders with a maximum stroke height of 700 mm. Hydraulic cylinders for opening the movable door are controlled by hydraulic fluid pressure with two pumps. The following Table 1 shows the basic technical parameters of the melting furnace KOV 010/1998.

Table 1. Basic technical parameters of the melting furnace KOV 010/1998

Essential dimensions of the furnace width/ length/height	4930/3200/3080
Maximum furnace capacity	8000 kg
Maximum melting power	700 up to 900 kg·h^{-1}
Method of heating (gas burners)	2x700 kW
Source of heat	natural gas
Working pressure	5 – 10 kPa
Installed el. Input of the fan	5.2 kW; 400 V
Installed input of the hydraulic unit	7.7 kW
Standby weight of the melting furnace	35000 kg

The current monitoring system of the gas melting furnace KOV 010/1998 used for Al alloys melting is constituted by basic technical equipment only. Online information on operating parameters of the gas melting furnace are being obtained via simple resistance temperature sensors. The following Fig. 2 presents a method of installation of the resistance temperature sensor Limatherm Sensors TTSC-22.

Figure 2. Installation of the resistance temperature sensor Limatherm Sensors TTSC-22 in the gas melting furnace KOV 010/1998

Resistance temperature sensors Limatherm Sensors TTSC-22 which are installed in the gas melting furnace KOV 010/1998 provide information about temperature at the front side of the furnace and temperature just above the surface of an Al molten alloy. The system is composed of two resistance temperature sensors TS1 a TS2, which are installed approximately 40 cm from burners and one resistance temperature sensor TS3 located in the ceiling lining. The ceiling lining is usually most overheated; therefore, it is very important to monitor parameter of the lining temperature during the operation. During the operation, temperature of the ceiling lining of the gas melting furnace is usually slightly higher than temperature of melt itself. These real-time data on the current temperature are shown on the electro-switch device. The electro-switch device can be seen in the following Fig. 3. It controls gas burners performance based on information on interior temperature of the gas melting furnace KOV 010/1998.

Figure 3. The electro-switch device for controlling performance of burners in the gas melting furnace KOV 010/1998

The electro-switch device controls burners power based on information on interior temperature of the gas melting furnace KOV 010/1998 via resistance temperature sensors TS1, TS2 and TS3 and also allows emergency stop of burners in case of emergency situation. The following Fig. 4 shows a simplified scheme of the resistance temperature sensors layout in the gas melting furnace and their connection to the electro-switch device.

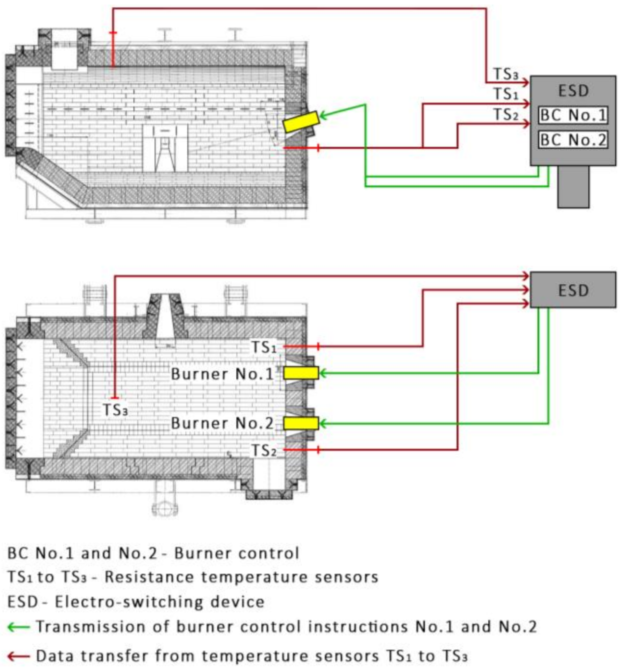

Figure 4. Simplified scheme of the current layout of the gas melting furnace monitoring system KOV 010/1998

