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(71) Applicants:
- **Citic Dicastal Co., Ltd.**
  Quinhuangdao Heibei 066011 (CN)
- **Qinhuangdao Xinyue Intelligent Equipment Co., Ltd.**
  Qinhuangdao, Hebei 066011 (CN)

(72) Inventors:
- **XU, Zuo**
  Qinhuangdao 066011 (CN)
- **ZHU, Zhihua**
  Qinhuangdao 066011 (CN)
- **LI, Yiming**
  Qinhuangdao 066011 (CN)
- **CUI, Hongfeng**
  Qinhuangdao 066011 (CN)
- **YUAN, Tianxiao**
  Qinhuangdao 066011 (CN)
- **GUO, Shiwei**
  Qinhuangdao 066011 (CN)
- **WANG, Ji**
  Qinhuangdao 066011 (CN)
- **LIU, Shuangyong**
  Qinhuangdao 066011 (CN)
- **QIAO, Xia**
  Qinhuangdao 066011 (CN)
- **LI, Shide**
  Qinhuangdao 066011 (CN)
- **WANG, Weixin**
  Qinhuangdao 066011 (CN)
- **ZHANG, Donghui**
  Qinhuangdao 066011 (CN)
- **LI, Zhihua**
  Qinhuangdao 066011 (CN)
- **LI, Yuxing**
  Qinhuangdao 066011 (CN)

(74) Representative: **Gong, Jinping**
CocreateIP
Neumarkterstr. 21
81673 München (DE)

(54) DIE CASTING MACHINE WITH MOLD TEMPERATURE CONTROL

(57) The present disclosure relates to the technical field of die casting machine devices, in particular to a digital die casting machine with mold temperature control, including: a die casting machine configured to die-cast a casting through a mold, a cooling flow control apparatus configured to control a mold temperature by controlling a cooling medium flow, a temperature collection apparatus configured to collect the mold temperature , a control cabinet configured to acquire and store data collected by the temperature collection apparatus and control operation of the die casting machine, the cooling flow control apparatus and an automatic control apparatus, an edge computer configured to execute a die casting temperature optimization strategy according to the collected data stored in the control cabinet, and the automatic control apparatus. The present disclosure improves the molding quality of castings by adjusting the mold temperature in a casting process.

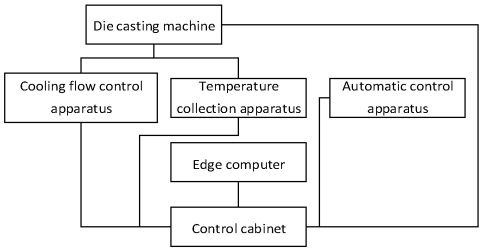

Fig. 1

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Description

Technical Field

[0001] The disclosure relates to the technical field of die casting machine devices, in particular to a digital die casting machine with mold temperature control.

Background

[0002] In the production of automotive parts, aluminum parts, as an important link in the lightweight and energy-saving technology of automotive chassises, have now surpassed iron parts and become key parts in mainstream automotive configurations. Compared to the iron parts, the aluminum parts have a lower casting temperature and are prone to generating defects in the casting process, and the aluminum parts have poor toughness and hardness and are prone to deformation. Therefore, the casting process requirements for the aluminum parts are more stringent, and the temperature control requirements for castings in the casting process are more urgent. Therefore, it is necessary to invent a die casting machine with an ability to adjust a mold temperature.

[0003] The Chinese patent, with a publication patent number: CN112453351B, discloses a method for adjusting process parameters of a die casting machine, a system and a storage medium, which can receive mold wheel type, aluminum liquid temperature, interruption time and defect information in real time, respond to the above information sequentially according to a set response priority, and select die casting process parameters to automatically adjust different process parameters of different products and different working conditions. A plurality of die casting machines can be controlled simultaneously, and manual adjustment is replaced.

[0004] In the related art, a strongly correlated factor affecting casting quality is a mold temperature, including a mold temperature value and mold temperature distribution, and changes in casting pressure, and opening and closing, and flow of a cooling channel can all be intuitively reflected in mold temperature changes. However, since the changes in the mold temperature in the casting process cannot be directly observed manually, the casting process can only be evaluated manually based on the internal quality of completed casting products, and the casting situation may also be judged by collecting the temperature of a mold cavity surface through a thermal camera. However, the heat exchange situation between the mold and the air is complex, collection time points are different, temperature data will change, the change situation of the mold temperature in the whole casting process cannot be completely restored only relying on the temperature situation of a mold cavity at one time point, and currently, the die casting machine devices have no ability to adjust the mold temperature in the casting process. In the above case that the mold temperature cannot be intuitively represented and cannot be independently adjusted in the casting process, the casting process can be manually adjusted only relying on experience subjectively, which is prone to causing a long adjustment time and an increase in waste materials.

[0005] It may be seen that there is a problem in the prior art that the mold temperature cannot be effectively adjusted independently in the casting process.

Summary

[0006] For this purpose, the present disclosure provides a digital die casting machine with mold temperature control to overcome the problem in the prior art that a mold temperature cannot be effectively adjusted independently in a casting process, and then the molding quality of castings cannot be effectively ensured.

[0007] In order to achieve the above purpose, the present disclosure provides a digital die casting machine with mold temperature control, including:

a die casting machine, configured to die-cast a casting through a mold;
a cooling flow control apparatus, connected with the die casting machine and configured to control a mold temperature by controlling a cooling medium flow;
a temperature collection apparatus, connected with the die casting machine and configured to collect the mold temperature using a preset collection strategy in a die-casting process;
an automatic control apparatus, connected with the die casting machine, and including a filter screen automatic placing unit configured to place a filter screen and a casting automatic transferring unit configured to transfer the casting;
a control cabinet, connected with the die casting machine, the cooling flow control apparatus, the temperature collection apparatus and the automatic control apparatus respectively, and configured to acquire and store data collected by the temperature collection apparatus and control operation of the die casting machine, the cooling flow control apparatus and the automatic control apparatus; and

an edge computer, connected with the control cabinet, and including a mold temperature control program and a cooling flow control program, wherein the mold temperature control program is used for executing a die casting temperature optimization strategy according to the collected data stored in the control cabinet; wherein
the preset collection strategy is to acquire a die casting key position of the casting and perform temperature acquisition on an inner wall and an outer wall of the mold corresponding to the die casting key position; and
the die casting temperature optimization strategy is to adjust a temperature of the die casting key position and/or an overall temperature of the mold according to the collected data, or adjust a temperature of the outer wall of the mold according to a temperature difference between the inner wall and the outer wall of the mold.

[0008] Further, the temperature collection apparatus is composed of a temperature collection unit, temperature collection connecting lines and a die casting material temperature sensor configured to collect a temperature of the inner wall of the mold and a temperature of a die casting material, a shell of the temperature collection unit is a cuboid, the shell includes a connection surface, a line outlet surface, a covering surface and three socket installation surfaces, the connection surface is connected with the die casting machine, the covering surface is a covering structure and used for optimizing an installation process of a shell of the temperature collection unit and a thermocouple female socket, a plurality of thermocouples are installed on the socket installation surfaces, and the temperature collection connecting lines are centrally exported from the line outlet surface and are connected to the control cabinet; wherein
the temperature collection unit is installed on a vertical column of the die casting machine and/or installed on a top plate according to a mold action mode, the thermocouples are respectively installed on the inner wall and the outer wall of the mold according to the die casting key position, and the die casting material temperature sensor is installed on the vertical column or the top plate.

[0009] Further, the die casting key position is determined by historical fault positions of the same casting, or by performing finite element analysis on application scenarios of the casting.

