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(54) Device for limiting the condensation pressure in a refrigerating machine

(57) A device for limiting the condensation pressure of a refrigerating machine, comprising means (17) for the continuous and controlled regulation of superheating at the evaporator (10).

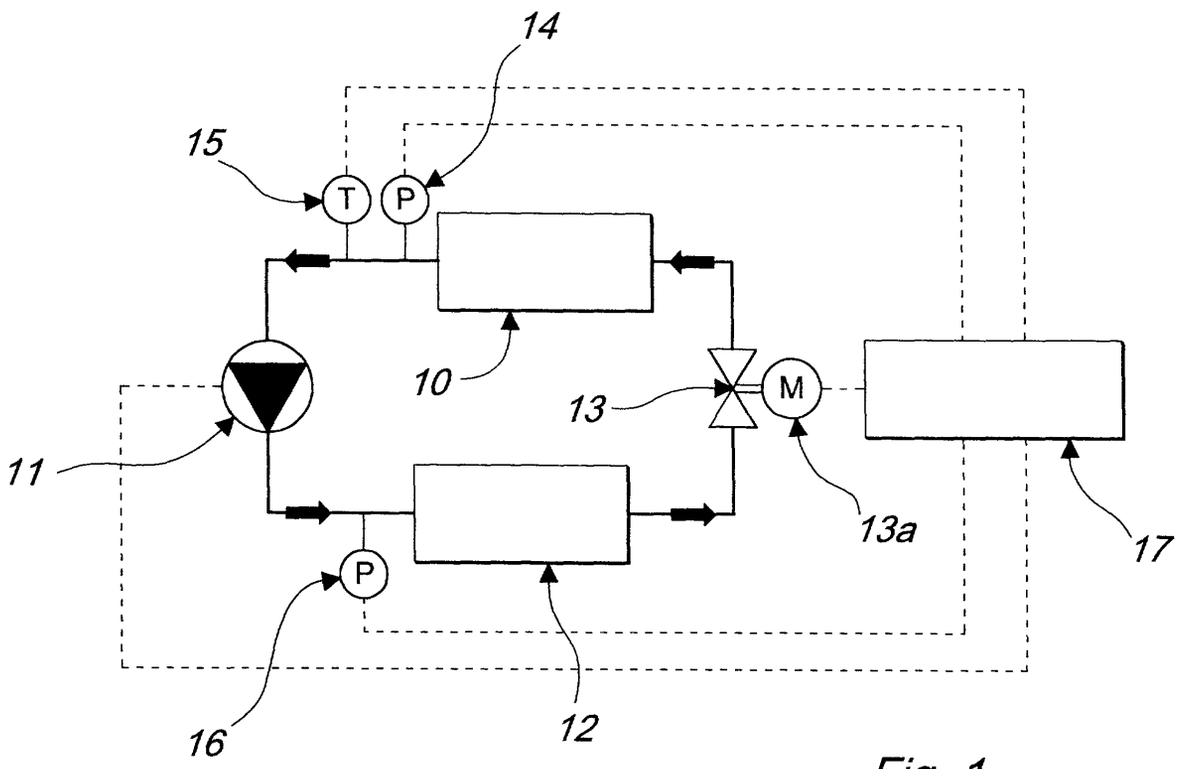

Fig. 1

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Description

[0001] The present invention relates to a device for limiting the condensation pressure of a refrigerating machine.

[0002] As is known, the refrigerating capacity of a refrigerating machine increases with the saturation temperature at evaporation, which in turn is linked to the temperature of the refrigerated fluid.

[0003] The increase in refrigerating capacity also entails automatically an increase in the thermal power that the refrigerating machine must dissipate at the condenser.

[0004] As the thermal power to be dissipated increases, so does necessarily the difference in primary temperature at the condenser (difference between the condensation temperature and the temperature of the cooling fluid).

