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ON THERMODYNAMIC PARAMETERS APPROPRIATE CHOICE FOR IMPROVEMENT OF HOLLOW CYLINDRICAL CASTING'S FABRICATION PRACTICE UNDER CENTRIFUGAL CASTING

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ABSTRACT

Based on the boundary-value problem solution on solidification and cooling of hollow cylindrical casting a study is made for the some thermodynamic parameters to be chosen to improve manufacturing methods of the casting mentioned produced with centrifugal casting on the roundabout-type plant. The appropriate parameters choice makes it possible to ensure both necessary crystallization fronts meeting position inside the casting and equality of the mould temperatures at the production cycle's beginning and its termination.

Key words: hollow cylindrical casting, thermodynamic parameters' values choice, massive metallic mould, centrifugal casting, roundabout -type plant.

Statement of the problem. The only way that one can influence both mechanical properties and grain structure of a casting having given shape, dimensions and fixed chemical composition is the controlling of thermal phenomena accompanied the casting solidification and cooling processes.

So the problem under study may be stated as follows. To choose the thermodynamic parameters' values for the manufacturing process of a hollow cylindrical casting being cast at roundabout-type plant by centrifugal casting, with holding true next propositions:

– the meeting point position of the crystallization fronts moving inside the casting towards each other from the casting inner and outer surfaces is assigned in advance;

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– the ratio of time intervals during which the casting being in and out of its mould (the intervals sum makes a casting manufacturing cycle) is given;

– although varying over the manufacturing cycle, the mould's temperature at the starting and finishing cycle's moments have to be the same;

– casting's knock-out temperature is strictly fixed.

Taking into account a great number of the parameters in question one, for the subjective factors to be avoided and the parameters' values to be chosen in proper manner, has to base his choice on the computer calculations resulting from the boundary-value problem solution simulating mathematically phenomena and processes of interest.

In our previous paper [2] there are investigated a series of Cauchy's and the boundary-value problems being concerned with mathematical simulation for solidification and cooling of the hollow cylindrical casting under centrifugal permanent-mould casting, such assumption being adopted as simplifying ones [1,3,4]: i) the calorimetric temperature concept; ii) the equivalent casting method (being only used when an alloy is to be applied for the casting to produce); iii) existence of constraints in form of inequalities related to the casting-mould geometrical parameters: $l_1 << R << H$, $l_1 \leq l_2$, where l_1, l_2 - is the thickness of the casting's and mould's wall respectively, H - the casting's height and R - its external surface radius (the first of two inequalities makes it possible to consider the temperature field of the casting-mould system in the axially symmetric case as that of an infinite plate and the second one – to consider the mould as massive in comparison with the casting).

An illustrative example. For the studied in this paper the thermodynamic parameter-choice problem to give a little more concrete content there in this section is considered an example of application for the boundary-value problem solution having been developed in the cited paper [2], the input and output data being written as follows.

1. **Input data**

1.1. Casting's parameters

material ……………….. grey cast iron
density, *kg/m³* ………………..….7200
thermal capacity, *J/kgK*...................560
heat conductivity, *W/mK*...................42
thermal diffusivity, *m²/s*……..1,04e-05
inner radius, *m*……………………0,05
outer radius, *m* …………………...0,06
front meeting point position, *m*….0,008
melt crystallization
specific heat, *J/kg*……………215
temperature, *K*
melt…………………………1620
liquidus……………………...1570
solidus………………………1420
crystallization……………....1495
knock-out……………………920

1.2 Mould's parameters

material……………………...titanium
density *kg/m³*………………..….3150
thermal capacity, *J/kgK*……........712
heat conductivity, *W/mK*……......8,5
thermal diffusivity, *m²/s*……3,79e-06
inner radius, *m*…………………..0,06
outer radius, *m* ………………….0,07

1.3 Other parameters

environment temperature outside
of mould, *K*...................................290
insulating paint thickness, *m*…...0,001
its heat conductivity, *W/mK*………0,2
time intervals ratio (casting
out of / casting in mould)…..……5/4

2 Output data

2.1 Temperature, *K*
interior to casting……………1007
exterior to mould……………..290
calorimetric……………..…875,6

2.2 Heat-transfer coefficient, *W/m²s*
casting inner surface…..….1952,5
mould outer surface……..…124,3
casting-mould transition........505,3
mould-casting transition…....330,9

2.3 Time interval, *s*
melt overheating removal…..…4,3
casting solidification………..24,4
casting knock-out…………....71,0
manufacturing cycle……..…159,8

Some additional information on both the casting-mould system's temperature fields and the choice of time parameters (casting's knock-out moment, manufacturing cycle duration) may be obtained from Fig. 1-5, where some computer-made results are represented in dimensionless form (definition of dimensionless variables see in paper [2]).

