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Knaak

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[54] **METHOD OF OPERATION OF A CHAMBER FURNACE**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 118,812, Feb. 25, 1971, Pat. No. 3,726,515.

[30] **Foreign Application Priority Data**

Mar. 3, 1970 Germany 2009761

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[51] **Int. Cl.** **F27b 9/14**, F27b 3/26

[58] **Field of Search** 432/5, 20

[56] **References Cited**

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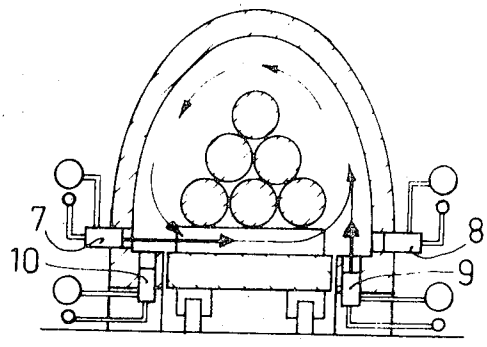
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[57] **ABSTRACT**

A method of operating a chamber furnace for heat treatment of material located in the furnace spaced from the wall thereof by a plurality of high-speed burners arranged so that half of the burners produce a helix of combustion gases extending in one direction about the material to be treated and the other half a helix in the opposite direction and in which during operation of the furnace at full load, all burners are simultaneously operated, during operation of the furnace at 99-50% of its full load all burners are operated for a first time interval and then for a second time interval only half of the burners which produce a helix in the same direction, and during operation of the furnace at less than 50 percent of the full load, only burners which produce a helix in the same direction are operated, whereby during operation of the furnace at less than full loads the burners which produce a helix in the one and in the opposite direction are cyclically changed.