[0005] Accordingly, in a refrigerating machine, for an equal temperature of the cooling fluid at the condenser, an increase in the saturation temperature at evaporation (which generally depends on an increase in the temperature of the cooled fluid) leads to an increase in the saturation temperature at condensation.

[0006] Conversely, a decrease in refrigerating capacity automatically leads to a decrease in the thermal power to be dissipated at the condenser and therefore to a decrease in the saturated temperature at condensation for an equal temperature of the hot source.

[0007] Therefore, if the condensation temperature tends to approach the safety value that would require shutting down the machine, it is possible to limit this rise by reducing the refrigerating capacity absorbed by the evaporator, since this is equivalent to a reduction in the thermal power affecting the condenser.

[0008] Among the various methods of achieving this, the best-known are:

a. regulation of the speed of the refrigerating compressor;
b. throttling, by means of appropriate regulator elements, the intake duct of the compressor in order to limit the flow-rate of refrigerating fluid;
c. mechanical reduction of the capacity of the compressor;
d. regulation of the temperature and/or flow-rate of the cooled fluid;
e. recirculation, in the evaporator, of part of the hot gases pumped by the compressor (known as hot gas bypass).

[0009] However, these known methods are affected by high manufacturing costs (for example a. and b.), discontinuous regulation (for example c.), sometimes unacceptable functional interference with the cooling process (for example d.), or unacceptable energy inefficiencies.

[0010] The aim of the present invention is to provide a regulator that is capable of modulating the refrigerating capacity absorbed by the evaporator according to the requirements of the moment, so as to adapt in each instance to:

- delivering the maximum refrigerating capacity that is compatible with the functional conditions of the machine;
- reducing the refrigerating capacity only when necessary and only to the required extent, in order to limit the saturation temperature at condensation when phenomena that might cause an excessive increase thereof occur.

[0011] Within this aim, an object of the invention is to provide a device that is simple, cheap and reliable.

[0012] This aim and this and other objects that will become better apparent hereinafter are achieved by a device for limiting the condensation pressure of a refrigerating machine, characterized in that it comprises means for the continuous and controlled regulation of superheating at the evaporator.

[0013] Further characteristics and advantages of the invention will become better apparent from the detailed description of an embodiment thereof, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a system diagram of a refrigerating machine provided with a device according to the invention;
Figure 2 is a flowchart of the regulation process.

[0014] With reference to the figures, a refrigerating machine comprises an evaporator 10, a compressor 11, a condenser 12 and a throttling valve 13, which are connected in succession and in series to each other.

[0015] A device according to the invention for limiting the condensation pressure of the refrigerating machine comprises means for the continuous and controlled regulation of superheating at the evaporator, constituted by a sensor 14 for detecting the evaporation pressure (or saturation temperature at evaporation), a sensor 15 for detecting the temperature of the superheated vapor in output from the evaporator, a sensor 16 for detecting the condensation pressure (or saturation temperature at condensation), and a microprocessor-based controller 17.

[0016] Further, the per se known throttling valve is of the type that is servoactuated, for example by a motor 13a.

[0017] The throttling valve 13 is chosen among the ones that have recently been introduced commercially and are servoactuated automatically, usually but not exclusively by means of an electric servomotor, and are controlled by electronic devices that allow to adjust the superheating according to the instantaneous requirements or convenience (known self-actuated mechanical

valves instead do not allow automatic variation of the overheating value according to the operating conditions, because setting occurs by means of a manually operated screw).

[0018] The microprocessor-based controller 17 is connected to said sensors 14, 15 and 16 and to the servoactuation of the throttling valve 13.

[0019] The device according to the invention utilizes the fact that the capacity of a refrigerating machine is, as a first approximation, proportional to the flow-rate of the evaporated refrigerating fluid, and that therefore if this flow-rate is decreased the overall refrigerating capacity is also decreased.

[0020] Therefore, if the device acts so as to decrease in a controlled fashion the flow-rate of refrigerating fluid introduced in the evaporator by way of the gradual throttling of the throttling valve, the evaporator is underfed and accordingly the refrigerating capacity of the machine is reduced.

