(19) Europäisches Patentamt
European Patent Office
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(11) **EP 4 316 689 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.02.2024 Bulletin 2024/06

(21) Application number: **22205687.1**

(22) Date of filing: **06.11.2022**

(51) International Patent Classification (IPC):
B22C 9/06 *(2006.01)* ***B22D 27/04*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B22D 27/04; B22C 9/065

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **05.08.2022 PL 44197322**

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(54) CONTROL SYSTEM FOR THE SOLIDIFICATION PROCESS IN LARGE-SIZE CASTINGS AND PROCESS CONTROL OF SOLIDIFICATION IN LARGE-SIZE CASTINGS

(57) The object of the invention is a system for controlling the solidification process in large-sized castings, and a method for controlling the solidification process in large-sized castings, characterised in that it consists of any number of active cooling segments made of at least two steel plates with a shape matching the casting and known heat capacity, permanently connected to a tube coil (4), whose inlet (13) and outlet (14) nozzles extend outside the casting mould, the inlet nozzle being connected by a flexible hose (5) with a proper cross-section to a compressed air supply module (6), provided with a supply collector (7) connected to a pneumatic network, a proportional air flow regulator (8), and an injector (9), which is connected to a proportional water flow regulator (10), connected to the water mains, while the outlet nozzle is provided with a cooling medium temperature sensor (11), and the proportional air flow regulator, the proportional water flow regulator, and the cooling medium temperature sensor are connected to an automatic solidification process control console (12).

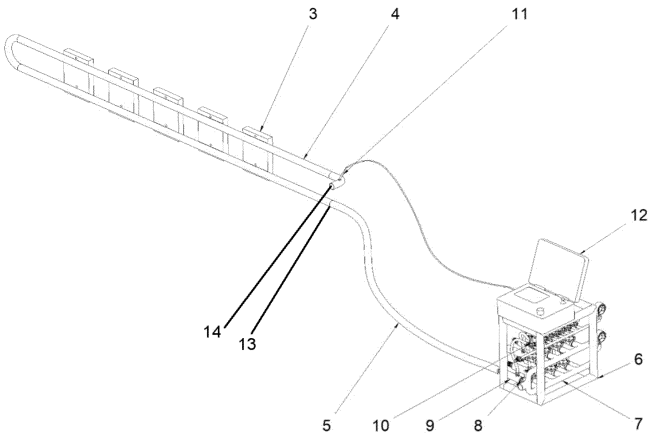

Fig. 2.

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Description

[0001] The object of the invention is a system for controlling the solidification process in large-sized castings, and a method for controlling the solidification process in large-sized castings.

[0002] Volumetric chills for cooling castings are known from common usage. They are usually metal inserts with thermal conductivity several times higher than the conductivity of the moulding sand, placed in the mould cavity or near the surface of the casting, which allow for local control of solidification. The first chill type is an internal chill, made of the same material as the casting, which is placed in the space filled by the metal, and its function is to melt into the casting. The second chill type constitutes a part of the mould cavity surface, matching the part of the casting which is being cooled down. The determining factors for the rate and the amount of heat extraction from a casting undergoing solidification by an external chill are the type of material of which it is made, its heat capacity, and the thermal conductivity coefficient.

[0003] A characteristic phenomenon during the use of external chills is the extraction of heat from the chill placement zone in the first step of the solidification process, until reaching an equilibrium of the temperatures of the cooling casting and the chill. Once the temperatures reach an equilibrium, the cooling rate of the casting in the chill placement zone drops drastically, and most importantly and also undesirably, a so-called local thermal node is created, indirectly affecting the microstructure of the casting.

[0004] The purpose of the present invention is to provide a stable process for cooling large-sized castings, the ability to precisely control this process, and to improve the microstructure of a casting undergoing solidification, as well as the geometrical, dimensional, utilitarian and qualitative properties of the final product.

[0005] The essence of the solution with respect to the first invention is in that the system consists of active cooling segments placed inside a casting mould, made of at least two steel plates with a shape matching the casting and known heat capacity, permanently connected to a tube coil, whose inlet and outlet nozzles extend outside the mould. The inlet nozzle is connected by a flexible hose with a proper cross-section to a compressed air supply module, provided with a supply collector connected to a pneumatic network, a proportional air flow regulator, and an injector, which is connected to a proportional water flow regulator, connected to the water mains. The outlet nozzle is provided with a cooling medium temperature sensor. The proportional air flow regulator, the proportional water flow regulator, and the cooling medium temperature sensor are connected to an automatic solidification process control console.

