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IMPROVEMENT OF CASTING TECHNOLOGY BY USING OF EXOTHERMIC FEEDER HEAD AND SIMULATION THE SOLIDIFICATION ALLOY

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ABSTRACT

This paper presents a simulation program use of feeders exothermic and insulating plates. High quality casting is considerably improved by using solidification simulation flow and cast.

KEYWORDS: feeder exotermic, simulation flow, thermal gradient

1. Introduction

To improve the quality of large castings by preventing the appearance of defects in their walls during solidification process can used the exothermic feeders. Also the solidification process can be improved by computer simulation.

Achieving a high temperature gradient between the feeder head and part (thermal nodes are powered) can be obtained by using exothermic mixtures (as powdery or made up).

2. Improvement of casting technology by exothermic feeder head

The exothermic feeder head is provided with a coating mixture that in contact with liquid metal releases heat, as a result of the exothermic reaction between its components.

There are two kind of exothermic feeders:

- low-temperature gradient (50-100K) performed as plates and inserts;
- high-temperature gradient (400-500K) carried by metalothermic load.

The heat released by exothermic mixture is based on exothermic reactions (reduction-oxidation). This type of reactions can be divided into three categories:

- Goldschmidt's reaction, i.e. aluminium oxidation under the action of an oxide (iron oxides)
- aluminium oxidation under the action of oxygen from atmosphere or under the action of chemical combinations that produce oxygen
- combustion of the organic materials (charcoal, sawdust etc.).

Goldschmidt's reaction occurs according to the following equation:

$$2Al + Fe_2O_3 = 2Fe\ Al_2O_3 + Q \quad (1)$$
$$2Al + 3\ FeO = 3Fe + Al_2O_3 + Q \quad (2)$$

Materials for exothermic feeders heads are divided into five groups:

- active components which come directly into the oxidation process like aluminum powder, aluminum chips and, ferrosilicon powder;
- oxidizing components (that provide oxygen needed to carry out the exothermic reactions) like iron oxides, manganese oxides, iron ore, piroluzit, hematite, sodium nitrate or potassium nitrate, chlorides and fluorides;
- catalysts (special additives for oxidation process control) like fluorides of alkali metals, cryolite and cupola powder;
- inert components (that ensure slowing of exothermal reaction and the lowering of temperature exothermic reaction) as quartz sand, chamotte powder, wood flour etc.;
- binder as bentonite, sodium silicate, clay, dextrin and, resins.

The components of exothermic mixture (i.e. the substances that participate in the exothermic reactions and the substances that are thermally inert) cause the reactions with thermal effect. As result this has influence towards the ignition temperature and the burning rate of the mixture.

For these reasons, these exothermic mixtures are chosen depending on the nature alloy (iron, steel, nonferrous alloys), the geometry of the parts and the casting conditions too.

In addition, the exothermic mixtures must also meet others characteristics:

-exothermic coating must be sufficiently resistant to mechanical action generated by liquid metal flow;

-after reaction finishing the exothermal shell must have the good thermal insulation properties;

-the products of exothermic reactions cannot develop other chemical reactions with the cast metal;

-low cost exothermic mixtures.

Additionally to exothermic feeders heads can be used the exothermic powders.

These are placed above alloys after casting. Their role is to protect the surface of casting alloy to atmosphere contact and provide a supplementary heat input.

Exothermic materials used to realize exothermic heads are chosen depending on the alloy. For the steel parts the composition of these materials are given in Table 1.

Table1. *Exothermic material for carving large pieces of steel*

Product name	Mass content, %					MnO, in slag %
	Aluminum powder	Slag furnace	Manganese ore	Fluorine	Sodium silicate	
EXO-1	14	46	12	10	18	4.30
EXO-2	14	40	20	8	18	6.21
EXO-3	14	34	30	4	18	6.32
EXO-4	14	28	40	4	14	7.81
EXO-5	14	20	50	4	12	13.20

Exothermic mixtures are classified according to the nature binder:

a. Exothermic mixtures with resins

Last time "FOSECO" made a series of exothermic mixtures for feeders heads used for different alloys. These improve a higher removal index (75-80%). The four types of mixtures named Feedex is given in Table 2.

Table2. *Types of mixtures Feedex created by "FOSECO"*

Type of mixture	Water content, %
Feedex 3	4
Feedex4	5
Feedex 50	10
Feedex 93	7...9

b. Exothermic mixtures with dextrin

Exothermic mixtures with dextrin have lower hygroscopicity. As result the bushings made of these mixtures can be maintained until the molding up to 2 ... 3 days. The utilization of these mixtures is limited because dextrin is a poor material.

c. Exothermic mixtures with sodium silicate

The bushings made of exothermic mixtures with sodium silicate are less hygroscopicity and can be maintained during a longer time (within 6 days), if the humidity not exceed 2%.

d. Exothermic powder mixtures to cover the upper surface of the feeders

The addition of the exothermic powders to feeder surface is the most simple and common practical solution. On liquid alloy surface develops a strongly exothermic reaction (the heat released is in accordance with the composition of the mixture and with its amount). On alloy surface a slag layer is created that minimizes the heat loss by radiation (the heat released by feeder surface condition is 15 ... 20%).