[0010] Further, the cooling flow control apparatus is composed of a cooling flow control cabinet and cooling pipelines, the cooling flow control cabinet includes an angle seat proportional valve configured to control the cooling medium flow in the cooling pipelines and a flow sensor configured to measure the cooling medium flow in real time, and the cooling pipelines are uniformly distributed on the outer wall of the mold and cover the die casting key position; wherein
the flow sensor measures a flow value of the cooling pipelines in real time and feeds back the flow value to the cooling flow control program in the edge computer for feedback calculation, and the control cabinet controls the angle seat proportional valve to adjust the cooling medium flow according to a feedback calculation result, so as to correct a control error.

[0011] Further, the die casting temperature optimization strategy includes establishing a standard temperature curve corresponding to a single thermocouple, and setting a control temperature and a control slope according to the standard temperature curve, wherein in a die casting process, the temperature collection unit collects a temperature of a thermocouple at a preset collection frequency, and the edge computer compares the control temperature and the control slope with a temperature and a slope at a current moment to adjust a working mode of the cooling flow control apparatus; wherein

an abscissa of the standard temperature curve is a die casting time, and an ordinate is a control temperature; and
the temperature at the current moment is a temperature corresponding to a collection moment closest to the current moment, and the slope at the current moment is an average value of collection slopes of a preset quantity of collection moments closest to the current moment.

[0012] Further, the edge computer compares the control temperature and the control slope with the temperature and the slope at the current moment;

in a case that a result is a preset comparison result, the control cabinet controls the cooling pipeline corresponding to the thermocouple to execute a switching action; wherein
the preset comparison result meets that the control slope is greater than 0, the slope at the current moment is greater than 0, the temperature at the current moment is greater than or equal to a set temperature at the current moment, and a minimum value in the temperatures corresponding to the preset quantity of collection moments is smaller than the control temperature; or the control slope is smaller than 0, the slope at the current moment is smaller than 0, the temperature at the current moment is smaller than or equal to the set temperature at the current moment, and a maximum value in the temperatures corresponding to the preset quantity of collection moments is greater than the control temperature; and
the switching action is that in a case of the cooling pipeline being in an open state, the cooling flow control cabinet closes the cooling pipeline, and in a case of the cooling pipeline being in a closed state, the cooling flow control cabinet opens the cooling pipeline.

[0013] Further, in a case that the edge computer determines that a comparison result of the control temperature and the control slope with the temperature and the slope at the current moment is another comparison result except the preset comparison result, the cooling flow control cabinet adjusts the cooling medium flow according to the control temperature and the temperature at the current moment in the standard temperature curve.

[0014] Further, after the die casting process is performed for a preset time, in a case that an average value of difference values between the temperature of the inner wall of the mold and the temperature of the outer wall of the mold is smaller than a preset difference value, and a temperature of a die casting material measured by a die casting material temperature sensor is smaller than a preset temperature, the casting automatic transferring unit transfers a molded casting out of the die casting machine.

[0015] Further, the thermocouple female socket is a K-type thermocouple female socket.

[0016] Further, a single temperature collection unit outputs the temperature of a single thermocouple, and meanwhile outputs a temperature average value and a temperature standard deviation of detected temperatures of all thermocouples installed in the temperature collection unit, so as to determine a detection ability and rationality of arrangement positions of the temperature collection unit.

[0017] Compared with the prior art, the present disclosure has the beneficial effects that, by reforming a traditional die casting machine device and additionally installing the temperature collection apparatus and the edge computer, high-quality temperature control in the casting process can be achieved, the stability of the casting product quality is improved, the self-adjusting ability in the casting process is achieved, and thus the molding quality of the casting is improved.

[0018] Further, the temperature collection apparatus of the present disclosure acquires the die casting key position of the casting and performs temperature collection on the inner wall and the outer wall of the mold corresponding to the die casting key position, the collected data and calculation amount are reduced, by determining the key position, the temperature control pertinence and testing efficiency are improved, and the molding quality of the casting is further improved.

[0019] Further, the die casting temperature optimization strategy of the present disclosure is to adjust the temperature of the die casting key position and/or the overall temperature of the mold according to the collected data, or adjust the temperature of the outer wall of the mold according to the temperature difference between the inner wall and the outer wall of the mold, so as to optimize both the local and overall temperatures of the mold, and the molding quality of the casting is further improved.

[0020] Further, the present disclosure improves the testing convenience and further improves the molding quality of the casting by designing the structure of the temperature collection unit.

[0021] Further, the edge computer of the present disclosure establishes the standard temperature curve corresponding to a single thermocouple, sets the control temperature and the control slope according to the standard temperature curve, and compares the control temperature and the control slope with the temperature and the slope at the current moment, so as to adjust a working mode of the cooling flow control apparatus, the temperature adjustment accuracy is improved, and the molding quality of the casting is further improved.

[0022] Further, the single temperature collection unit of the present disclosure outputs the temperature average value and the temperature standard deviation to determine the detection ability and rationality of arrangement positions of the temperature collection unit, monitoring and optimization of the temperature collection unit are achieved, and the molding quality of the casting are further improved.

Brief Description of Figures

[0023]

Fig. 1 is a structural block diagram of a digital die casting machine with mold temperature control of the present disclosure.

Fig. 2 is a schematic diagram of a die casting machine in an embodiment of the present disclosure.

Fig. 3 is a schematic diagram of a temperature collection apparatus in an embodiment of the present disclosure.

Fig. 4 is a schematic diagram of a temperature collection unit in an embodiment of the present disclosure.

Fig. 5 is a schematic diagram of a shape of a thermocouple hole in an embodiment of the present disclosure.

Fig. 6 is a schematic diagram of a filter screen automatic placing unit in an embodiment of the present disclosure.

Fig. 7 is a schematic diagram of a thermocouple hole and a cooling position in an embodiment of the present disclosure.

Fig. 8 is a temperature and flow curve diagram of a B1 cooling channel corresponding to an r5 thermocouple in an embodiment of the present disclosure.

Fig. 9 is a temperature and flow curve diagram of a T4 cooling channel corresponding to an r4 thermocouple in an embodiment of the present disclosure.

[0024] In the figure: 1, first temperature collection unit; 2, second temperature collection unit; 3, casting automatic transferring unit; 4, control cabinet; 5, temperature collection connecting line; 6, thermocouple socket; 7, socket installation surface; 8, line outlet surface; 9, covering surface; 10, connection surface; 11, r1 thermocouple; 12, r2 thermocouple; 13, r3 thermocouple; 14, T4 water-cooled channel; 15, r4 thermocouple; 16, B3 air-cooled channel; 17, r6 thermocouple; 18, B4 air-cooled channel; 19, B1 air-cooled channel; 20, r5 thermocouple; and 21, B2 air-cooled channel.

Detailed Description

[0025] In order to make the purpose and advantages of the present disclosure clearer, the present disclosure is further described in conjunction with embodiments below. It should be understood that the specific embodiments described herein are only used to explain the present disclosure and are not used to limit the present disclosure.

[0026] Preferred implementations of the present disclosure are described below with reference to accompanying drawings. It should be understood by those skilled in the art that these implementations are only used to explain the technical principles of the present disclosure and do not limit the protection scope of the present disclosure.

[0027] It needs to be noted that in the description of the present disclosure, directional or positional relationships indicated by terms such as "upper", "lower", "left", "right", "inner" and "outer" are based on directional or positional relationships as shown in the accompanying drawings, and are only for the purposes of facilitating description, rather than indicating or implying that the apparatus or element has to have a specific direction or be constructed and operated in the specific direction, and therefore, they cannot be regarded as limitations on the present disclosure.

