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TEMPERATURE MEASUREMENT OF A LINING OF A CASTING LADLE
MĚŘENÍ TEPLoty VYZDÍVKY LICÍ PÁNVE

Abstrakt

Príspevek popisuje mēřící přístroj pro mēření teploty vyzdívky licí pánve, která obsahuje tekutou ocel. Úkolem mēřícího přístroje je mēřit teplotu ve vyzdívce pomocí termočlánků s určitou periodou a následně ji uložit do paměti. Cílem celého projektu je získání průběhů teplot v jednotlivých cyklech pánve. Tyto průběhy by měly odhalit teplotní zatížení vyzdívky pánve.

Poněvadž je mēření prováděno v extrémních podmínkách, musí být mēřící subsystém odolný vůči několika nepříznivým vlivům. Mezi tyto vlivy patří vysoká teplota, možnost přímého kontaktu s ocelí, mechanické rázy a vysoká elektromagnetická indukce.

Abstract

This article describes a measuring device for a lining temperature measurement of a casting ladle. The main task of the measuring device is to measure the temperature by thermocouples with a certain period and then save it to the memory. The overall objective of the measurement is to obtain the temperature trends in every cycle of the ladle. These trends should detect a load of the lining of the casting ladle.

The measuring is realized in the extreme conditions. The measuring device has to be design to survive in such an environment. To the harmful influences belongs high temperature, direct contact with a steel, mechanical beats and high electromagnetic induction.

Key words: temperature measurement, casting ladle, extreme conditions

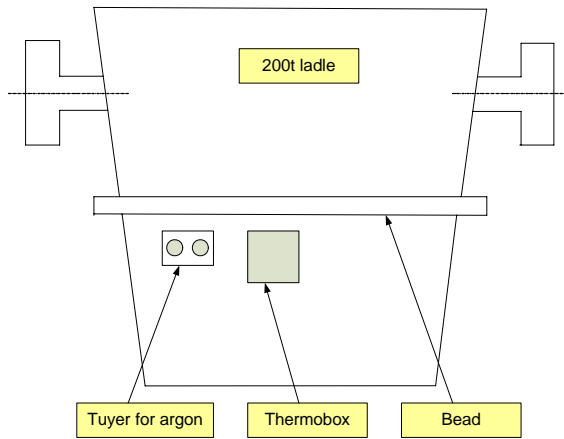
1 INTRODUCTION

It is suitable to tell something about a place where the device (further datalogger) will be used before it will be described in detail. The datalogger is situated on a casting ladle where it measures the temperatures of its lining. The casting ladle is a very important part in a steel plant. If we briefly mention a main purpose of this appliance we can start at a tap of some furnace. All volume of the furnace except slag is poured into the ladle. Then the ladle goes to the ladle furnace where a heat is finished. It means that the ladle furnace fixes a chemical composition and temperature and prepares the heat for casting. Finally the ladle goes to a caster where all volume is poured to a tundish.

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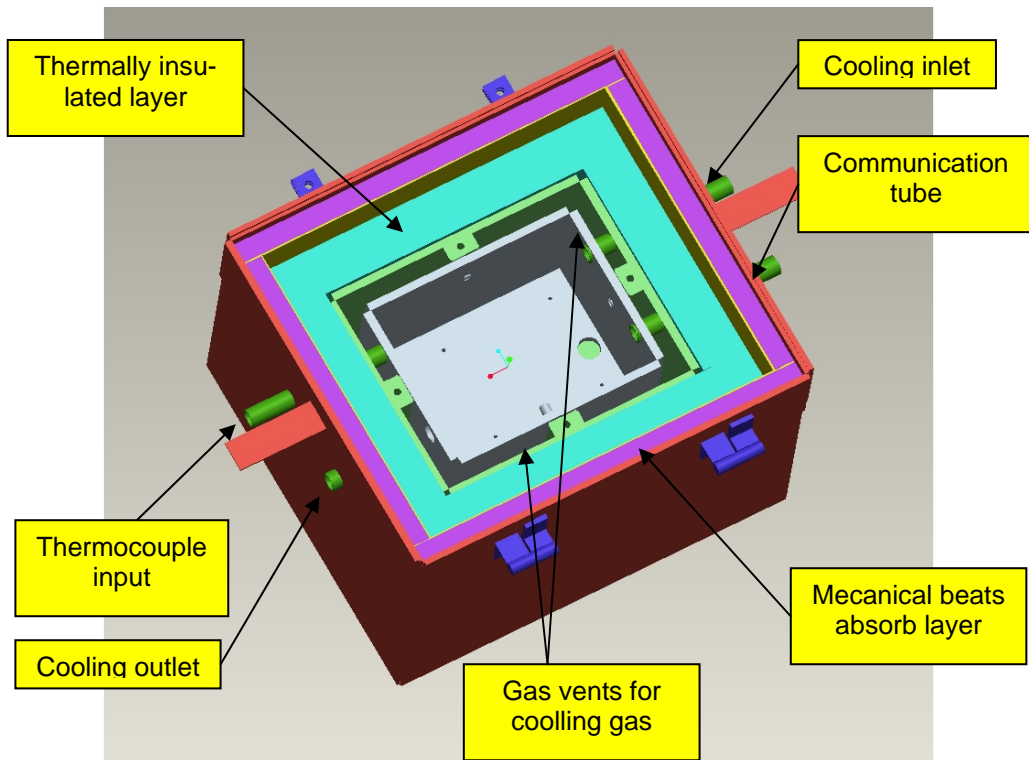
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Pic.1 Casting ladle