4 Claims, 6 Drawing Figures



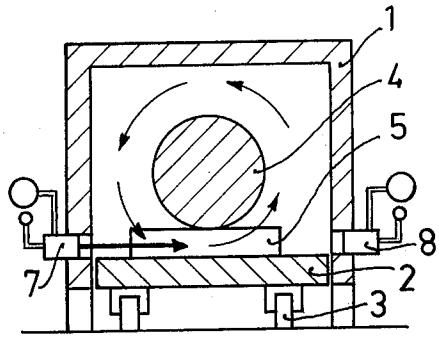


Fig.1

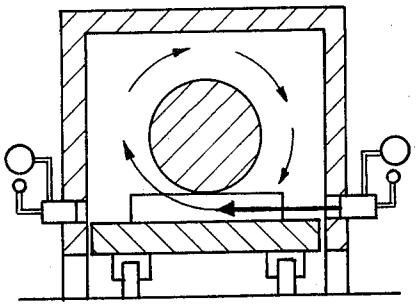


Fig.2

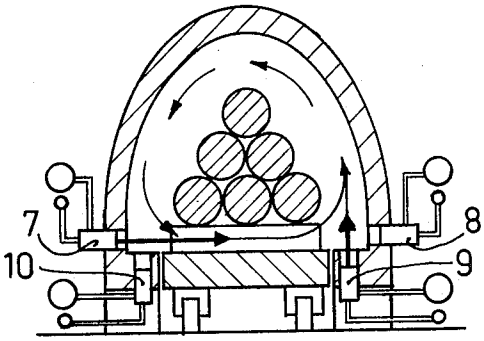


Fig.3

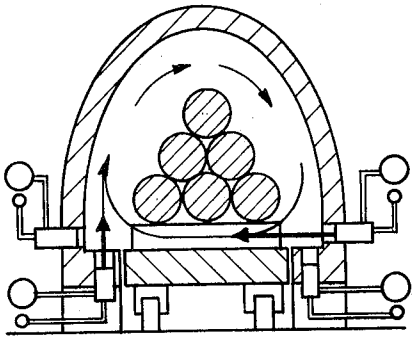


Fig.4

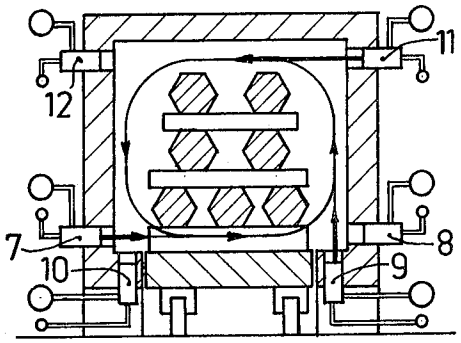


Fig.5

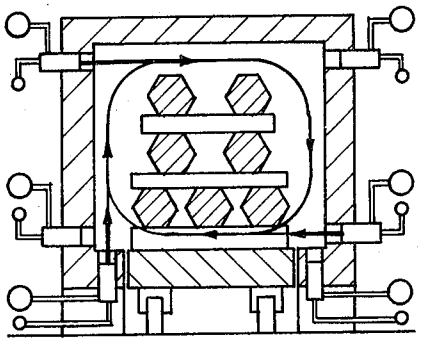


Fig.6

METHOD OF OPERATION OF A CHAMBER FURNACE

CROSS-REFERENCES TO RELATED APPLICATIONS

The present application is a continuation-in-part of the copending application Ser. No. 118,812 filed Feb. 25, 1971, now U.S. Pat. No. 3,726,515.

BACKGROUND OF THE INVENTION

Industrial ovens or chamber furnaces are known in the art in which the material to be heated is located in the furnace spaced from the walls thereof and in which a plurality of high-speed burners are arranged in the walls of the furnace in such a manner that half of the burners will produce a helix of combustion gases extending in one direction about the material to be heated, whereas the other half of the burners will produce a helix of combustion gases extending in the opposite direction about the material.

Such chamber furnaces are for instance disclosed in the copending application Ser. No. 188,182. The aforementioned application describes also a method of operating a furnace in which, during operation of the furnace as full load, all burners are simultaneously operated, whereas during operation of the furnace at a load or heat requirement less than full load, only those burners are operated at any time which produces a helix extending in the same direction about the material to be treated, whereby in the latter case the operation of the burners is cyclically changed so that alternatingly only the burners which produce a helix in one direction and then the burners which produce a helix in the opposite direction are operated, whereby this alternating operation of the burners and resulting change in the direction in which the helix extends about the material to be heated is preferably automatically controlled by a programmed switch arrangement.

This known operation of the burners has, however, a decisive disadvantage in that all of the burners which are operated at any time are simultaneously switched on or off, whereby during such switching off or on of the burners certain pressure variations will occur in the interior of the furnace since the amount of combustion gasses fed thereinto will be suddenly changed. This sudden change of the pressure in the interior of the furnace may lead to an extinguishing of the burners which should be operated or to sucking of air from the exterior of the furnace into the latter. Both such occurrences are evidently highly undesirable.

SUMMARY OF THE INVENTION

It is an object of the present invention to overcome these disadvantages of the above-described known methods of operation of a chamber furnace of the aforementioned kind.

It is a further object of the present invention to provide for a method of operation of a chamber furnace of the aforementioned kind in which the pressure variations within the furnace during operation thereof at less than full load can be held to a minimum.

With these and other objects in view, which will become apparent as the description proceeds, the method of operating a chamber furnace for heat treatment of material located therein spaced from the walls thereof, by high-speed burners arranged in n groups in such a manner that the impulses of the flames and combustion gases emanating from $n/2$ groups produce a helix of combustion gases rotating in one direction about the material to be heated and those from the remaining $n/2$ burner groups a helix rotating in the opposite direction about the material, mainly comprises the steps of operating, during full-load operation of the furnace, the burners of all burner groups simultaneously, operating, during operation of the furnace at 50–99 percent of its full load, only the burners of $n/2$ burner groups which produce a helix in one direction for a first time interval, then operating the burners of all burner groups simultaneously for a second time interval, then operating the burners of $n/2$ burner groups which produce a helix in the opposite direction again for said first time interval, and then operating again the burners of all groups for said second time interval, and, during operation of the furnace at less than 50% of its full-load capacity, alternatingly operating the groups of burners which respectively produce a helix in the one and in the opposite direction, each for a predetermined time interval.

Furthermore, during operation of the furnace at 50–99 percent of its full load, the mentioned first time interval is decreased and the second time interval correspondingly increased when the load at which the furnace is to be operated approaches 99 percent of its full load capacity, whereas when the load at which the furnace is to be operated approaches 50 percent of its full-load capacity, said first time interval is increased and the second time interval correspondingly decreased.

Therefore, during operation of the furnace from full load to 50% of the full load, there will always be some burners operated during the time the other burners are switched on or off, so that sudden changes of the pressure in the interior of the furnace will be avoided.