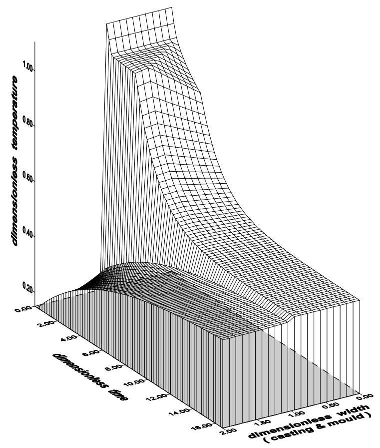

Fig. 1. Casting-mould system's temperature field (without casting's knock-out)
Rys. 1. Pole temperatur systemu odlew – kokila (odlew nie jest wyjmowany z kokili)

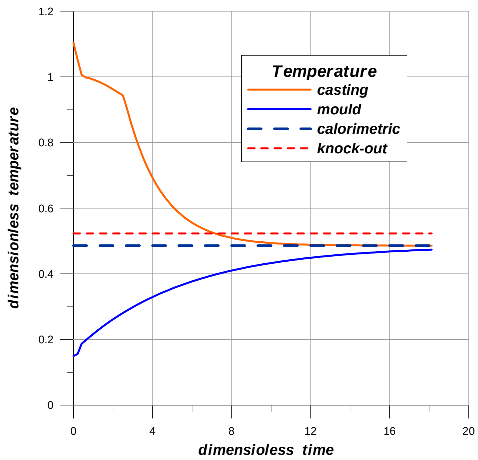

Fig. 2. Time variation of casting and mould width-mean temperature
Rys. 2. Zmienność w czasie średniej szerokości odlewu i kokili temperatury

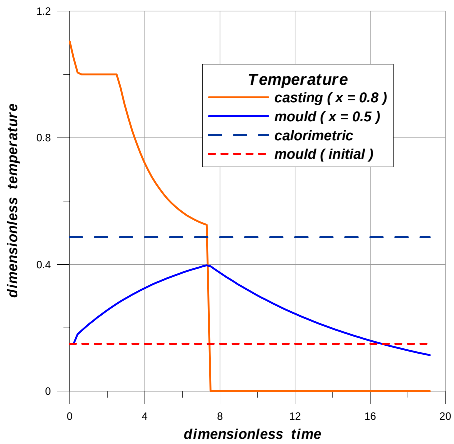

Fig. 3. Time variation of casting temperature (up to its knock-out) and mould temperature (during manufacturing cycle)
Rys. 3. Zmienność w czasie temperatury odlewu (przed wyjęciem odlewu z kokili) i temperatury kokili (w czasie trwania cyklu wykonywania odlewu)

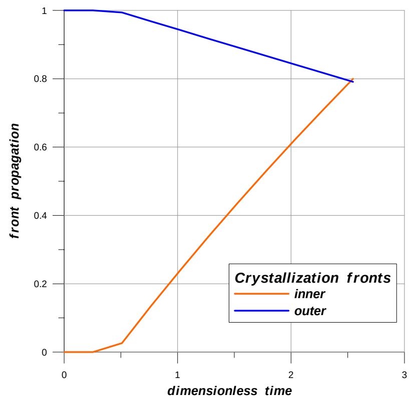

Fig. 4 Kinetics of casting solidification
Rys. 4. Kinetyka zastygania odlewu

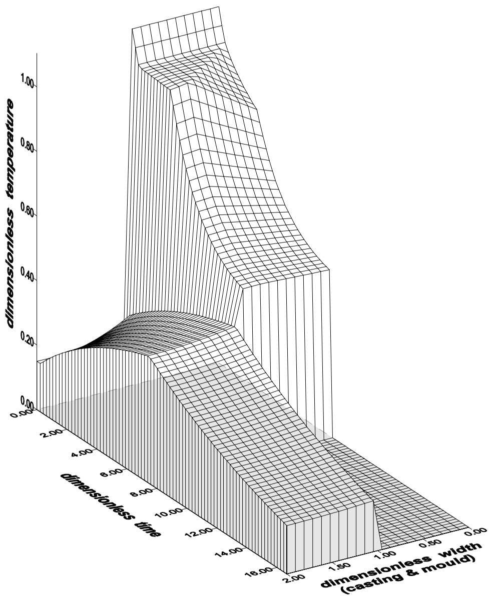

Fig. 5. Casting-mould system's temperature field (with casting's knock-out)
Rys. 5. Pole temperatur systemu odlew – kokila (odlew jest wyjmowany z kokili)

Conclusions. Having analyzed the computational data on the solution of the problem under study one can came to the conclusions:

- the modern computer-oriented techniques may be applied for the comprehensive casting problems to be solved efficiently (with higher accuracy and in relatively short time);

- although somewhat idealized (see simplifying assumptions adopted) the approach, developed in this study for the parameter-choice problem to be solved, makes it possible to derive a series of results that may be helpful when responsible technical decision is to be made;

- the results obtained by using developed approach may be valuable not only under appropriate thermodynamic parameters choice for to improve the casting manufacturing process but also for performance of the roundabout-type plant itself to be made higher when its designing.

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O WŁAŚCIWYM WYBORZE PARAMETRÓW TERMODYNAMICZNYCH W CELU UDOSKONALENIA TECHNOLOGII PRODUKCJI WYDRĄŻONEGO ODLEWU CYLINDRYCZNEGO METODĄ ODLEWANIA ODŚRODKOWEGO

STRESZCZENIE

Rozwiązanie zagadnienia brzegowego, dotyczącego zastygania i ochładzania wydrążonego odlewu cylindrycznego, stanowi podstawę dla wyboru niektórych parametrów termodynamicznych w celu udoskonalenia technologii produkcji cechowanego odlewu metodą odlewania odśrodkowego przy użyciu urządzenia obrotowego. Właściwy wybór wymienionych parametrów pozwala zapewnić zarówno wymaganą lokalizację punktu zetknięcia frontów krystalizacji wewnątrz odlewu, jak i równość temperatury kokili na początku i na końcu cyklu wykonywania odlewu.

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