3 DESIGN OF A TECHNICAL SOLUTION FOR THE INNOVATION OF THE MONITORING SYSTEM OF GAS MELTING FURNACE KOV 010/1998

As mentioned above, information about the actual temperature of the interior is crucial in terms of monitoring of the gas furnace KOV 010/1998 operating parameters. It is important to choose the appropriate type of sensors and their appropriate layout for reliable delivery of this information. Another important operating parameter is the melt temperature information. Its value in the current monitoring system can only be estimated based on the data from installed resistance sensors on the back wall and in the ceiling lining of the furnace. No less important operating parameter is information about the burner operation. This is mainly the performance parameters of the combustion process, including the air supply. Therefore, the proposal for a technical solution for upgrading the current monitoring system of the KOV 010/1998 gas melting furnace is to implement a new layout of the temperature sensors, which also allows the melt temperature measurement. At the same time, an innovative monitoring system should allow the control of the combustion process, including air supply control.

3.1 Upgrading the temperature sensing monitoring system

The upgrading of the actual monitoring system of the KOV 010/1998 gas melting furnace regarding temperature sensing is based on the new layout of the temperature sensors. When compared to the original solution, additional temperature sensors will be added to the furnace side walls as well as melt temperature sensors. There is a schematic illustration of a new layout of the resistance sensors for sensing the temperature in the interior space of the gas melting furnace KOV 010/1998 in the following Fig. 5.

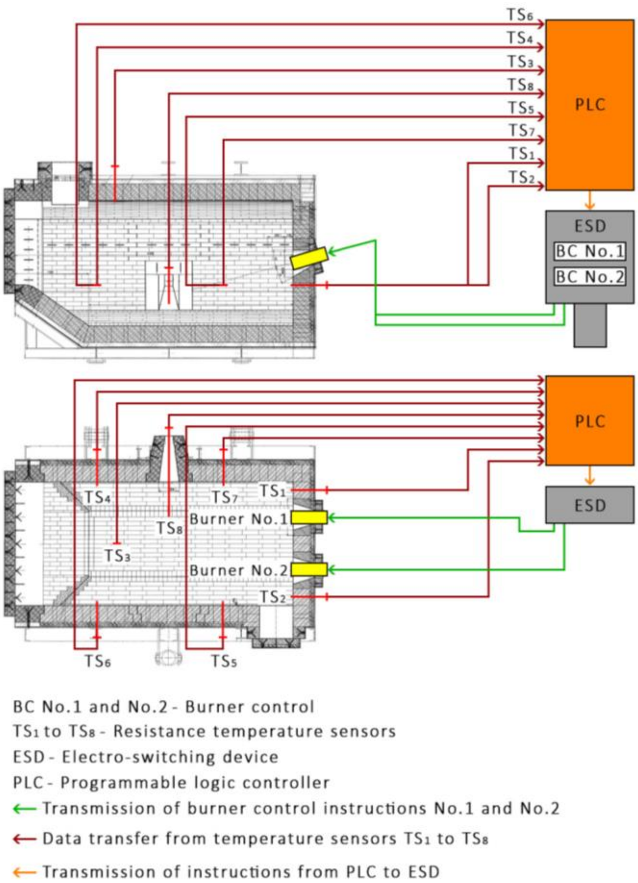

Figure 5. Upgrading the monitoring system for sensing operating parameters of gas burners

Actual KOV 010/1998 gas melting furnace temperature and melt information will be displayed on a simple PLC instrument. It will also be connected to the original electrical switching device. On the basis of more accurate temperature information, the system will be able to more accurately regulate the burner power and thereby substantially reduce the risk of scorch.

3.2 Upgrading the monitoring system for sensing operating parameters of gas burners

Another innovation of the KOV 010/1998 gas melting furnace monitoring system consists in the implementation of gas burner operating parameters, which is totally absent in the current monitoring system. The solution will consist mainly in sensing and subsequent controlling of the gas burner power parameters, including the air supply. There is a schematic illustration of an innovative solution of a monitoring system for sensing the performance of gas burner power and supplying air to a gas melting furnace KOV 010/1998 in the following Fig. 6.