[0021] In the normal operation of known dry-expansion evaporators, the refrigerating fluid first changes state and is then superheated: i.e., to ensure the complete absence of a liquid phase (which is potentially harmful to the compressor) in output, the temperature of the vapor produced by the complete evaporation of the fluid is raised by a controlled extent with respect to the saturation temperature at evaporation.

[0022] A reduction in the mass flow of fluid fed to the evaporator leads to faster evaporation, i.e., to a reduction of the portion of surface used to change the state of the refrigerating fluid and to a consequent increase of the portion where the fluid is superheated.

[0023] The device according to the invention causes an increase in the superheating of the vapor that leaves the evaporator and obtains in cascade:

a. an increase in the portion of surface intended for superheating;
b. a decrease in the portion of surface dedicated to evaporation;
c. a decrease in the flow-rate of refrigerant throttled by the valve;
d. a decrease in the refrigerating capacity associated with a decrease in the saturation temperature at evaporation;
e. a decrease in the thermal power at the condenser;
f. a decrease in the saturation temperature at condensation for an equal temperature of the cooling fluid.

[0024] By limiting indirectly the saturation temperature at condensation, one is conditioned by the minimum evaporation temperature that can be tolerated before the occurrence of undesirable effects or of effects that damage the process (for example, in a water refrigerator the evaporation temperature should never be lower than 0 °C due to the risk of freezing).

[0025] By lowering the superheating, which must nonetheless be given a value that is high enough to allow a stable and safe regulation process, one can also achieve an increase in the flow-rate of refrigerating fluid and therefore in the refrigerating capacity.

[0026] The flowchart of the regulation process is summarized in Figure 2.

[0027] The microprocessor-based controller 17, in addition to the normal functions of controlling the machine, measures the saturation temperature at evaporation (usually by means of a measurement of the corresponding pressure) and the temperature of the superheated vapor by way of the sensors 14 and 15, mounted proximate to the evaporator 10 or inside it, and calculates their difference, obtaining the value of the superheating; then it applies a regulation action to the servomotor 13a of the throttling valve 13, in order to keep the superheating at the optimum value (in normal conditions, the lowest value that is compatible with regulation stability, in order to ensure maximum refrigerating capacity).

[0028] The microprocessor-based controller 17 further measures the saturation temperature at condensation (usually by means of a measurement of the corresponding pressure) by way of the sensor 16 mounted proximate to the condenser 12 or inside it.

[0029] If the saturation temperature at condensation exceeds the threshold allowed for what is defined as normal operation, the microprocessor 17 raises appropriately the value of the superheating by closing partially the throttling valve 13, with the result of underfeeding the evaporator 10 and of decreasing the refrigeration capacity, consequently also reducing the thermal power affecting the condenser 12 and ultimately the saturation temperature at condensation.

[0030] As a consequence of the underfeeding of the evaporator 10, the saturation temperature at evaporation also tends to decrease with respect to the initial value, until it might drop below the preset threshold following a marked increase in superheating.

[0031] The microprocessor-based controller 17 is designed to check that the maximum threshold of the saturation temperature at condensation and the minimum threshold of the saturation temperature of evaporation are not passed, giving however priority to the latter and therefore preventing an excessive throttling of the throttling valve 13.

[0032] However, if the safety threshold of either temperature were passed, the microprocessor-based controller 17 would stop the compressor 11 in order to prevent unacceptable operating conditions.

[0033] Obviously, as soon as the saturation temperature at condensation drops below the threshold, the microprocessor-based controller 17 restores the superheating to lower values, opening the throttling valve 13 in a controlled fashion.

[0034] In practice it has been observed that the device for limiting the condensation pressure of the refrigerat-

ing machine according to the invention has achieved the intended aim and object.