[0006] The essence of the solution with respect to the second invention is in that inside the casting mould there are mounted active cooling segments, made of at least two steel plates with a shape matching the casting and known heat capacity, permanently connected to a tube coil
whose inlet and outlet nozzles extend outside the mould. Upon filling the casting mould with liquid metal, compressed air is introduced into the tube coils, upon which its temperature is controlled in a continuous manner, and upon reaching an air temperature of 105°C, water is introduced into the system and mixed with compressed air, generating water mist which constitutes a cooling medium. In the further course of the process, the pressure and flow of the coolant as well as the degree of saturation of air with water are controlled and adjusted, thus changing the intensity of heat extraction from the steel plates. When the temperature of the cooling medium drops below 105°C, the inflow of water is closed, and the cooling process ends when the coolant temperature drops below 80°C. Preferably, the casting solidification process is controlled by means of a control console provided with an algorithm.
Preferably, the air flow rate has a value ranging from 300 to 1000 l/min. Preferably, the degree of saturation of the cooling mixture with water mist is no higher than 5% in a volume ratio.

[0007] The advantage of the solution according to the invention is the ability to provide a stable process for cooling large-sized castings, to precisely control this process, and to improve the microstructure of a casting undergoing solidification, as well as the geometrical, dimensional, utilitarian and qualitative properties of the final product. Using a water and air mixture in a temperature above 105°C ensures increasing the performance of the system of tube coils, as well as the safety of the process by fast evaporation of water and evacuation of water vapour generated in this manner, which prevents the phenomenon of condensation and local concentration of water in the liquid state.

[0008] The solution according to the invention with respect to the system is presented in the drawing, where Fig. 1 presents a layout of a complete automated system for controlling the solidification process of a large-sized casting, Fig. 2 - a single cooling segment, Fig. 3 - a block diagram illustrating the operating principle of the system.

[0009] Inside the casting mould 1, there are mounted active cooling segments 2 made of at least two steel plates 3, with a shape matching the casting and known heat capacity, permanently connected to a tube coil 4, whose inlet 13 and outlet 14 nozzles extend outside the casting mould 1. The inlet nozzle 13 of the active cooling segment 2 is connected by a flexible hose 5 with a proper cross-section to a compressed air supply module 6. The compressed air supply module 6 is made of a supply collector 7, a proportional air flow regulator 8, and an injector 9. In addition, the injector 9 is connected to a proportional water flow regulator 10, connected to the water mains. At the outlet of the cooling segment there is a cooling medium temperature sensor 11. The proportional air flow regulator 8, the proportional water flow regulator 10, and the cooling medium temperature sensor

11 are connected to an automatic solidification process control console 12. The supply collector 7 is connected to a pneumatic network.

[0010] The first step of the process is to fill the casting mould 1 with liquid metal. Upon finishing the filling process, an automatic cycle is activated by means of the control console 12, provided with an algorithm controlling the course of solidification. By means of the control console 12, a control signal is transmitted to the proportional compressed air flow regulators 8, in order to open them and ensure the flow of air through the system of tube coils 4. The values of air temperatures at the outlet of the system of tube coils of the active cooling segments 2 are recorded and controlled in a continuous manner. Upon reaching a temperature of approx. 105°C at the outlet of the tube coil system, a signal is transmitted to the proportional water flow regulators 10, opening the flow of water towards the injector 9. In the injector 9, air is mixed with water, resulting in the generation of water mist, which is a cooling medium, considerably increasing the performance and efficiency of extracting heat from the steel plates, the degree of saturation of the cooling mixture with water mist being no higher than 5% in a volume ratio. The values of coolant temperatures at the outlet of the system of tube coils are still recorded and controlled in a continuous manner, with simultaneous smooth control of the proportional air 8 and water flow 10 regulators; the pressure and flow of the coolant through the system of tube coils 4 and the degree of saturation of air with water are adjusted, thus changing the intensity of heat extraction from the chills 3, which directly translates into the cooling rate of the casting. The air flow rate has a value ranging from 300 to 1000 l/min. In the final step of the process, when the temperature of the cooling medium at the outlet of the system of tube coils drops below 105° C, a signal is transmitted from the control console 12 to the proportional water flow regulators 10, and the inflow of water to the injector 9 is closed. The process ends when the temperature of the coolant drops below 80°C.