If you are able to imagine such a heavy duty it is almost impossible to leave any electronics with no protection. A special thermally insulated box (further thermobox) was designed from this reason. The thermobox is situated approximately in middle of a ladle height under a ladle bead. This place is protected against the direct contact with liquid steel. The thermobox has got several layers. Each of them meets its own task. The most important area damper layer which absorbs the mechanical beats and thermally insulated layer which protects the electronics inside the thermobox against high temperature.

None of isolations can constantly keep the low temperature therefore the thermobox has to be cooled. An air or argon is used as a cooling medium. A gas flows through the thermobox.



Pic.2 Look inside the thermobox

2 REQUIREMENTS AND SOLUTIONS OF THE ELECTRONIC DEVICE

The electronic device creates a base of the whole subsystem which can measure and store the temperatures. A lot of problems had to be solved during the design of this device. They are described in the following features:

Power supply from a cell – the device must be supplied by a galvanic cell because it is mounted on the casting ladle. A special galvanic cell was used from this reason. The basic parameters are here:

- One cell has capacity 13Ah.
- The nominal voltage is 3.9V
- Operating temperature is from -20°C to 165°C.
- Diameter 24.76mm
- Length 102.62mm

Three weeks lifetime without an exchange of the cell – this requirement have two reasons. The first one is because of a high price of the cell and the second one is related to duration of the casting ladle campaign. The lining of the casting ladle must be changed approximately in average every 45-50 heats witch is one campaign. One campaign takes just three weeks.

Low current consumption – related to the mentioned features.

High temperature – all parts of the measuring device must work in the temperature of 120°C. In a case that the temperature will increase over this temperature, the device hasn't to be damaged earlier than the temperature will be over 140°C.

Small dimensions – the measuring device should be as small as possible. The SMD electronic components are used in the last version of datalogger.

8 measuring channels required – the device has to be able to measure eight temperatures from eight thermocouples. The thermocouples of type B and K can be used. These two types of thermocouples have a different output characteristic.