[0035] The device according to the present invention is in fact able to modulate simply, cheaply and functionally, by controlling the superheating, the refrigerating capacity absorbed by the evaporator according to the instantaneous requirements, so as to adapt in each instance to:

-- delivering automatically the maximum refrigerating capacity that is compatible with the functional conditions of the machine;
-- reducing the refrigerating capacity only when required and to the required extent, in order to limit the saturation temperature at condensation when phenomena occur that would cause its excessive increase.

[0036] The invention thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the inventive concept.

[0037] All the details may further be replaced with other technically equivalent elements.

[0038] In practice, the materials employed, so long as they are compatible with the contingent use, as well as the dimensions, may be any according to requirements.

[0039] The disclosures in Italian Patent Application No. PD2001A000173, from which this application claims priority, are incorporated herein by reference.

[0040] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. A device for limiting the condensation pressure of a refrigerating machine, **characterized in that** it comprises means for the continuous and controlled regulation of superheating at the evaporator.

2. The device according to claim 1, **characterized in that** said means for the continuous and controlled regulation of superheating at the evaporator comprise at least one servoactuated throttling valve, a sensor for the saturation temperature (or pressure) at evaporation, a sensor for the temperature of the superheated vapor that leaves the evaporator, a sensor for the saturation temperature (or pressure) of condensation, which are connected to a microprocessor-based controller that coordinates their measurements and operation.

3. A method for limiting the condensation pressure of a refrigerating machine that uses a device according to one or more of claims 1 and 2, comprising the step of regulating the superheating of the vapor that leaves the evaporator at a level that contains the saturation temperature at condensation within the preset limit.

4. A method for limiting the condensation pressure of a refrigerating machine that uses a device according to one or more of claims 1 and 2, comprising the steps of increasing the superheating of the evaporator if the saturation temperature at condensation exceeds a threshold, thus causing a decrease in refrigerating capacity and accordingly in the thermal power affecting the condenser, thus limiting indirectly the condensation temperature for an equal temperature of the cooling fluid of the condenser.

5. A method for limiting the condensation pressure of a refrigerating machine that uses a device according to one or more of claims 1 and 2, comprising the step of regulating the superheating of the evaporator to the minimum value that is compatible with operating stability and safety if the exchange capacity of the condenser and the temperature of the cooling fluid allow normal values of the saturation temperature at condensation.

6. A method for limiting the condensation pressure of a refrigerating machine that uses a device according to one or more of claims 1 and 2, comprising the step of monitoring the saturation temperature at evaporation and of preventing the corrective action aimed at reducing the superheating in order to contain the refrigerating capacity of the machine, so as to limit the saturation temperature at condensation, from causing said evaporation temperature to drop below any threshold that is potentially dangerous for the integrity or functionality of the system.

7. A method for limiting the condensation pressure of a refrigerating machine that uses a device according to one or more of claims 1 and 2, comprising the step of blocking the normal operation of the refrigerating machine by stopping the compressor if, despite the superheating regulation action or possibly also as a consequence thereof, the maximum safety threshold of the saturation temperature at condensation or the minimum safety threshold of the saturation temperature at evaporation is passed for a minimum significant time.