In order to reduce the pressure variations in the furnace also during operation of the latter at less than 50 percent of its full load, the load range between 50 percent and zero may be divided into a plurality of load ranges stepwise increasing from a minimum to a maximum and wherein during operation within the smallest load range only the burners of one group are intermittently operated and said one group is cyclically changed within the $n/2$ burner groups so as to alternatingly produce a helix in the one and the opposite direction, wherein in the next-higher load range the burners of one group are intermittently operated while at the same time the burners of another group which produce a helix in the same direction as the burners of the one group are continuously operated and wherein said one and said other groups are cyclically changed within the $n/2$ burner group, and so on, until in the highest load range $(n/2)-1$ groups are continuously operated and only one group which produces a helix in the same direction as the $(n/2)-1$ burner groups is intermittently operated while changing the $(n/2)-1$ groups and said one group cyclically within the $n/2$ groups, and wherein the time T during which the burner groups are operated which will produce a helix in the same direction is subdivided into $n/2$ time intervals and wherein the cyclical change within the $n/2$ groups is performed in time intervals which equals $2T/n$.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages

thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a somewhat diagrammatic transverse cross section through a chamber furnace to be operated according to the present invention;

FIG. 2 is a cross section through the furnace shown in FIG. 1 and showing the furnace during a different operating stage;

FIG. 3 is a view similar to FIG. 1 but illustrating a further embodiment of a furnace;

FIG. 4 illustrates the furnace of FIG. 3 during a different stage of operation;

FIG. 5 is a cross section similar to FIG. 1 and showing still another embodiment of a furnace; and

FIG. 6 illustrates the embodiment of FIG. 5 in a different stage of operation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawing, and more specifically to FIGS. 1 and 2 thereof, it will be seen that the furnace which is to be operated according to the present invention may comprise wall means 1 and 2 which define within it a furnace chamber, and wherein the wall 2 is constituted by a hearth carriage with wheels 3 provided thereon, and on the carriage 3 there is supported a workpiece (here illustrated in cylindrical configuration) which is supported on the hearth carriage via supports 5.

A plurality of burners are arranged in the embodiment shown in FIGS. 1 and 2 in the side walls of the furnace and the burners are arranged in such a manner that half of the burners, that is the burners 7, when operated, will produce a helix of combustion gases extending in counter clockwise direction, as indicated by the arrows shown in FIG. 1, about the material or workpiece 4 to be heated, whereas the other half of the burners, that is the burners 8, will produce a helix about the material 4 rotating in clockwise direction as indicated by the arrows in FIG. 2. While FIGS. 1 and 2 illustrate only one burner 7 and one burner 8, it is to be understood that a plurality of burners 7 and a plurality of burners 8 are arranged respectively in the left and right side wall of the furnace spaced in longitudinal direction of the latter from each other.

The burners are high-speed burners of known construction of a type that the combustion gases leave the burners at a speed greater than 50 m/sec. The regulation of the temperatures within the furnace chamber is carried out not by throttling of the burners, but by switching them on and off, as will be set forth later on in detail to obtain the desired temperature regulation within the furnace chamber.

Referring now to FIGS. 3 and 4, it will be seen that the furnace illustrated therein is substantially the same as that shown in FIG. 1. The cross-sectional configuration differs somewhat, and the workpieces have smaller dimeters and are arranged in a stack on the support 5. However, these features are only obvious differences from the configuration of FIG. 1. However, while in the embodiment shown in FIGS. 1 and 2 only two burner groups 7 and 8 are provided, in the embodiment in FIGS. 3 and 4 there are four burner groups provided of which again half of the burner groups, that is the burners 7 located in the left side wall of the furnace and the burners 9 located in the bottom wall of the furnace in the region of the right side wall thereof, produce, when operated, a helix of combustion gases extending in counter clockwise direction about the material to be heated, as shown in FIG. 3, whereas the other half of the burner groups, that is the burners 8 in the right side wall of the furnace adjacent to the bottom wall and the burners 10 located in the bottom wall adjacent to the left side wall of the furnace will produce, when operated, a helix of combustion gases which extends in clockwise direction about the material to be heated, as shown in FIG. 4.

FIGS. 5 and 6, finally, show still a further embodiment. Again, the furnace in these figures is basically the same as in FIGS. 1 and 2 and will not be described further. The workpieces are of different configuration and are stacked in a different manner, as for instance shown in FIGS. 3 and 4, but this is evidently of no importance.