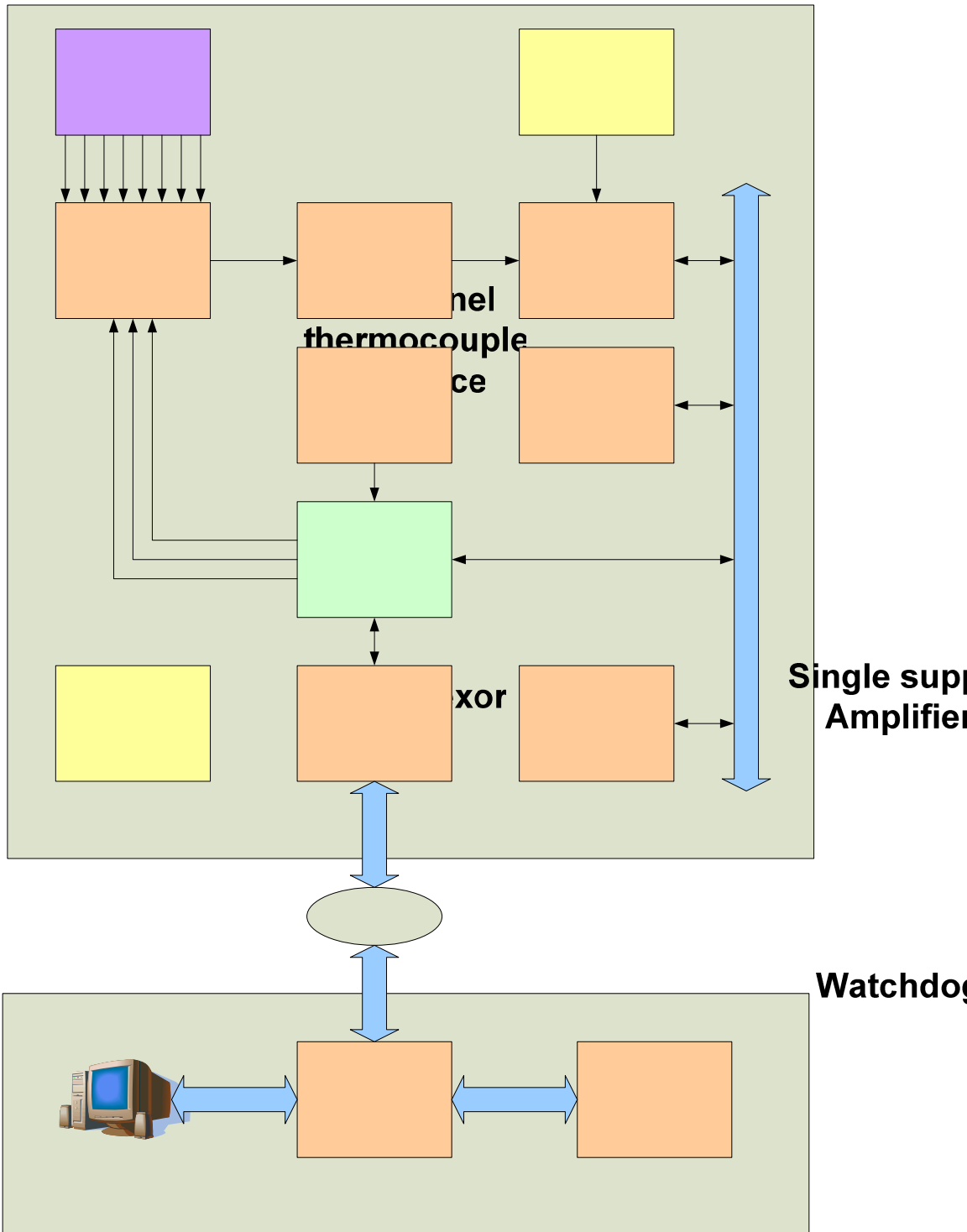
Thermocouples							
B type		B type		K type		K type	
°C	mV	°C	mV	°C	mV	°C	mV
0	0	1000	4,834	0	0	1000	41,276
100	0,033	1100	5,78	100	4,096	1100	45,119
200	0,178	1200	6,786	200	8,138	1200	48,838
300	0,431	1300	7,848	300	12,209	1300	52,41
400	0,787	1400	8,956	400	16,397	---	---
500	1,242	1500	10,099	500	20,644	---	---
600	1,792	1600	11,263	600	24,905	---	---
700	2,431	1700	12,433	700	29,129	---	---
800	3,154	1800	13,591	800	33,275	---	---
900	3,957	---	---	900	37,326	---	---

Tab.1 Thermocouple characteristics

2.1 Device description

The presented measuring system measures the temperatures of the lining of the casting ladle. Due to the high demands of operability the microcontroller PIC18LF2520 was chosen. This microcontroller can handle multiple communication buses such as RS232, I2C and USB. Another

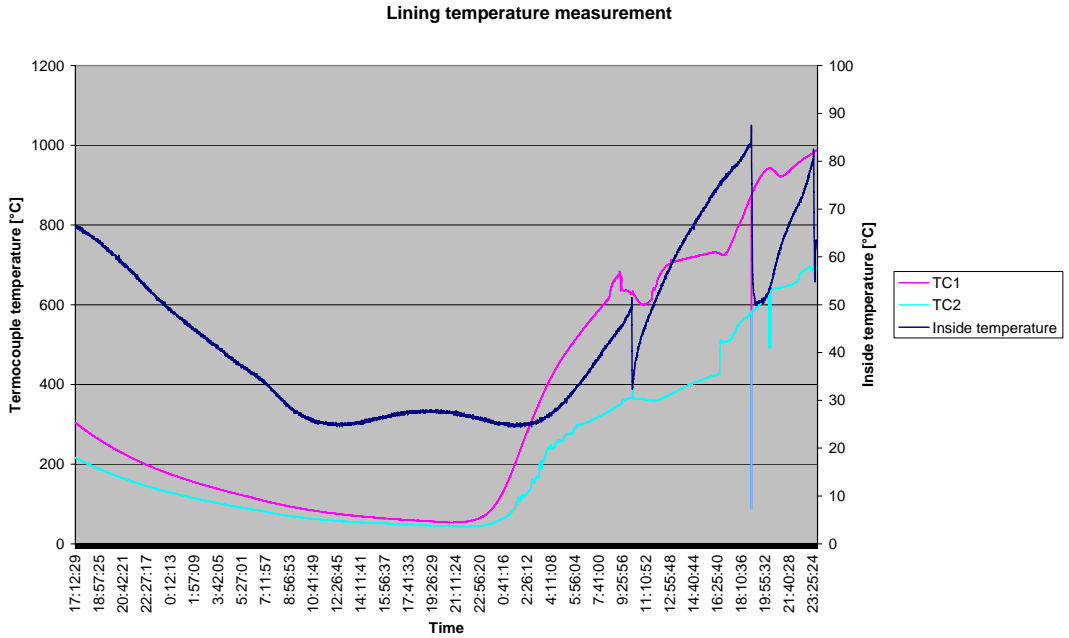
reason of the choice is a low current consumption and quite a big flash memory. The following picture shows a block schema of the datalogger.