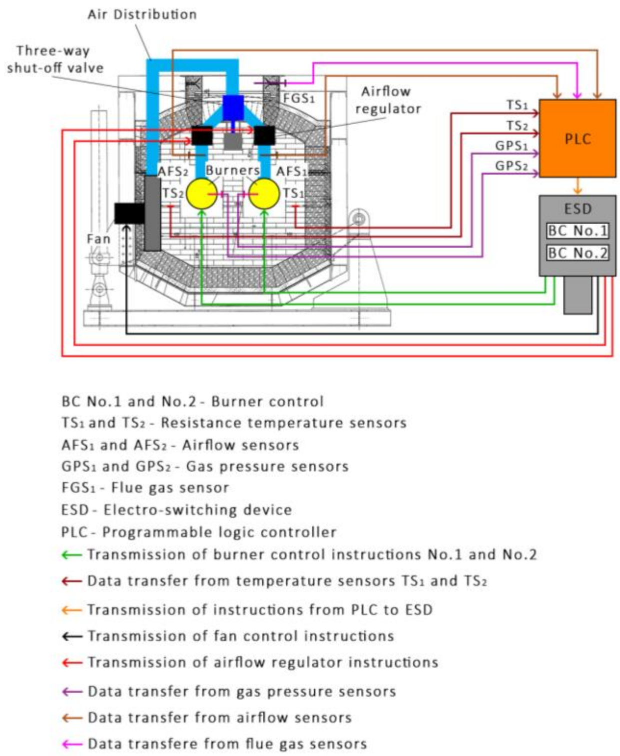

Figure 6. Schematic representation of an innovative solution for a monitoring system for sensing gas burner power parameters and supplying air to a gas melting furnace KOV 010/1998

An innovative monitoring system for sensing the gas burner power parameters and supplying air to the KOV 010/1998 gas melting furnace will consist of an flue gas sensor FGS_1, gas pressure sensors GPS_1; GPS_2, temperature sensors TS_1, TS_2 and air flow sensors from the fan through the air distribution to the individual gas burners AFS_1 and AFS_2. Additionally, the system will be supplemented with regulatory elements that control the power of gas burners, regulate the fan power, or close the air flow to the individual burners, based on current temperature information of the melting furnace interior, melt temperature and emissions.

4 CONCLUSIONS

An important element of almost every modern technical device is currently the monitoring system. We can always keep up-to-date information regarding operating parameters and the current technical condition of a device via monitoring system. Furthermore, functions or more precisely, planned maintenance interventions can be subsequently managed or modified through it. The aim of this paper was to describe the proposal of a solution for the monitoring system innovation for monitoring operating parameters of the KOV 010/1998 gas melting furnace operating parameters. The furnace is in practice predominantly used for melting of non-ferrous metals with a low melting point. The innovation concerned two main areas of monitoring its operating parameters. It was the system for sensing the temperature of the interior space and melt and also the system for sensing parameters related to gas burners power. The proposal for the solution for the innovation of the monitoring system is to make the operation of the KOV 010/1998 gas furnace more efficient, to improve the quality of the castings produced, and at the same time to reduce the risk of batch deterioration.

ACKNOWLEDGMENTS

The authors would like to thank the grant agency for supporting research work the projects VEGA 1/0205/19.

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CONTACTS:

assoc. prof. Ing. Ľuboslav Straka,PhD.; prof. Slavko Pavlenko, CSc.; assoc. prof. Ing. Peter Michalík, PhD.; Ing. Matej Hrabčák
Department of Automotive and Manufacturing Technologies Faculty of Manufacturing Technologies of the Technical University of Košice with a seat in Prešov, Štúrova 31, 080 01 Prešov, Slovakia, tel.:+421 55 602 6365
e-mail: luboslav.straka@tuke.sk, slavko.pavlenko@tuke.sk, peter.michalik@tuke.sk, matej.hrabcak@tuke.sk