In the embodiment shown in FIGS. 5 and 6, there are, however, six burner groups of which again half of the burner groups will produce, when operated, a helix extending in clockwise direction about the material to be heated, whereas the other half of the burner groups will, when operated, produce a helix rotating in counter clockwise direction about the material to be heated.

As evident from FIG. 5, the burner groups which during operation produce a helix rotating in counter clockwise direction about the material to be heated are constituted by the burners 7 located in the left side wall adjacent to the bottom wall of the furnace, the burners 9 located in the bottom wall of the furnace adjacent to the right side wall, and the burners 11 located in the right side wall of the furnace adjacent to the top wall thereof, whereas, as evident from FIG. 6, the burner groups which will produce a helix rotating in clockwise direction about the material are constituted by the burners 10 located in the bottom wall of the furnace adjacent to its left side wall, the burners 8 located in the right side wall adjacent to the bottom wall of the furnace, and the burners 12 located in the left side wall adjacent to the top wall of the furnace.

The furnace may be subdivided into several temperature-regulating zones which are located one behind the other in the longitudinal direction of the furnace.

According to the present invention, the burner groups illustrated in the various embodiments are operated in the following manner.

During full-load operation of the furnace, especially during heating up of the furnace at the start of operation, all burner groups are simultaneously operated. During operation of the furnace at 50–99 percent of its full load, only the burners of the burner groups which produce a helix in one direction are operated for a first time interval, then the burners of all burner groups are simultaneously operated for a second time interval, and then the burners of the burner groups which produce a helix in the opposite direction are operated again for the first time interval, whereafter the burners of all burner groups are again operated for the second time interval.

In other words, in the embodiment shown in FIG. 1, the burners of the group 7 are first operated for the first time interval, and after for instance four minutes the burners of the groups 7 and 8 are simultaneously operated, subsequently thereto only the burners 8 are operated which produce a helix in clockwise direction

about the material, and then again both burner groups are simultaneously operated.

In a similar manner, in the embodiment shown in FIGS. 3 and 4, the burners of the burner groups 7 and 9 which produce a helix rotating in counter clockwise direction are operated for a first time interval, whereafter, for instance after four minutes, all burner groups are simultaneously operated, and subsequently thereto, only the burner groups 8 and 10 which will produce a helix rotating in clockwise direction about the material are operated for the first time interval, and then again all burner groups are simultaneously operated.

In the same manner, in the embodiment shown in FIGS. 5 and 6, the burners of the groups 7, 9 and 11 are operated for a first time interval, then all burners are simultaneously operated for a second time interval; subsequent thereto the burners of the groups 8, 10 and 12 are operated again for a first time interval, and then all burners are operated simultaneously.

Therefore, during switchover in which at least one of the burner groups is turned on or off, at least one of the other burner groups will be in operation so that sudden changes in pressure in the interior of the furnace chamber will be avoided.

At operation of the furnace at less than 50 percent of its full-load capacity, the burner groups which respectively produce a counter clockwise or clockwise helix about the material to be heated are alternately operated each for a predetermined time interval.

During operation of the furnace in the range of 50–99 percent of the full-load capacity, the abovementioned first time interval may be decreased and the second time interval correspondingly increased when the load at which the furnace is to be operated approaches full load, whereas when the load at which the furnace is to be operated approaches 50 percent of its full-load capacity, the first time interval is increased and the second time interval is correspondingly decreased.

In order to reduce also the pressure variations in the interior of the furnace further during operation of the furnace at less than 50 percent of its full-load capacity, the burners are divided into n burner groups of which $n/2$ burner groups will produce during operation a helix rotating in clockwise direction and the other half a helix rotating in counter clockwise direction, and the operation range of the furnace at less than 50 percent of its full load is divided into a plurality of load ranges increasing from a minimum to a maximum load range and, during operation within the smallest of the aforementioned load ranges only the burners of one group are intermittently operated, and this one group is cyclically changed within the $n/2$ burner groups so as to alternatingly produce a helix in the one and in the opposite direction, wherein in the next higher load range the burners of one group are intermittently operated, while at the same time the burners of an other group which produce a helix in the same direction as the burners of the one group are continuously operated, and wherein said one and said other group are cyclically changed within the $n/2$ burner groups, and so on, until in the highest load range, that is in the load range approaching 50 percent of the full-load capacity of the furnace, $n/2 - 1$ groups are continuously operated and only one group which produces a helix in the same direction is intermittently operated and where said one $n/2 - 1$ group and said one group are cyclically changed within the $n/2$ burner groups. The time T during which the burner groups are operated which produce a helix in the same direction is subdivided into $n/2$ time intervals and the cyclical change within the $n/2$ burner groups is performed at time intervals equalling $2T/n$.

