ARRANGEMENT FOR GAS QUENCHING OF HEAT-TREATED PARTS AND METHOD FOR CARRYING OUT SAME

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ABSTRACT
An arrangement for quenching structural components in a hot gas stream with which rapid cooling of the structural components to a holding temperature takes place at which transformation of the austenitic structure to bainite occurs. The control of the process can be carried out if a thermal buffer is disposed in the cooling gas stream.
ARRANGEMENT FOR GAS QUENCHING OF HEAT-TREATED PARTS AND METHOD FOR CARRYING OUT SAME

[0001] The invention relates to an arrangement for gas quenching heat-treated structural components with a quenching chamber for the batch-wise acceptance of the structural components, with a cooling gas circulation comprising a ventilator and connected to the quenching chamber and a cooling device for cooling the cooling gas heated on the structural components as well as a measuring device for determining the temperature of the cooling gas at least at one site in the cooling gas circulation as well as a regulating device for regulating the cooling device.

[0002] With such an arrangement heat-treated structural components can be quenched such that their austenitic structure undergoes transformation to bainite. Preconditions for this transformation is rapid cooling of the structural components from the austenisation temperature, which is typically between 850 to 950 °C, to a holding temperature, which, depending on the material, is between 150 and 400 °C. After the structural component has cooled down, it is held at the holding temperature. Rapid quenching and holding at a specific holding temperature is important for the prealloyed cooling leads to the formation of pearlite and if the temperature falls below the holding temperature, martensite is formed. Both structure forms are undesirable and lower the quality of the structural component. Bainitic tempering is currently predominantly carried out in a salt bath. The structural components are transferred while exposed from the austenization furnace to a liquid salt bath at holding temperature and are immersed therein. When the structural components have cooled to holding temperature in the salt bath, they are transferred to an air circulation furnace in which the transformation to a bainitic structure occurs. Of disadvantage is here the expenditure for the subsequent cleaning of the structural components. In the case of highly stressed structural components with fine bores—for example for fuel injection techniques—cleaning compatible with reliable production results is not possible, which may lead to corrosive attack and, entailed therein, to failure of the structural component. Transfer of the structural components through the air represents a further disadvantage, since herein the structural component surfaces oxidize. Further disadvantages result from the fact that the quenching salts employed are environmentally harmful and the treatment can only be automated with difficulty i.e. it cannot be integrated into a production line.

[0003] For that reason proposals have already been made for carrying out the quenching in a gas stream. An arrangement according to the preamble of claim 1 is disclosed in DE 199 02 032 C1. According to this document the structural components are introduced into a cold quenching chamber and a cold cooling gas, preferably nitrogen, is admitted into the chamber. This gas is subsequently circulated via an external ventilator located in a conduit. The circulated gas flows through two branch lines, and it can be heated in the one branch line and cooled in the other. Through the regulation of the throughput rate through the two branch lines by means of two valves, the quenching process is intended to be controlled in the quenching phase as well as also in the holding phase. Due to the dimensions of the chamber, which, as a rule, are large, and the connected conduit systems as well as due to the large quantity of introduced gas relative to the weight of the structural components to be treated, problems involving regulation techniques are encountered such that in particular supercooling of thin-walled structural component segments cannot be excluded. This would lead to the structural component being martensitically transformed at these sites.

[0004] The invention therefore addresses the problem of providing measures with which the process control is devised to be simplified and be more reliable, and, in particular, supercooling of the structural components, even if only occurring in sections, is to be avoided.

[0005] The invention provides as a solution of the problem that a thermal buffer is disposed in the cooling gas circulation.

[0006] By thermal buffer is to be understood a structure with high thermal capacity with the capability of absorbing large heat quantities without its temperature being significantly increased. The heat capacity is here to be measured from the heat capacities of the installation itself and from the quantity of the cooling gas to be circulated. Such a buffer can absorb a large quantity of heat in particular in the quenching phase, such that the regulation of the further devices for the cooling of the cooling gas only has low regulation intensity, whereby in particular overdriving is avoided. In the temperature holding phase the cooling gas absorbs thermal energy again from the buffer, however, without its temperature drastically increasing herein, since, due to its high thermal capacity, the buffer had previously only experienced a slight temperature increase and its temperature is therewith virtually at the predetermined holding temperature. Therefore additional regulating interventions are only minimally necessary even in the temperature holding phase such that overdriving is here also avoided.

[0007] One form of the cooling device for cooling the cooling gas heated on the structural components is comprised of a gas outlet from the cooling gas circulation downstream of the quenching chamber and of a valve-controlled cooling gas intake connected to a gas tank, upstream of the quenching chamber. The gas is either at ambient temperature or at the holding temperature. Under the control of the pressure, precisely that quantity of cooling gas is discharged from the gas outlet which corresponds to the quantity of the gas supplied into the cooling gas circulation via the cooling gas intake.