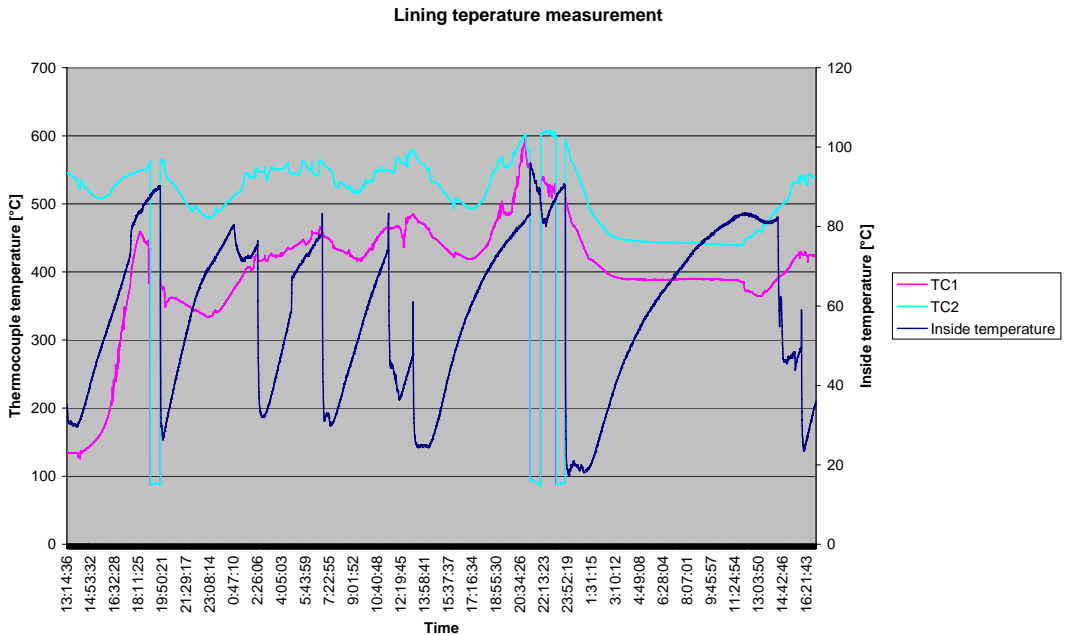
Pic.3 Block diagram of the measuring device

3 THE RESULTS OF THE MEASUREMENT

The measuring device was tested on the ladle number eight during one campaign. On the following pictures you can see two segments of the measurement.



Pic.4 Temperature measurement no. 1



Pic.5 Temperature measurement no. 2

4 SUMMARY

In this document was described a special measuring device called datalogger which measures the temperatures of the lining of the casting ladle. The datalogger is positioned in the special protective box called thermobox which protects the electronics against harmful influences.

Datalogger was designed to survive in a dangerous environment. The operating temperature range is from -20°C to 120°C . The storage temperature range is from -40°C to 140°C . If the temperature steps over the storage temperature range, then the datalogger will be destroyed.

The measuring device was tested on the ladle number eight during one campaign. It means approximately 50 heats per three weeks. The datalogger kept to measure during this period. The data were downloaded about every 34 hours. You can see two sets of the trends on the picture number four and five. Both charts consist of two shapes of the thermocouples and one shape of the temperature inside thermobox.

The picture number four shows the trends when the ladle eight went to fast reparation. The temperatures went slowly down at the beginning. The workers could repair the ladle when it was cool enough. You can see that the temperature inside the thermobox is about 25°C . When the ladle was repaired then it went to a preheating.

The picture number five shows several cycles of the ladle. The highest inside temperature was 95°C .

If we recapitulate the measuring test then we can say that it was successful from 80%. There is one problem which decreases the full success. The problem was with the installation of the thermocouples. We installed four thermocouples at the beginning of the test (2xB, 2xT). The TCs of type B were destroyed immediately during first a few hours.

The measuring system was patented.

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Opponent: Ing. Petr Orság, Ph.D.