Claims

1. A system for controlling the solidification process in large-sized castings, comprising chills placed inside a casting mould (1), **characterised in that** it consists of any number of active cooling segments (2) made of at least two steel plates (3) with a shape matching the casting and known heat capacity, permanently connected to a tube coil (4), whose inlet (13) and outlet (14) nozzles extend outside the casting mould (1), the inlet nozzle (13) being connected by a flexible hose (5) with a proper cross-section to a compressed air supply module (6), provided with a supply collector (7) connected to a pneumatic network, a proportional air flow regulator (8), and an injector (9), which is connected to a proportional water flow regulator (10), connected to the water mains, while the outlet nozzle (14) is provided with a cooling medium temperature sensor (11), and the proportional air flow regulator (8), the proportional water flow regulator (10), and the cooling medium temperature sensor (11) are connected to an automatic solidification process control console (12).

2. A method for controlling the solidification process in large-sized castings, **characterised in that** inside the casting mould there are mounted active cooling segments, made of at least two steel plates, with a shape matching the casting and known heat capacity, permanently connected to a tube coil, whose inlet and outlet nozzles extend outside the mould, wherein compressed air is introduced into the tube coils after filling the casting mould with hot metal, upon which its temperature is controlled in a continuous manner, and after reaching an air temperature of 105°C, water is introduced into the system and mixed with compressed air, generating water mist, which constitutes a cooling medium; further in the process, the pressure and flow of the coolant as well as the degree of saturation of air with water are controlled and adjusted, thus changing the intensity of heat extraction from the steel plates, upon which, when the temperature of the cooling medium drops below 105°C, the inflow of water is closed, and the cooling process ends when the temperature of the coolant drops below 80°C.

3. The method according to claim 2, **characterised in that** the casting solidification process is controlled by means of a control console provided with an algorithm.

4. The method according to claim 2 or 3, **characterised in that** the air flow rate has a value ranging from 300 to 1000 l/min.

5. The method according to claim 2 or 3 or 4, **characterised in that** the degree of saturation of the cooling mixture with water mist is no higher than 5% in a volume ratio.