A prescription for the exothermic mixture that can be placed on the alloy surface is as follows (mass %): 10 % aluminum powder; 4% iron ore; 3% manganese ore; 3% cryolite, 80% chamotte powder.

In order to improve the efficiency of the exothermic heads used for large castings the insulating boards can be used. They are made of the same material as exothermal heads.

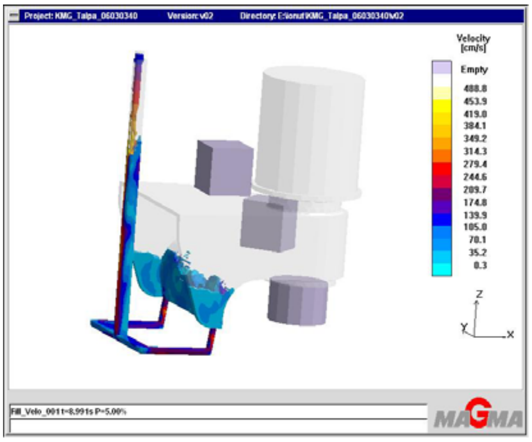
Insulation board is presented in Figure 1.

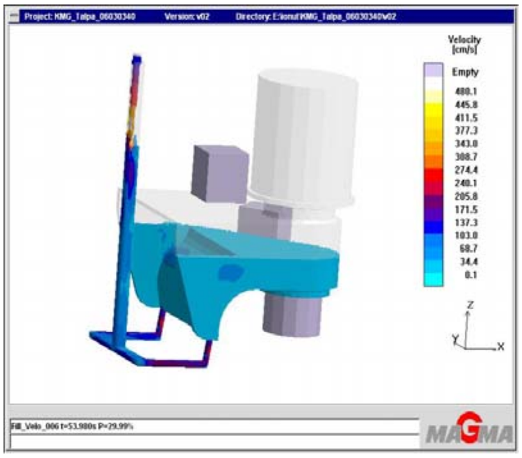
Fig. 1. *Example of insulation board*

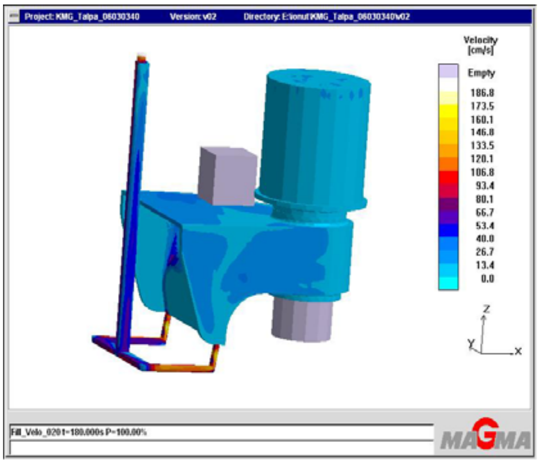
3. Simulation of the solidification alloy

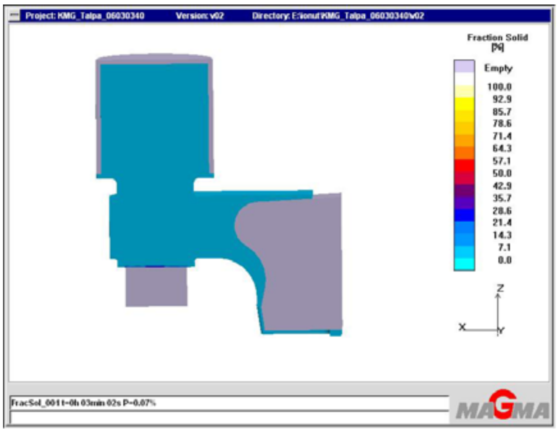
Other solution to improve the quality of large castings by preventing the appearance of defects in their walls can be the solidification process by computer simulation. MAGMA program is used in this application.

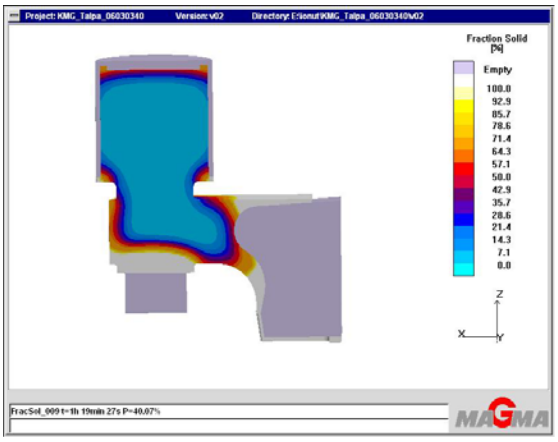
Following some images of the variation of the solidification front and the temperature areas, are presented.