[0028] In addition, it further needs to be noted that, in the description of the present disclosure, the terms "installed", "connected" and "connection" should be understood in a broad sense unless otherwise specified and defined, for example, "connection" may be a fixed connection or a detachable connection or an integrated connection, may be a mechanical connection or an electric connection, may be a direct connection or an indirect connection through an intermediate medium, and may be an internal connection of two elements. For those skilled in the art, the specific meanings of the above terms in the present disclosure may be understood according to specific situations.

[0029] Please refer to Fig. 1, which is a structural block diagram of a digital die casting machine with mold temperature control of the present disclosure, and the digital die casting machine with mold temperature control includes:

a die casting machine, configured to die-cast a casting through a mold;

a cooling flow control apparatus, connected with the die casting machine and configured to control a mold temperature by controlling a cooling medium flow;

a temperature collection apparatus, connected with the die casting machine and configured to collect the mold temperature using a preset collection strategy in a die-casting process;

an automatic control apparatus, connected with the die casting machine, and including a filter screen automatic placing unit configured to place a filter screen and a casting automatic transferring unit configured to transfer the casting; wherein

please refer to Fig. 6 in conjunction with Fig. 2, Fig. 2 is a schematic diagram of a die casting machine in an embodiment of the present disclosure, and Fig. 6 is a schematic diagram of a filter screen automatic placing unit in an embodiment of the present disclosure; it should be understood that the automatic control apparatus is a riser filter screen automatic placing device and a casting automatic transferring unit 3 in Fig. 2, which has an automatic execution ability, ensuring that the overall casting rhythm is not affected by human factors, and reducing the impact of temperature control due to changes in the casting rhythm;

a control cabinet, connected with the die casting machine, the cooling flow control apparatus, the temperature collection apparatus and the automatic control apparatus respectively, and configured to acquire and store data collected by the temperature collection apparatus and control operation of the die casting machine, the cooling flow control apparatus and the automatic control apparatus; and

an edge computer, connected with the control cabinet, and including a mold temperature control program and a cooling flow control program, wherein the mold temperature control program is used for executing a die casting temperature optimization strategy according to the collected data stored in the control cabinet.

[0030] It should be understood that the function of the edge computer is to run a casting intelligent control program, including a mold temperature control program and a cooling flow control program, the mold temperature control program includes a die casting temperature optimization strategy, the edge computer is in data communication with the control cabinet, the edge computer is further configured to perform quality determination and smoothing processing on the acquired cooling flow data and mold temperature data, and if there is any abnormal data, an alarm apparatus is triggered.

[0031] The preset collection strategy is to acquire a die casting key position of the casting and perform temperature acquisition on an inner wall and an outer wall of the mold corresponding to the die casting key position; and

the die casting temperature optimization strategy is to adjust a temperature of the die casting key position and/or an overall

temperature of the mold according to the collected data, or adjust a temperature of the outer wall of the mold according to a temperature difference between the inner wall and the outer wall of the mold.

[0032] A specific mode of adjusting the overall temperature of the mold according to the collected data is as follows.

[0033] Firstly, a temperature average value Tp of the inner and outer walls of a position corresponding to a single thermocouple is calculated, then an absolute value Txn of a difference value between a temperature average value Tpn of the inner and outer walls of any position and a temperature Ty of a die casting material measured by a die casting material temperature sensor is calculated, the edge computer generates a mold temperature distribution diagram in conjunction with the temperature of the inner wall of the mold measured by the die casting material temperature sensor, the mold temperature distribution diagram shows Txn at the die casting key position, and shows an absolute value Txm of a difference value between the temperature of the inner wall and the temperature Ty of the die casting material measured by the die casting material temperature sensor at other positions, and a linear change trend is analyzed. When it is impossible to analyze the linear change trend, a linear change amplitude is greater than a preset amplitude, or the linear trend of the die casting key position is contradictory with that of adjacent positions, the overall flow of cooling media of all cooling pipelines is adjusted to optimize the overall temperature of the mold or adjust die casting process parameters, so as to make strength of the casting uniform, thereby improving the molding quality of the casting.

[0034] Adjusting the temperature of the outer wall of the mold according to the temperature difference between the inner wall and the outer wall of the mold is to adjust the cooling medium flow of the outer wall of the mold according to a preset adjustment amount when the temperature difference between the inner wall and the outer wall of the mold is higher than a preset difference value, and the preset adjustment amount is set according to the temperature difference and an average temperature of the inner and outer walls.

[0035] Please refer to Fig. 3 and Fig. 4, Fig. 3 and Fig. 4 are schematic diagrams of a temperature collection apparatus in an embodiment of the present disclosure and a temperature collection unit in an embodiment of the present disclosure respectively.

[0036] The temperature collection apparatus is composed of the temperature collection unit, temperature collection connecting lines and a die casting material temperature sensor configured to collect a temperature of a die casting material, a shell of the temperature collection unit is a cuboid, the shell includes a connection surface 10, a line outlet surface 8, a covering surface 9 and a socket installation surface 7, as well as other two socket installation surfaces, the connection surface 10 is connected with the die casting machine, the covering surface 9 is a covering structure and used for optimizing an installation process of the shell of the temperature collection unit and a thermocouple female socket, a thermocouple socket 6 and a plurality of thermocouple sockets are installed on the socket installation surfaces, and the temperature collection connecting lines 5 are centrally exported from the line outlet surface and are connected to the control cabinet 4; wherein

the temperature collection unit is installed on a vertical column of the die casting machine and/or installed on a top plate according to a mold action mode, the thermocouples are respectively installed on the inner wall and the outer wall of the mold according to the die casting key position, and the die casting material temperature sensor is installed on the vertical column or the top plate.

[0037] Optionally, the die casting material temperature sensor is an infrared thermometer that can measure the temperature of the inner wall of the mold during die assembly, or the die casting material temperature sensor includes the infrared thermometer for measuring the temperature of the inner wall of the mold and a thermocouple for measuring the temperature of the die casting material, the thermocouple is sleeved with a protective pipe and is placed in an insulation furnace at the bottom of the die casting machine.

[0038] The covering structure is a structure that can be flipped over by any axis or separated to form a hole.

[0039] Example 1: on a certain aluminum wheel low-pressure die casting machine, the composition and configuration of the die casting machine are shown in Fig. 2, which is a schematic diagram of the die casting machine in the embodiment of the present disclosure. Optionally, the control cabinet is controlled through Siemens PLC (S7-1500), and the temperature collection apparatus includes five temperature collection units, which are located on side surfaces of four vertical columns and an upper side of a top plate respectively. In the figure, a first temperature collection unit 1 is the temperature collection unit installed on the top plate, and second temperature collection units 2 are the temperature collection units installed on the vertical columns. Optionally, the temperature data of the temperature collection units is transmitted into the PLC through an analog input module. Optionally, the edge computer adopts an NEXCOM embedded industrial personal computer, which is connected to the PLC through industrial Ethernet, and reads and issues the data through an S7 protocol. A communication frequency between the edge computer and the PLC is 20 Hz, through the die casting temperature optimization strategy, it may be ensured that a flow actual value quickly responds to a set value, opening and closing of the cooling pipeline can be controlled through a temperature value, at the same time, the connection state and shaking state of the thermocouple and whether a temperature limit value is exceeded may further be monitored in real time, and if there is any abnormality, an alarm indicator will be triggered for alarm.

[0040] Specifically, the die casting key position is determined by historical fault positions of the same casting, or by performing finite element analysis on application scenarios of the casting.