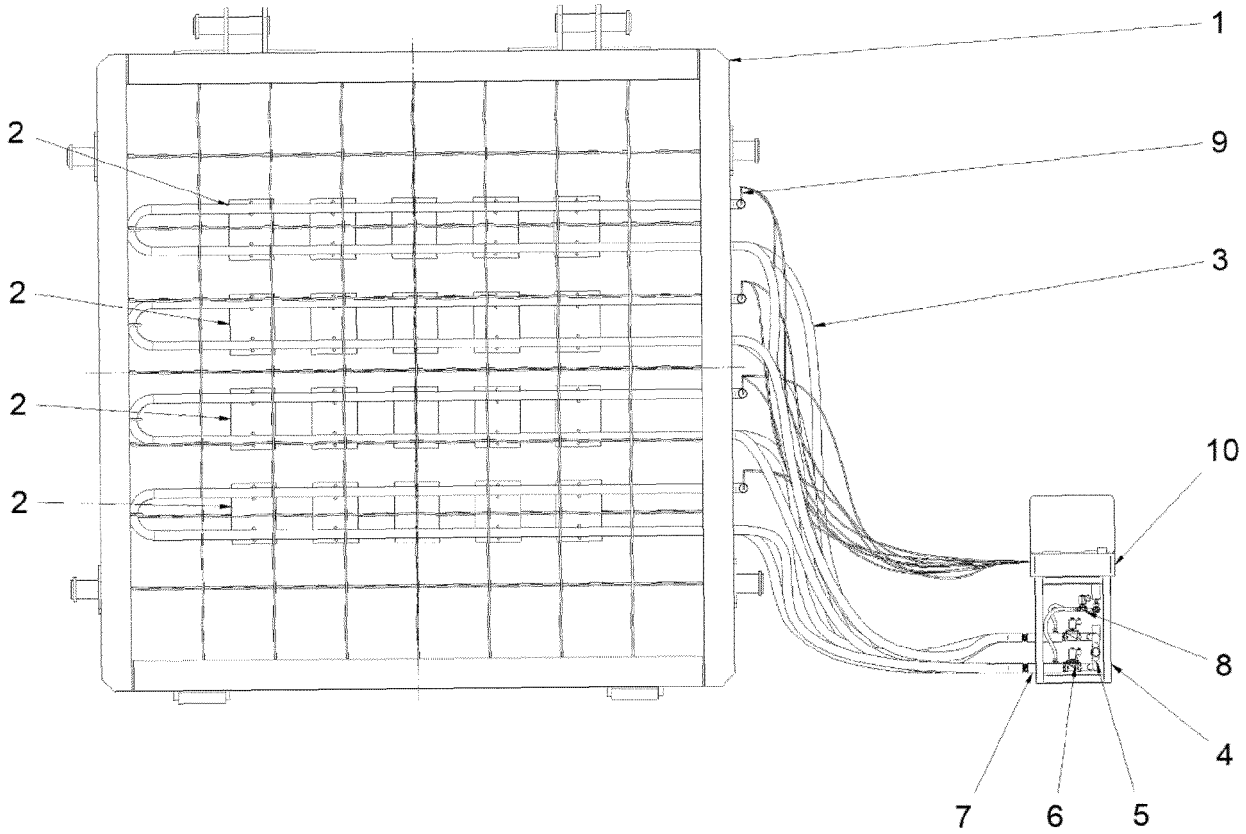

Fig. 1.

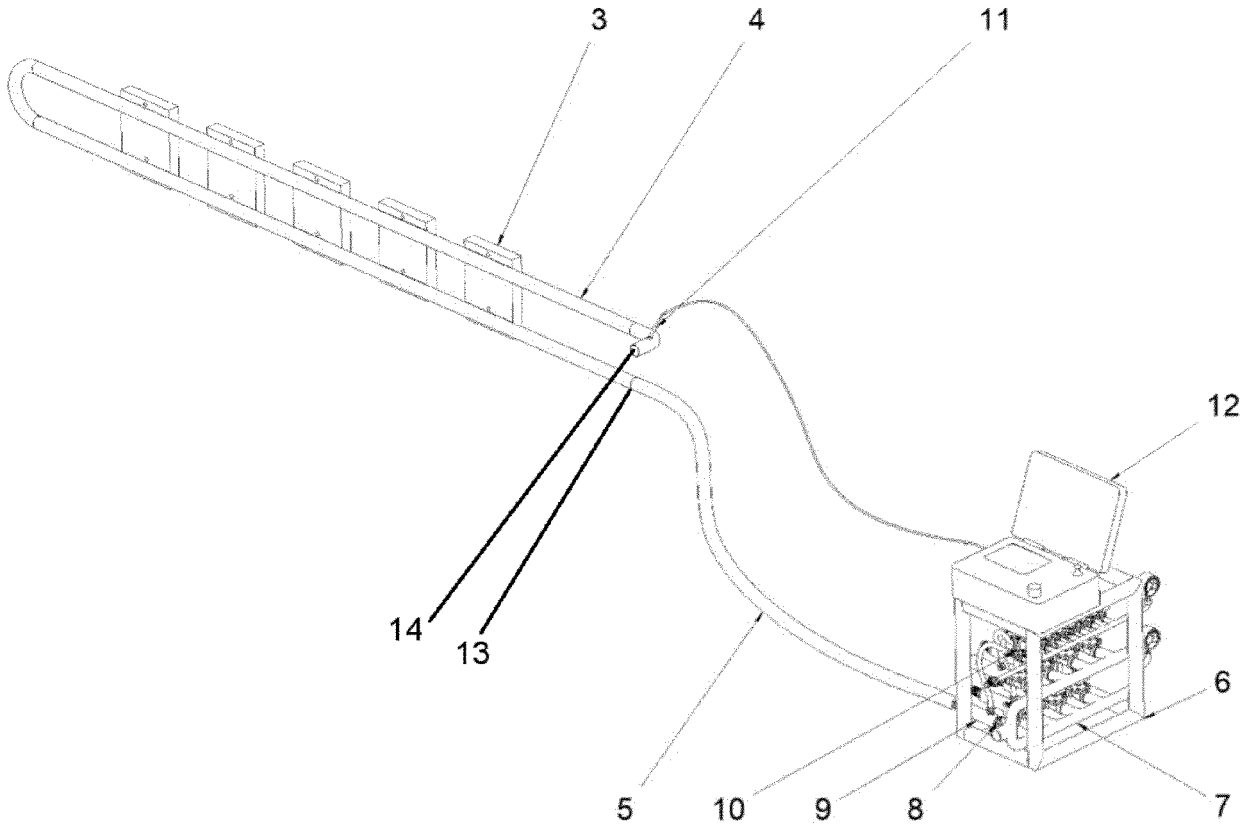

Fig. 2.