[0008] In such an arrangement the thermal buffer, seen in the direction of flow, is preferably ahead of the cooling gas intake, such that first a temperature regulation “through the buffer” takes place and only subsequently through the supply of cooled liquid cooling gas a succeeding fine regulation occurs, which therefore can be carried out free of overdriving.

[0009] In the event the supplied cooling gas is an intensively cooled gas, it is reasonable to dispose the thermal buffer, viewed in the direction of flow, following the cooling gas intake in order to enable the cooling gas before it reaches the quenching chamber to flow through the buffer and herein assume its temperature. In this way an equalization of the temperature is attained with which the cooling gas enters the quenching chamber, such that fewer regulation interventions are necessary and supercooling of the cooling gas below the holding temperature is avoided.
The cooling can also be comprised of a parallel line to the cooling gas circulation disposed parallel to the thermal buffer, in which case the heat exchanger is disposed.

The buffer is preferably a metallic structure with a large surface and with high thermal mass relative to the circulated gas stream. The buffer can be, for example, a tubing bundle. Such a tubing bundle is simple in production and only needs to be disposed in the cooling gas circulation in order to develop the desired buffer effect.

To preheat the arrangement a heating means is disposed in the cooling gas circulation located preferably ahead of the thermal buffer. With the heating means the arrangement is to be brought to the projected holding temperature before the batch to be quenched is loaded into the quenching chamber. Since the heating means is located immediately ahead of the buffer, the buffer is also preheated to the holding temperature before the batch is loaded. Due to the effect of the buffer, a base temperature for the automatic regulation is set as a result.

The cooling of the cooling gas during the quenching process can take place through the supply of gas at ambient temperature or it can take place with a intensively cooled gas, which is especially effective.

Through the system, namely the use of a hot gas stream for cooling and a large thermal buffer, the thermal conditions in a salt bath are ideally emulated, however, without having to accept the significant disadvantages of salt baths described above. There is furthermore the advantage that, compared to salt bath quenching, the structural components no longer need to be cleaned after the heat treatment, such that components with narrow bores can also be treated, which in installations according to prior art could not be tempered haphazardly. In comparison to known dry processes, the advantage is gained that during the entire quenching process the structural components are quenched with hot gas such that complex and complicated structural component geometries can also be treated with process reliability.

With the described arrangement primarily a quenching process according to the attached method claims can be carried out.

The sole FIGURE indicates schematically an arrangement in order to clarify the invention.

The arrangement is comprised of a quenching chamber 1, into which is loaded a batch of structural components 2 to be cooled and which, not further shown here, can be hermetically closed. The quenching chamber 1 is disposed in a cooling gas circulation 3 with the cooling gas being conducted into the quenching chamber 1 through an inflow 4 and is conducted out of it again via an outflow 5, after having been directed over the structural components 2. Directly ahead of the inflow 4 is located a ventilator 6 driven by an electric motor, which circulating the gas in the cooling gas circulation.

Following the outflow 5, a line to a collecting tank 8 branches off at an outlet 7. In this line is disposed an overpressure valve 9 which is set, for example, to 6 bar, such that with a supply of gas, described in the following, into the cooling gas circulation 3, which would result in an increase of pressure, at outlet 7 a corresponding quantity of gas is again taken out of the cooling gas circulation 3, such that there is always the same quantity of gas in the circulation. In the line is located furthermore a heat exchanger 9a, which cools the heated cooling gas down again on its way into the collecting tank 8.

Viewed in the direction of flow, the outlet 7 is followed by a heating means 10 in the cooling gas circulation 3, which is succeeded by a thermal buffer 11, wherein the buffer may have the form of a tubing bundle. There are two feasibilities for choosing the precise position of the buffer:

(1) In the direction of flow following the thermal buffer 11 or at the level of the thermal buffer 11 are located one or several intakes 12 for the supply of cooling gas, preferably nitrogen. The intakes 12 are connected to a first supply tank 13 for cooling gas, which is preheated to holding temperature. A further connection is set up to a second supply tank 14, in which the cooling gas is kept at ambient temperature. This second supply tank 14 is fed from the collecting tank 8 via a compressor 15. A further connection of intakes 12 is set up to a third supply tank 16 with a highly supercooled liquified gas, for example with liquid nitrogen. All of the connections are valve controlled (intake valves 17, 18, 19).

(2) According to a position 11' indicated by dot-dash line, the thermal buffer can also be disposed directly ahead of the ventilator 6 and following the intakes 12. The position is of interest especially if via the intake 12 an intensively cooled gas is let from the third supply tank 16 into the cooling gas circulation as additional cooling gas. The temperature equalization in the buffer prevents in this case a possible supercooling of the structural components.

A temperature sensor 20 is located within the quenching chamber 1 in the inflow 4 to the structural components 2. The temperature measured by the temperature sensor 20 is acquired by means of a regulation device 21 and taken into account for the regulation of the cooling gas temperature through the actuation of the intake valves 17, 18, 19 and of the heating means 10.