[0041] Specifically, the cooling flow control apparatus is composed of a cooling flow control cabinet and cooling pipelines, the cooling flow control cabinet includes an angle seat proportional valve configured to control the cooling medium flow in the cooling pipelines and a flow sensor configured to measure the cooling medium flow in real time, and the cooling pipelines are uniformly distributed on the outer wall of the mold and cover the die casting key position; wherein the flow sensor measures a flow value of the cooling pipelines in real time and feeds back the flow value to the cooling flow control program in the edge computer for feedback calculation, and the control cabinet controls the angle seat proportional valve to adjust the cooling medium flow according to a feedback calculation result, so as to correct a control error.

[0042] Optionally, the die casting machine device has 17 cooling control units, one angle seat proportional valve and the flow collection apparatus serve as a control unit to control the magnitude of one path of cooling flow, and the thermocouple is installed at the die casting key position.

[0043] Optionally, one thermocouple corresponds to the cooling pipelines in a plurality of regions.

[0044] Optionally, the cooling medium includes an air-cooled medium and a water-cooled medium, and the water-cooled medium achieves cooling by designing a channel near the mold and then passing water; and the air-cooled medium performs cooling on an outer wall key position of the mold through an air pipe.

[0045] Optionally, the cooling flow control apparatus is composed of an air flow control cabinet and a water flow control cabinet and their corresponding cooling pipelines, a measurement accuracy of an air flow sensor is 0.01 cubic meter per hour, a measurement accuracy of a water flow sensor is 0.01 liter per minute, the flow control cabinet controls a respond time of the water flow from an initial value to a set value to be about 1.3 seconds, and a respond time of the air flow from an initial value to a set value to be about 0.5 second.

[0046] Specifically, the die casting temperature optimization strategy includes establishing a standard temperature curve corresponding to a single thermocouple, and setting a control temperature and a control slope according to the standard temperature curve, wherein in a die casting process, the temperature collection unit collects a temperature of a thermocouple at a preset collection frequency, and the edge computer compares the control temperature and the control slope with a temperature and a slope at a current moment to adjust a working mode of the cooling flow control apparatus; wherein

an abscissa of the standard temperature curve is a die casting time, and an ordinate is a control temperature; and the temperature at the current moment is a temperature corresponding to a collection moment closest to the current moment, and the slope at the current moment is an average value of collection slopes of a preset quantity of collection moments closest to the current moment.

[0047] Specifically, the edge computer compares the control temperature and the control slope with the temperature and the slope at the current moment;

in a case that a result is a preset comparison result, the control cabinet controls the cooling pipeline corresponding to the thermocouple to execute a switching action; wherein

the preset comparison result meets that the control slope is greater than 0, the slope at the current moment is greater than 0, the temperature at the current moment is greater than or equal to a set temperature at the current moment, and a minimum value in the temperatures corresponding to the preset quantity of collection moments is smaller than the control temperature; or the control slope is smaller than 0, the slope at the current moment is smaller than 0, the temperature at the current moment is smaller than or equal to the set temperature at the current moment, and a maximum value in the temperatures corresponding to the preset quantity of collection moments is greater than the control temperature; and

the switching action is that in a case of the cooling pipeline being in an open state, the cooling flow control cabinet closes the cooling pipeline, and in a case of the cooling pipeline being in a closed state, the cooling flow control cabinet opens the cooling pipeline.

[0048] It should be understood that the opening and closing of the cooling pipelines are uniformly considered as the actions of the pipelines, the conditions that trigger the actions of the cooling pipelines are the above two comparison results, namely, temperature rising and falling situations, that is, the opening and closing of the cooling pipelines both face the temperature rising and falling situations. If the triggering conditions for the opening and closing of the cooling pipelines are completely the same as preset conditions, the cooling pipelines will be closed immediately after opening. In addition, the present disclosure further additionally sets a timing logic, that is, the cooling pipelines can only trigger the cooling closing function after triggering the opening function, and all cooling is uniformly closed at the beginning of a new casting beat.

[0049] During engineering practice, there is a situation where cooling is opened during a decrease in temperature, and then temperature actually rises, and there is also a situation where cooling is closed during an increase in temperature, with natural cooling, the mold temperature will automatically decrease after cooling is closed.

[0050] Example 2: in a certain casting process, the die casting temperature optimization strategy contains the following steps:

step 1, a control temperature and a control slope are set: all thermocouples correspond to to-be-controlled cooling channels, a set temperature value Ts corresponding to actions of the cooling channels is set, a first control slope Ks1 is set to be equal to 1, and a second control slope Ks2 is set to be equal to -1.

[0051] It should be understood that the control temperature and the control slope change with a die casting time.

[0052] Step 2, the slope is calculated in real time, after die assembly begins, the temperature of the thermocouple corresponding to a certain cooling pipeline is collected at the same collection frequency (T), in the latest 5 temperature values (t_{n-4}, t_{n-3}, t_{n-2}, t_{n-1} and t_n) collected in real time, the temperature at the current moment is tn, and a slope kn at the current moment is calculated through a formula (1) to a formula (5):

$$k_1 = (t_n - t_{n-1})/T \quad (1)$$

$$k_2 = (t_n - t_{n-2})/2T \quad (2)$$

$$k_3 = (t_n - t_{n-3})/3T \quad (3)$$

$$k_4 = (t_n - t_{n-4})/4T \quad (4)$$

$$k_n = (k_1 + k_2 + k_3 + k_4)/4 \quad (5)$$

[0053] Where, k1 is the slope corresponding to t_{n-1}, k2 is the slope corresponding to t_{n-2}, k3 is the slope corresponding to t_{n-3}, and k4 is the slope corresponding to t_{n-4}.

[0054] Step 3, the opening and closing actions of the cooling pipeline are judged.

[0055] When the control slope corresponding to the current moment is a second control slope, if $k_n < 0$, $t_n \le T_s$, and a maximum value in the 5 temperature values $t_{max} > T_s$, the cooling pipeline is triggered to execute a switching action;

[0056] When the control slope corresponding to the current moment is a first control slope, if $k_n > 0$, $t_n \ge T_s$, and a minimum value in the 5 temperature values $t_{min} < T_s$, the cooling pipeline is triggered to execute the switching action;

it should be understood that in the same casting beat, the triggering condition for the opening action of the cooling pipeline is judged firstly, and after the cooling pipeline is opened, the triggering condition for the closing action of the cooling pipeline is judged; and

after a next casting beat begins, if the cooling pipeline is still in the opening state, the cooling pipeline is closed, and then step 2 and step 3 are performed again.

[0057] Specifically, in a case that the edge computer determines that a comparison result of the control temperature and the control slope with the temperature and the slope at the current moment is another comparison result except the preset comparison result, the cooling flow control cabinet adjusts the cooling medium flow according to the control temperature and the temperature at the current moment in the standard temperature curve.

[0058] It should be understood that the cooling medium flow is adjusted, or the opening and closing of the cooling pipeline are controlled by the angle seat proportional valve, and the temperature of the cooling medium at an input end of the cooling pipeline can be adjusted according to temperature control demands.

[0059] Specifically, after the die casting process is performed for a preset time, in a case that an average value of difference values between the temperature of the inner wall of the mold and the temperature of the outer wall of the mold is smaller than a preset difference value, and a temperature measured by a die casting material temperature sensor is smaller than a preset temperature, the casting automatic transferring unit transfers a molded casting out of the die casting machine.

[0060] Specifically, the thermocouple female socket is a K-type thermocouple female socket.

[0061] Specifically, a single temperature collection unit outputs the temperature of a single thermocouple, and mean-

while outputs a temperature average value and a temperature standard deviation of detected temperatures of all thermocouples installed in the temperature collection unit, so as to determine a detection ability and rationality of arrangement positions of the temperature collection unit.