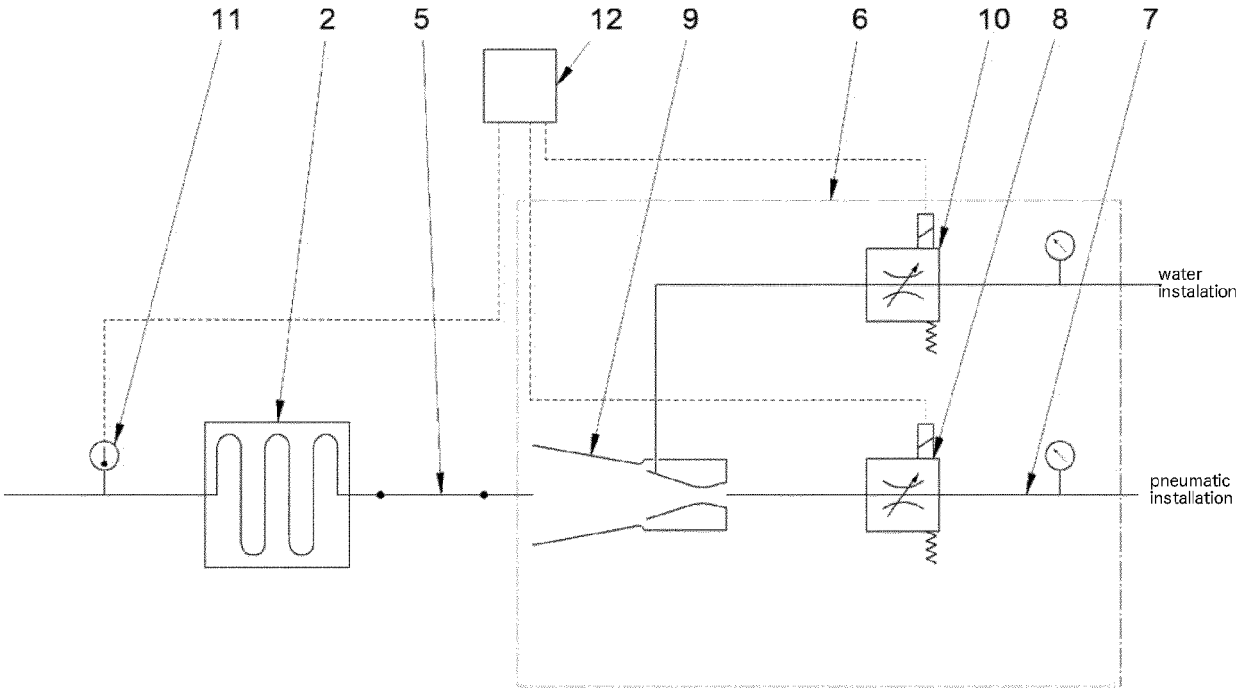

Fig. 3.

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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 5687

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	KR 2022 0071798 A (JINYANG MACHINERY CO LTD [KR]) 31 May 2022 (2022-05-31) * paragraphs [0002], [0006], [0008], [0023], [0040], [0041], [0056] - [0060], [0063], [0084], [0086], [0087], [0095], [0099], [0102] - [0109] * * figures 1-3 *	1-5	INV. B22C9/06 B22D27/04
A	KR 102 181 439 B1 (KOREA INST IND TECH [KR]) 23 November 2020 (2020-11-23) * paragraphs [0001], [0006] - [0009], [0030] - [0037] * * figures 1,4 *	1-5	
A	KR 2013 0087995 A (YU KI CHEOL [KR]) 7 August 2013 (2013-08-07) * paragraphs [0001], [0007] - [0045] * * figure 1 *	1-5	
			TECHNICAL FIELDS SEARCHED (IPC) B22C B22D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	4 August 2023	Grave, Christian

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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04-08-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 20220071798 A	31-05-2022	NONE	
KR 102181439 B1	23-11-2020	NONE	
KR 20130087995 A	07-08-2013	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82