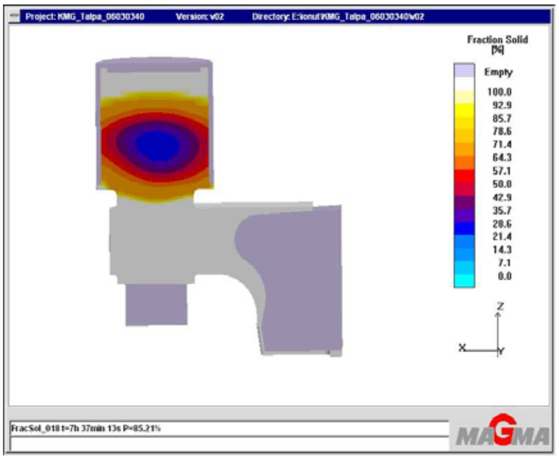












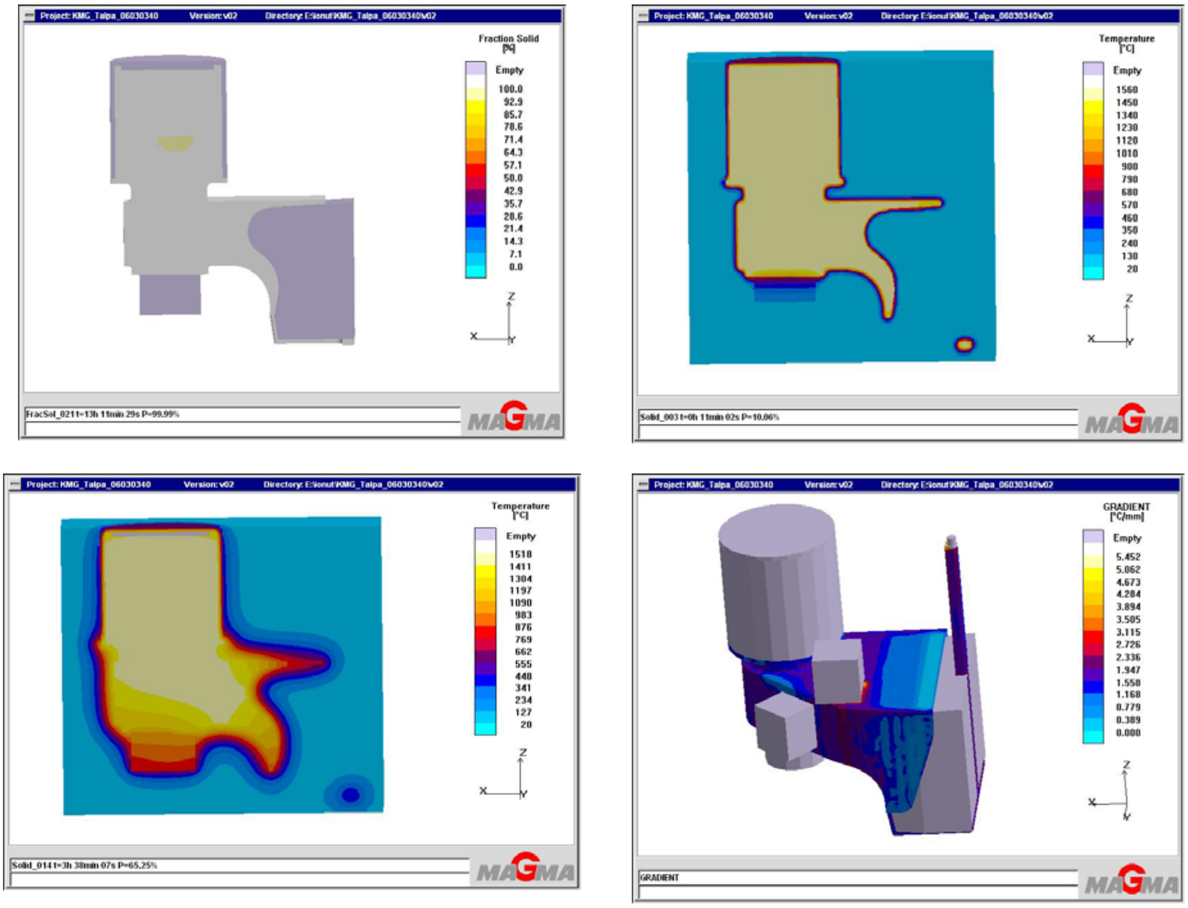


Fig. 2. *Variation of the solidification front and the temperature areas*

Flow simulation and solidification simulation using computer program MAGMA lead to efficient casting process.

Also the implementation of this program leads to the optimal placement of feeders with minimization of the heat loss.

4. Conclusion

The using of the exothermic feeders for large steel castings increases the removal index;

The insulating boards that surround the feeder lead to a smaller loss of heat transferred to the walls shape. The alloy of feeder is maintained longer as liquid.

The application of these methods leads to a healthier walls surface of castings and to a lower processing time.

The solidification simulation using MAGMA program leads to improving of large castings quality by preventing the appearance of defects in their walls. Also the metal consume is reduced.

The result of the simulation program, the exothermic feeder and the insulating plates use, could be a better quality of castings and shortening of the labor time.

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