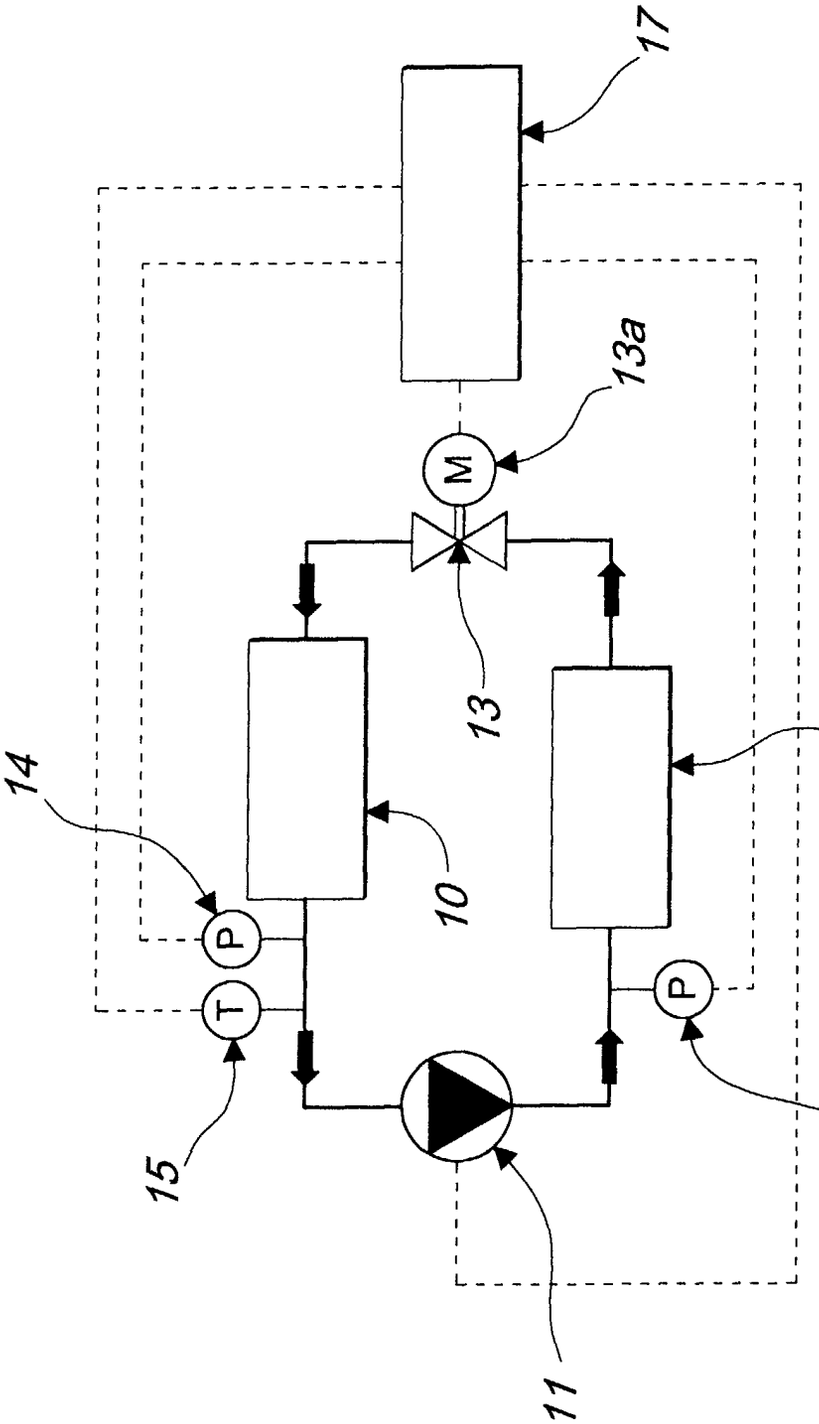

Fig. 1

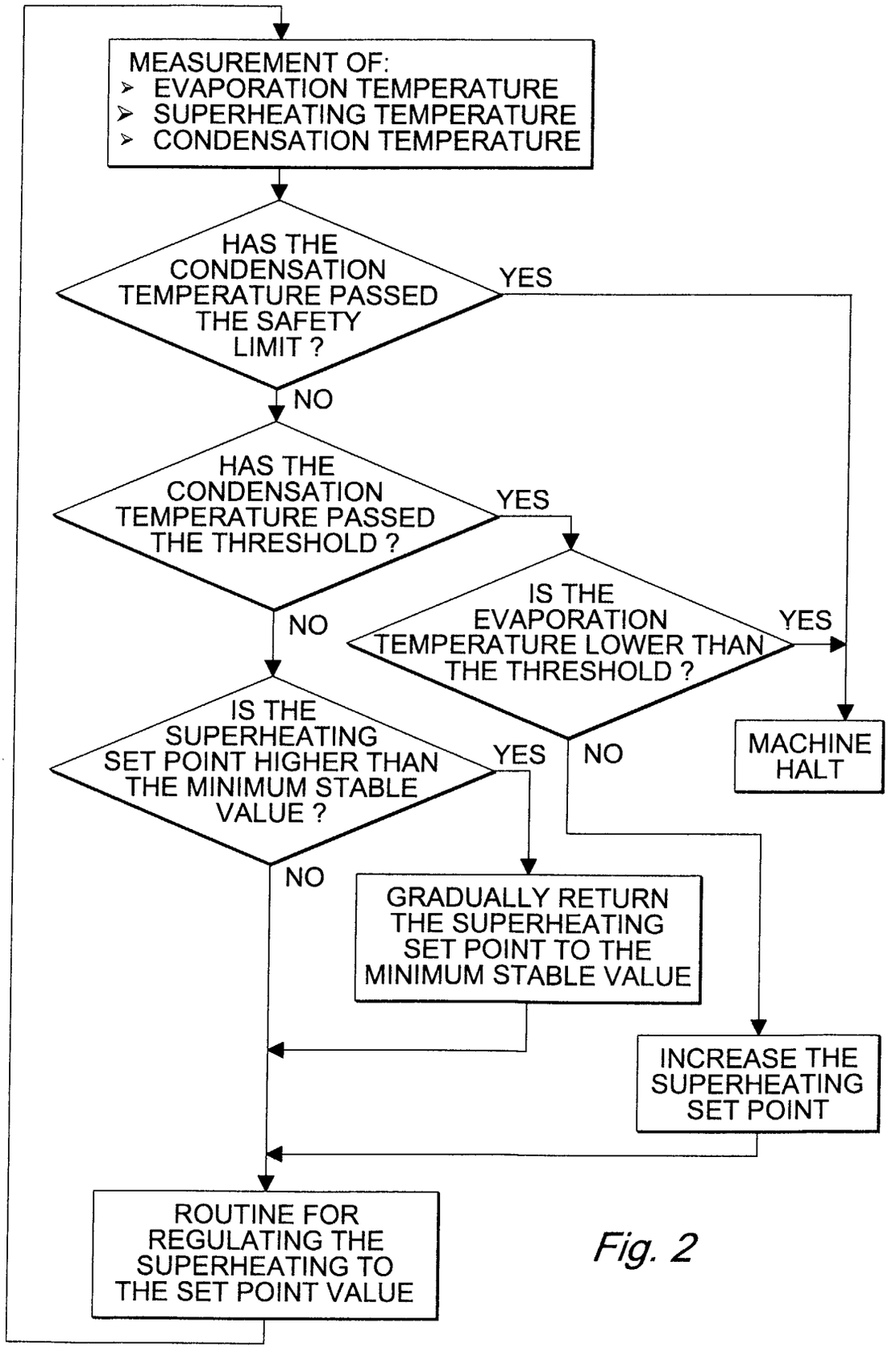
MEASUREMENT OF:
EVAPORATION TEMPERATURE
SUPERHEATING TEMPERATURE
CONDENSATION TEMPERATURE
HAS THE CONDENSATION TEMPERATURE PASSED THE SAFETY LIMIT ?
YES
NO
HAS THE CONDENSATION TEMPERATURE PASSED THE THRESHOLD ?
YES
NO
IS THE EVAPORATION TEMPERATURE LOWER THAN THE THRESHOLD ?
YES
NO
MACHINE HALT
IS THE SUPERHEATING SET POINT HIGHER THAN THE MINIMUM STABLE VALUE ?
YES
NO
GRADUALLY RETURN THE SUPERHEATING SET POINT TO THE MINIMUM STABLE VALUE
INCREASE THE SUPERHEATING SET POINT
ROUTINE FOR REGULATING THE SUPERHEATING TO THE SET POINT VALUE

Fig. 2