[0062] Optionally, a total of 6 thermocouples are installed on the socket installation surfaces of a single temperature collection unit and are uniformly distributed in the same region of the outer wall of the edge mold of the mold, when the measured data is output to the control cabinet, the control cabinet determines it according to the temperature average value firstly, if the average value is higher than a maximum die casting temperature, an alarm will be given, at the same time, a standard deviation of a plurality of temperatures measured by the 6 thermocouples is calculated, when the standard deviation of the temperatures is higher than a preset value, it indicates that there is an issue with the installation state of the thermocouples installed in the temperature collection unit on the mold, or that a single thermocouple and/or connecting line is faulty.

[0063] Embodiment 1: please refer to Fig. 5 and Fig. 7, Fig. 5 and Fig. 7 are schematic diagrams of a shape of a thermocouple hole in an embodiment of the present disclosure and a thermocouple hole and a cooling position in an embodiment of the present disclosure respectively. This embodiment performs temperature control on an aluminum wheel mold, which has 6 thermocouple holes provided with 6 thermocouples respectively, wherein an r1 thermocouple 11 and an r2 thermocouple 12 are located on an edge mold, an r3 thermocouple 13 and an r4 thermocouple 15 are located on a top mold, and an r5 thermocouple 20 and an r6 thermocouple 17 are located on a bottom mold. There is a T4 water-cooled channel 14 between the r3 thermocouple 13 and the r4 thermocouple 15, a B1 air-cooled channel 19 and a B2 air-cooled channel 21 are located on two sides of the r5 thermocouple 20 respectively, and a B3 air-cooled channel 16 and a B4 air-cooled channel 18 are located on two sides of the r6 thermocouple 17 respectively.

[0064] In this embodiment, a K-type grounding temperature resistant thermocouple of a TC40K3003-FE-HTC-G model of WIKA brand is used, with a length of 800 mm and a diameter of 3 mm, the opening and closing of the T4 cooling channel are controlled by the thermocouple at a position r3, the opening and closing of the B1 and B2 cooling channels are controlled by the thermocouple at a position r5, and the opening and closing of the B3 and B4 cooling channels are controlled by the thermocouple at a position r6.

[0065] When the temperature value and slope of cooling opening and closing are set in step 1, a situation that the T4 cooling channel is controlled by the temperature of the thermocouple at a position r4 is taken as an example, a flow is as follows:

firstly, the production of a traditional time process is performed, the opening and closing of T4 are controlled through time, and mold temperatures of 100 castings which are normally produced in the same process and have no defect are collected at a collection frequency of 1 Hz as sample values;

when a standard temperature curve of the r4 thermocouple is calculated, the sample values at each moment are accumulated and divided by the number of samples, an average value is a standard temperature value, and then the standard temperature curve L4 is obtained;

the corresponding set temperature and set slope in L4 are found through the opening time and closing time in the T4 time process, the opening time of T4 in this embodiment is 20 s after die assembly, so during temperature control, a 20^{th} piece of temperature data in L4 is a set opening temperature T_{s_open} of the T4 cooling channel, if the temperature at this moment is in a rising stage, then $K_{T4s\_open}=1$, otherwise $K_{T4s\_open}=-1$, and a setting principle of a set closing temperature of the T4 cooling channel is the same;

after measurement, temperature control set parameters of T4 are:

$$T_{T4s\_open}=510 \quad K_{T4s\_open}=1 \qquad T_{T4s\_close}=516 \quad K_{T4s\_close}=-1;$$

and

temperature control set parameters of B1 are:

$$T_{B1s\_open}=502 \quad K_{B1s\_open}=1 \qquad T_{B1s\_close}=423 \quad K_{B1s\_close}=-1.$$

[0066] In a temperature control process, the die casting temperature optimization strategy is normally operated according to designs, when the preset comparison result is reached, the opening and closing of the cooling channel will be triggered, so that the magnitude of the cooling medium flow is affected, and is correspondingly adjusted in other cases.

[0067] Please refer to Fig. 8 and Fig. 9, Fig. 8 and Fig. 9 are temperature and flow curve diagrams of a B1 cooling channel

corresponding to an r5 thermocouple in an embodiment of the present disclosure and a T4 cooling channel corresponding to an r4 thermocouple respectively. In the diagrams, B 1L(t) is a temperature curve of the B1 cooling channel, B1T(t) is a cooling medium flow curve of the B1 cooling channel, T4L(t) is a temperature curve of the T4 cooling channel, T4T(t) is a cooling medium flow curve of the T4 cooling channel, left ordinates in the diagrams all represent temperature, and right ordinates in the diagrams all represent medium flow. It should be understood that the flow control curve basically coincides with an actual curve, it may be seen that this set of die casting machine device can meet set temperature control demands, and have good temperature control performance, and compared to the traditional time process, casting products of the temperature process have significant advantages in casting quality and casting stability.

[0068] So far, the technical solutions of the present disclosure have been described in conjunction with the preferred implementations shown in the accompanying drawings. However, it is easy for those skilled in the art to understand that the protection scope of the present disclosure is clearly not limited to these specific implementations. Without deviating from the principles of the present disclosure, those skilled in the art can make equivalent modifications or replacements to the relevant technical features, and the technical solutions after these modifications or replacements will fall within the protection scope of the present disclosure.

[0069] The above is only preferred embodiments of the present disclosure and is not intended to limit the present disclosure. For those skilled in the art, the present disclosure may have various modifications and variations. Any modification, equivalent replacement, improvement, etc. made within the spirit and principle of the present disclosure should be included in the protection scope of the present disclosure.

Claims

1. A digital die casting machine with mold temperature control, **characterized in that** it comprises:

a die casting machine, configured to die-cast a casting through a mold;
a cooling flow control apparatus, connected with the die casting machine and configured to control a mold temperature by controlling a cooling medium flow;
a temperature collection apparatus, connected with the die casting machine and configured to collect the mold temperature using a preset collection strategy in a die-casting process;
an automatic control apparatus, connected with the die casting machine, and comprising a filter screen automatic placing unit configured to place a filter screen and a casting automatic transferring unit configured to transfer the casting;
a control cabinet, connected with the die casting machine, the cooling flow control apparatus, the temperature collection apparatus and the automatic control apparatus respectively, and configured to acquire and store data collected by the temperature collection apparatus and control operation of the die casting machine, the cooling flow control apparatus and the automatic control apparatus; and
an edge computer, connected with the control cabinet, and comprising a mold temperature control program and a cooling flow control program, wherein the mold temperature control program is used for executing a die casting temperature optimization strategy according to the collected data stored in the control cabinet; wherein
the preset collection strategy is to acquire a die casting key position of the casting and perform temperature acquisition on an inner wall and an outer wall of the mold corresponding to the die casting key position respectively; and
the die casting temperature optimization strategy is to adjust a temperature of the die casting key position and/or an overall temperature of the mold according to the collected data, or adjust a temperature of the outer wall of the mold according to a temperature difference between the inner wall and the outer wall of the mold.

2. The digital die casting machine with mold temperature control according to claim 1, wherein the temperature collection apparatus is composed of a temperature collection unit, temperature collection connecting lines and a die casting material temperature sensor configured to collect a temperature of the inner wall of the mold and a temperature of a die casting material, a shell of the temperature collection unit is a cuboid, the shell comprises a connection surface, a line outlet surface, a covering surface and three socket installation surfaces, the connection surface is connected with the die casting machine, the covering surface is a covering structure and used for optimizing an installation process of a shell of the temperature collection unit and a thermocouple female socket, a plurality of thermocouples are installed on the socket installation surfaces, and the temperature collection connecting lines are centrally exported from the line outlet surface and are connected to the control cabinet; wherein
the temperature collection unit is installed on a vertical column of the die casting machine and/or installed on a top plate according to a mold action mode, the thermocouples are respectively installed on the inner wall and the outer wall of the mold according to the die casting key position, and the die casting material temperature sensor is installed on the

vertical column or the top plate.