In addition to the described arrangement, a parallel line 22 may be provided extending parallel to the section of the cooling gas circulation with the thermal buffer 11, which is also valve controlled (valve 23), and includes a heat exchanger 24.

The procedure for quenching structural components 2 of a batch is as follows: If this has not yet taken place, by starting the heating means 10 and by circulating of, for example, air in the cooling gas circulation by means of the ventilator 6, the quenching chamber 1 and the cooling gas circulation 3, which are both thermally insulated through a suitably disposed insulating layer 26, are heated to the desired holding temperature of, for example 250 °C. Also preheated to holding temperature is the gas supply in the first supply tank 13. The gas in the second supply tank 14 is at ambient temperature.

This preheating is optionally repeated with succeeding quenching processes and the installation brought to holding temperature. For repeated preheating it is possibly sufficient to utilize the thermal energy introduced into the chamber with the ventilator 6 via the circulated gas volume.
The quenching chamber is subsequently evacuated and with the aid of a transport arrangement a batch is removed from a preceding vacuum furnace and transferred into the preheated quenching chamber. If the preceding furnace is a protective gas furnace, the quenching chamber is additionally filled with a protective gas, in order to maintain the protective gas atmosphere for the structural components. In this case, the quenching chamber can also already be preheated with protective gas.

As soon as the structural components are within the quenching chamber, the ventilator is started. The preheated cooling gas is subsequently introduced into the quenching chamber via the first intake valve until the desired working pressure has been reached. Depending on the alloy composition of the workpieces to be bainitically tempered, the working pressure can be between 1 to 20 bar. The temperature of the cooling gas is herein measured in inflow to the quenching chamber. Through the thermal energy conducted off from the batch the cooling gas is heated above the holding temperature. However, to maintain it at this temperature, via the second intake valve the ambient-temperature cooling gas is introduced into the cooling gas circulation from the second supply tank. A corresponding quantity of gas is simultaneously drained via the pressure valve into the collecting tank. For the temperature regulation the second intake valve is actuated by means of a controller as a function of the measured gas temperature. The heating means can also be including in the regulation as a further regulating element.

Instead of cooling gas at ambient temperature, an intensively cooled liquid cooling gas, for example nitrogen, can also be sprayed into the quenching chamber from the third supply tank. This has the advantage that a significantly higher temperature difference between the inflow and the outflow of the quenching chamber is attained and, in addition, the vaporization enthalpy of the gas can be utilized for conducting off the heat from the quenching chamber. The gas consumption is thereby considerably lowered and the method becomes more economical.

A further variant of the means for conducting off heat incorporates the parallel line. Via the regulatable valve a substream of the circulating cooling gas can be conducted across the heat exchanger and can therewith be cooled.

The intention of all of the methods listed above is to attain that the temperature at inflow into the quenching chamber does not fall below holding temperature.

With the aid of the thermal buffer this regulation is improved and made less sensitive. At the start of the process the thermal buffer is also heated to holding temperature. If, during the quenching, the hot gas flows through this buffer, a large portion of the heat quantity is initially given off to this buffer. Due to its high thermal mass, the temperature of the buffer increases herein only minimally. At the end of the quenching process the buffer is cooled down again through the gas stream which, in the meantime, has reached holding temperature. In this way, the expenditures for the regulation technique decrease since the temperature peaks can be efficiently buffered in the thermal mass.
5. Arrangement for gas quenching as claimed in claim 3 or 4, characterized in that the thermal buffer (11) in the direction is disposed following the outlet (7).

6. Arrangement for gas quenching as claimed in one of the preceding claims, characterized in that parallel to the thermal buffer (11) is provided a parallel line (22) to the cooling gas circulation (3), in which a heat exchanger (24) is disposed.

7. Arrangement for gas quenching as claimed in one of the preceding claims, characterized in that the thermal buffer (11) is a metallic structure with a large surface and with a high thermal mass relative to the circulated gas stream.

8. Arrangement for gas quenching as claimed in one of the preceding claims, characterized in that a heating means (10) is disposed in the cooling gas circulation (3) ahead of the thermal buffer (11).

9. Arrangement as claimed in one of the preceding claims, characterized in that the gas supply is comprised of a first supply tank (13) with heated gas, of a second supply tank (14) with gas at ambient temperature and of a third supply tank (16) with an intensively cooled gas.

10. Method for gas quenching structural components in a quenching chamber with a cooling gas, wherein the structural components, after their rapid cooling to holding temperature, are kept for a certain length of time at this holding temperature in order to make possible a structural transformation, and wherein the cooling gas is circulated in a cooling gas circulation including a ventilator and connected to the quenching chamber, characterized in that for cooling the cooling gas heated on the structural components an additional cooling gas is introduced into the cooling circulation, such that a temperature obtains which corresponds to the projected holding temperature.

11. Method for the gas quenching as claimed in claim 10, characterized in that in the circulation (3) a thermal buffer (11) is located which, before the start of the quenching, is heated to holding temperature.

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