3. The digital die casting machine with mold temperature control according to claim 2, wherein the die casting key position is determined by historical fault positions of the same casting, or by performing finite element analysis on application scenarios of the casting.

4. The digital die casting machine with mold temperature control according to claim 1, wherein the cooling flow control apparatus is composed of a cooling flow control cabinet and cooling pipelines, the cooling flow control cabinet comprises an angle seat proportional valve configured to control the cooling medium flow in the cooling pipelines and a flow sensor configured to measure the cooling medium flow in real time, and the cooling pipelines are uniformly distributed on the outer wall of the mold and cover the die casting key position; wherein
the flow sensor measures a flow value of the cooling pipelines in real time and feeds back the flow value to the cooling flow control program in the edge computer for feedback calculation, and the control cabinet controls the angle seat proportional valve to adjust the cooling medium flow according to a feedback calculation result, so as to correct a control error.

5. The digital die casting machine with mold temperature control according to claim 1, wherein the die casting temperature optimization strategy comprises establishing a standard temperature curve corresponding to a single thermocouple, and setting a control temperature and a control slope according to the standard temperature curve, wherein in a die casting process, the temperature collection unit collects a temperature of a thermocouple at a preset collection frequency, and the edge computer compares the control temperature and the control slope with a temperature and a slope at a current moment to adjust a working mode of the cooling flow control apparatus; wherein

an abscissa of the standard temperature curve is a die casting time, and an ordinate is a control temperature; and the temperature at the current moment is a temperature corresponding to a collection moment closest to the current moment, and the slope at the current moment is an average value of collection slopes of a preset quantity of collection moments closest to the current moment.

6. The digital die casting machine with mold temperature control according to claim 5, wherein the edge computer compares the control temperature and the control slope with the temperature and the slope at the current moment;

in a case that a result is a preset comparison result, the control cabinet controls the cooling pipeline corresponding to the thermocouple to execute a switching action; wherein
the preset comparison result meets that the control slope is greater than 0, the slope at the current moment is greater than 0, the temperature at the current moment is greater than or equal to a set temperature at the current moment, and a minimum value in the temperatures corresponding to the preset quantity of collection moments is smaller than the control temperature; or the control slope is smaller than 0, the slope at the current moment is smaller than 0, the temperature at the current moment is smaller than or equal to the set temperature at the current moment, and a maximum value in the temperatures corresponding to the preset quantity of collection moments is greater than the control temperature; and
the switching action is that in a case of the cooling pipeline being in an open state, the cooling flow control cabinet closes the cooling pipeline, and in a case of the cooling pipeline being in a closed state, the cooling flow control cabinet opens the cooling pipeline.

7. The digital die casting machine with mold temperature control according to claim 6, wherein in a case that the edge computer determines that a comparison result of the control temperature and the control slope with the temperature and the slope at the current moment is another comparison result except the preset comparison result, the cooling flow control cabinet adjusts the cooling medium flow according to the control temperature and the temperature at the current moment in the standard temperature curve.

8. The digital die casting machine with mold temperature control according to claim 7, wherein after the die casting process is performed for a preset time, in a case that an average value of difference values between the temperature of the inner wall of the mold and the temperature of the outer wall of the mold is smaller than a preset difference value, and a temperature of a die casting material measured by a die casting material temperature sensor is smaller than a preset temperature, the casting automatic transferring unit transfers a molded casting out of the die casting machine.

9. The digital die casting machine with mold temperature control according to claim 2, wherein the thermocouple female socket is a K-type thermocouple female socket.

10. The digital die casting machine with mold temperature control according to claim 1, wherein a single temperature collection unit outputs the temperature of a single thermocouple, and meanwhile outputs a temperature average value and a temperature standard deviation of detected temperatures of all thermocouples installed in the temperature collection unit, so as to determine a detection ability and rationality of arrangement positions of the temperature collection unit.

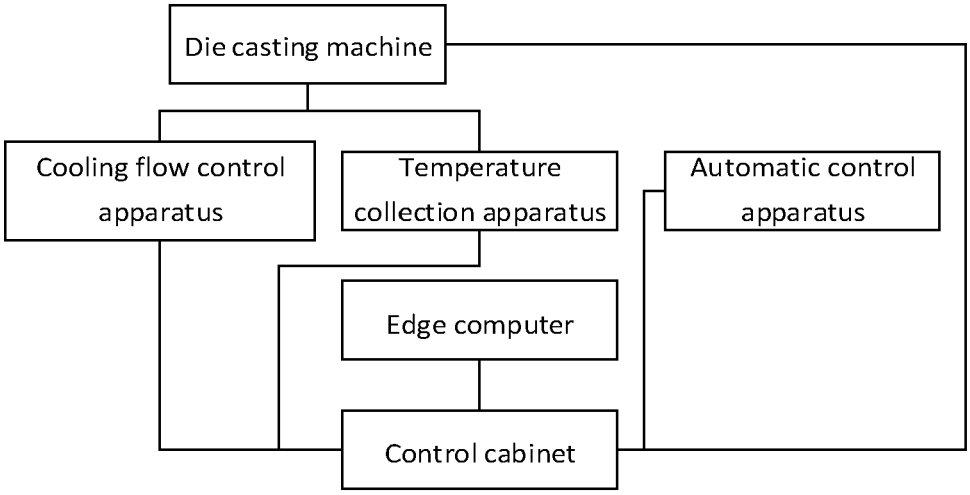
Die casting machine
Cooling flow control apparatus
Temperature collection apparatus
Automatic control apparatus
Edge computer
Control cabinet

Fig. 1

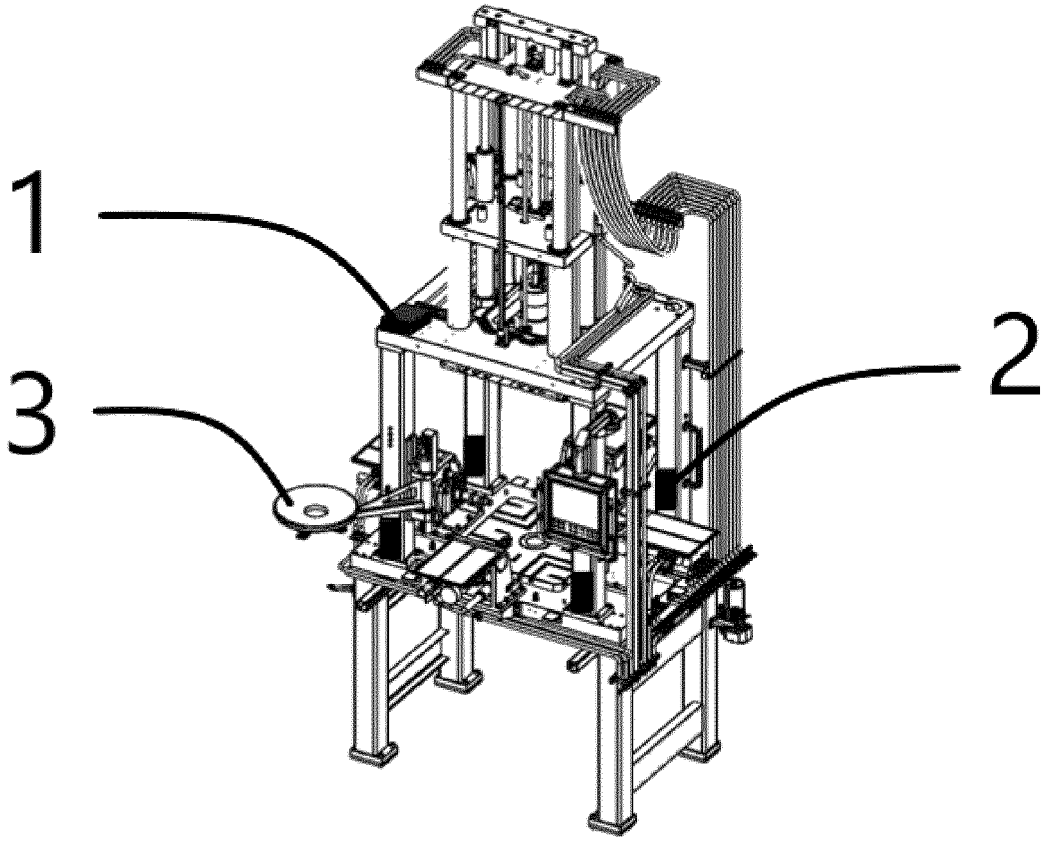
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Fig. 2

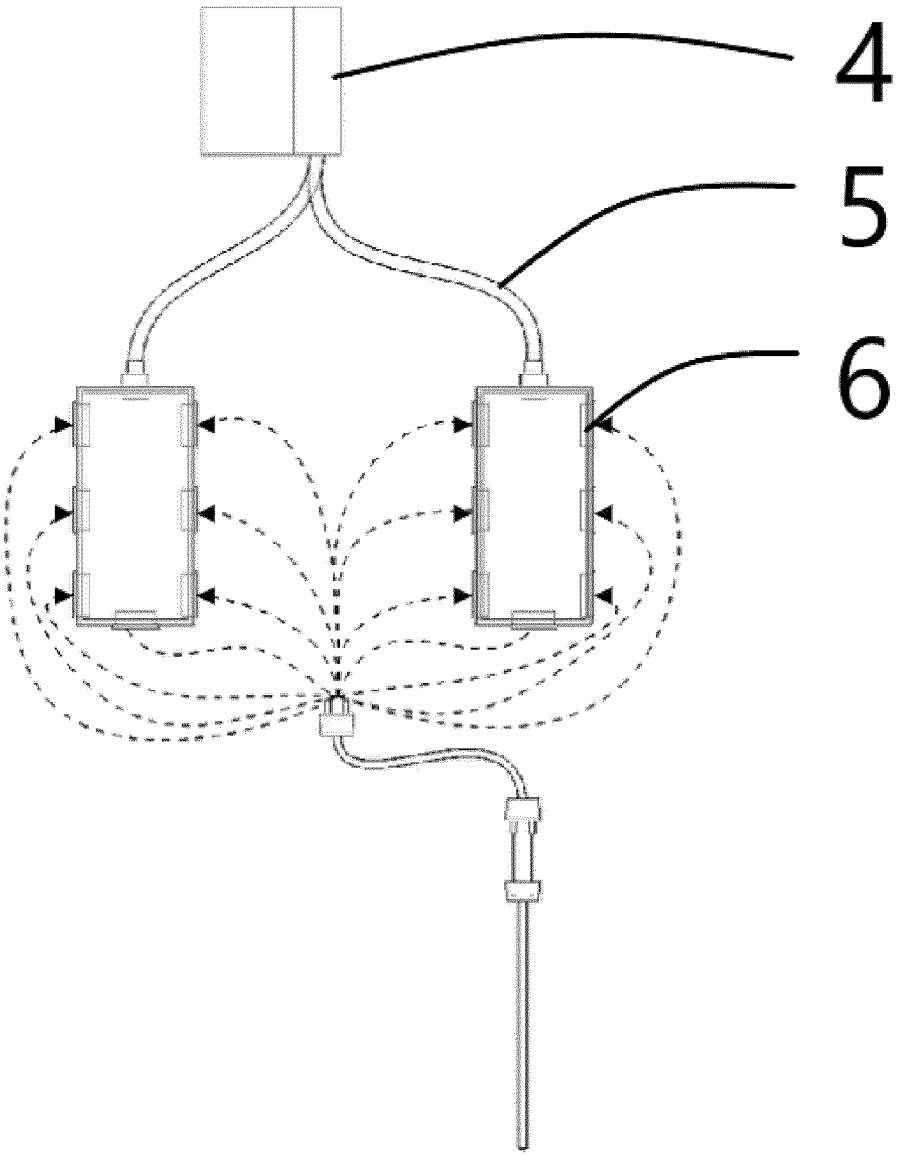

Fig. 3

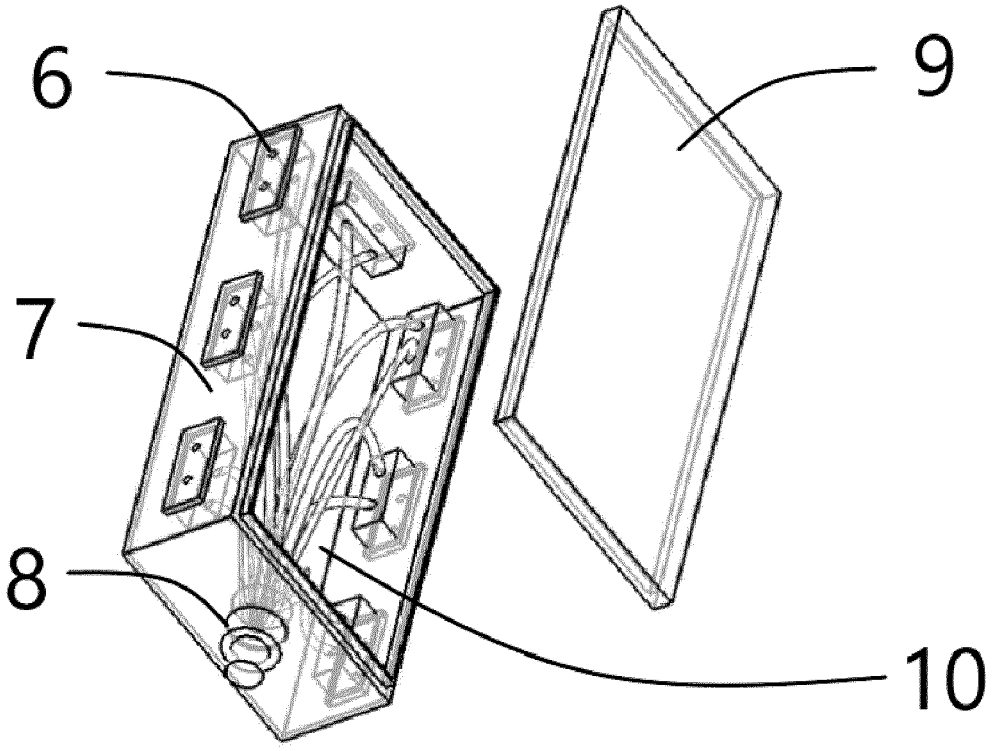

Fig. 4

Fig. 5

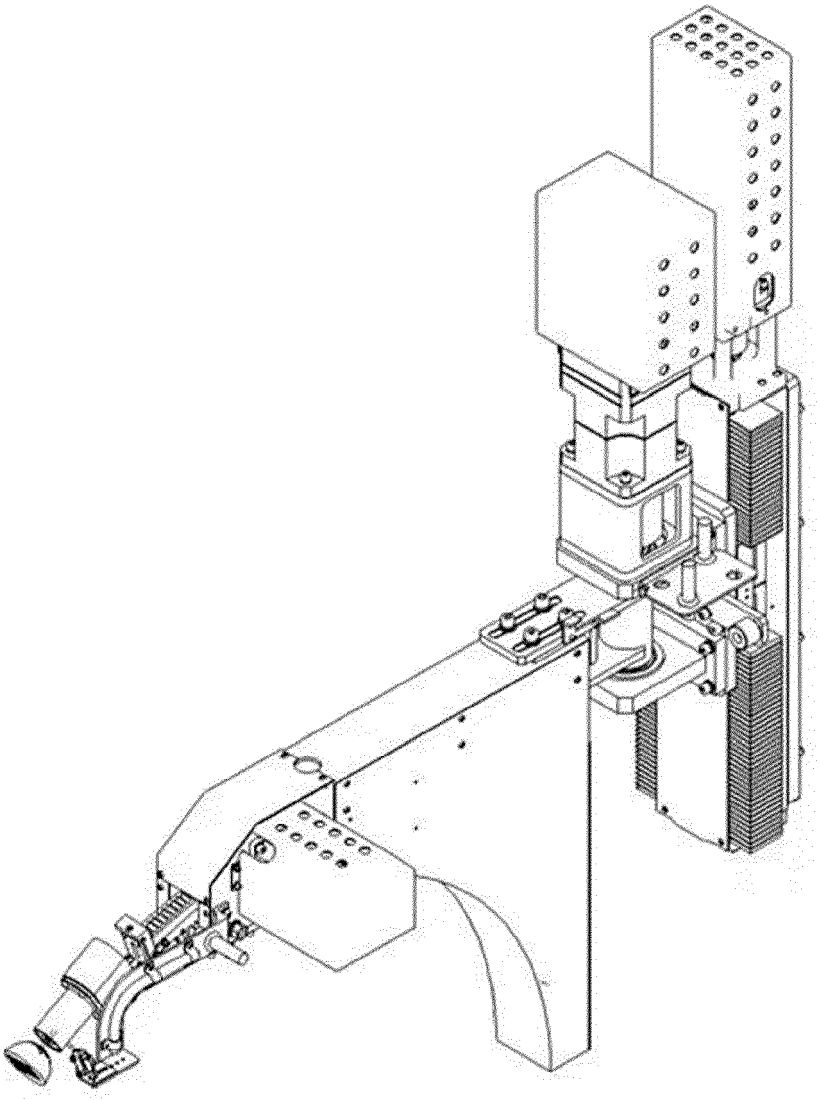

Fig. 6

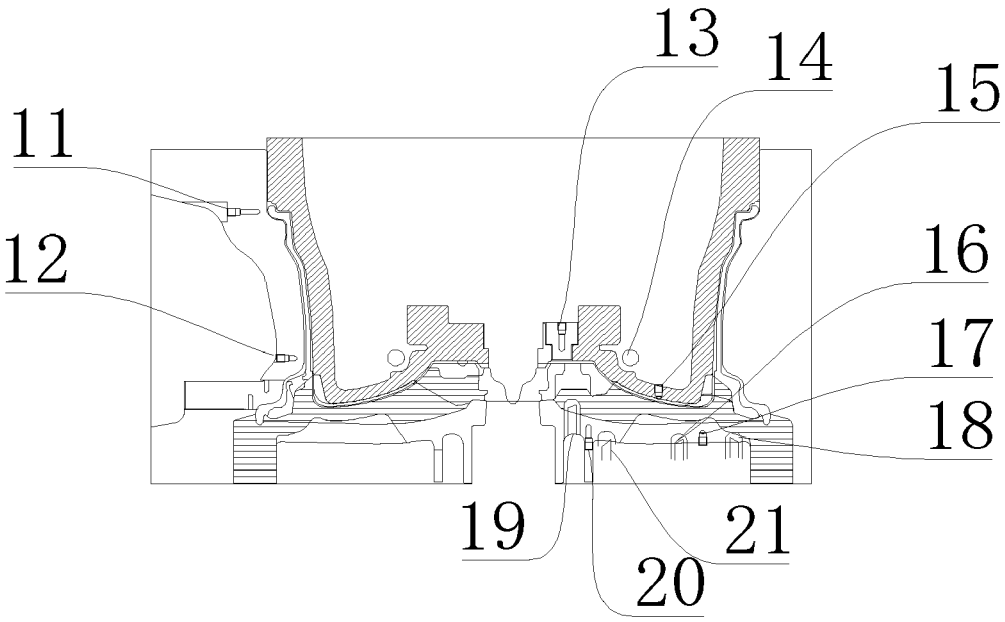
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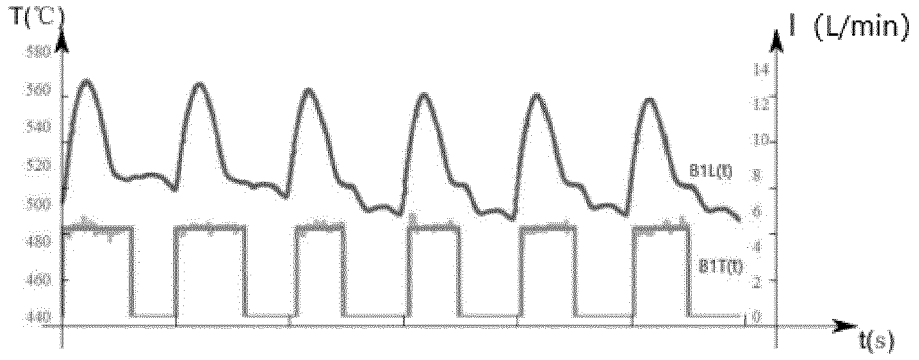
Fig. 7


T(℃)
580
560
540
520
500
480
460
440
I (L/min)
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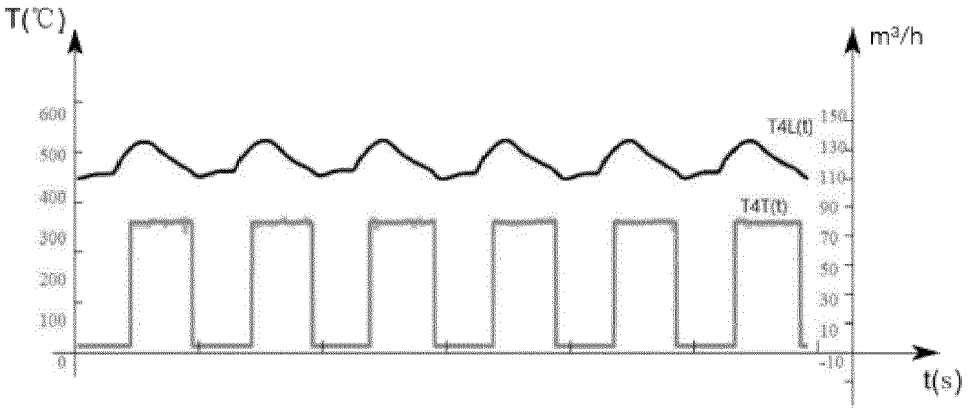
12
10
8
6
4
2
0
B1L(t)
B1T(t)
t(s)

Fig. 8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150
130
110
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70
50
30
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-10
T4L(t)
T4T(t)
t(s)

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 6080

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	* Machine translation; paragraph [Summaryoftheinvention]; figures 1,2 *	2	
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Y	* Machine translation; claims 1-4; figure 3 *	2	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	11 April 2024	Desvignes, Rémi

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

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