Considering this mode of operation, the burner groups of the embodiment shown in FIGS. 3 and 4 may be operated in the following manner.

In the load range of 25–50 percent of full-load capacity, for instance, the burners of the burner group 8 may be operated as base load and the burners of the group 10 may be switched on and off so as to be operated as regulating load, and after passing of a time interval T1 the burners of group 10 are operated as a base load and the burners of group 8 are switched on and off to be operated as a regulating load. After a passage of a time interval T2, the burners of group 9 are switched on and off so as to be operated as a regulating load, and after passage of a time interval T1, the burners of group 9 are operated as base load, and the burners of group 7 as regulating load, whereafter the aforementioned cycle of operation is again repeated so that during the first half of the aforementioned cycle a helix rotating in clockwise direction about the material to be heated will be produced, whereas during the second half of the cycle a helix of combustion gases rotating in counter clockwise direction will be produced.

In the load range between 0 and 25 percent of the full load capacity of the furnace, the burner groups are operated in the following manner. First, the burners of the group 8 are operated as regulating loads by activating and deactivating these burners and after a time interval T1, the burners of the group 10 are operated as regulating load so that during these two periods of operation a clockwise rotating helix of combustion gases will be produced. After passing of time interval T2, the burners of group 7 are operated as regulating load, and after passing of a further time interval T the burners of group 9 are operated as a regulating load, whereafter the abovementioned cycle of operation is again repeated. The mentioned time intervals T1 and T2 may for instance each be 2 minutes so that as before in a time interval of 4 minutes the direction of rotation of the combustion gases about the material to be heated is changed.

With the embodiment as shown in FIGS. 5 and 6, the six burner groups shown therein may be operated in the following manner. When the furnace is to be operated at a load range between 0 and 16.60 percent of its full load, only one burner group is actuated and the time in which a helix of combustion gases rotating in one direction is to be produced is divided into three time periods, that is three equal time periods T1, T2 and T3, and during the time period T1 the burners of the group 7 are operated as regulating load, during the time period T2 the burners of group 9 are operated in this manner and during the time period T3 the burners of group 11 are operated as regulating load. Thereafter, the direction of rotation of the combustion gases about the material to be heated is reversed, and the burner groups 8, 10 and 12 are respectively operated for the time periods T1, T2 and T3. In the load range of 16.6 to 50 percent of the full-load range, one of the burner groups is operated as base load, two burner groups are operated as regulating load by switching the same on and off, whereby during the time period T1 the burner group 7 is operated as base load and the burner groups

9 and 11 as regulating load, during the time period T2 the burner group 9 is operated as base load and the burner groups 7 and 11 are operated as regulating loads, whereas during the time T3 the burner group 11 is operated as base load and the burner groups 7 and 9 as regulating loads. Subsequently thereto, the direction of rotation of the helix of combustion gases is again reversed, and the aforementioned cycle repeated.

During operation of the furnace illustrated in FIGS. 5 and 6 at a load range of 50–100 percent of full load, the burners of the groups 7, 9 and 11 may be operated as base load, and the burners of the groups 8, 10 and 12 as regulating load, whereafter the direction of rotation of the helix of combustion gases is reversed and the burners of the groups 8, 10 and 12 are operated as base load and the burners of the groups 7, 9 and 11 as regulating load.

Of course, it is also possible to subdivide the burners in some other manner, as long as the principle of maintaining the change of direction of rotation of the helix of combustion gases within predetermined time intervals and subdividing of the total load in base loads and regulating loads with a cyclical change of the loads is sustained.

If, as mentioned above, the furnace is subdivided into a plurality of regulating zones located one behind the other in the longitudinal direction of the furnace, care has to be taken that the change of rotational direction of the combustion gases is carried out at the same time and in the same direction for all regulating zones of the furnace.

The sequence and time of operation of the various burner groups as mentioned above is preferably automatically controlled by means of a temperature regulator which does not regulate the amount of fuel and air fed through the burners, but which regulates over a corresponding switching device the switching on and off of the various burners in the manner as described above.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of methods of regulating an elongated chamber furnace differing from the type described above.

While the invention has been illustrated and described as embodied in a method of regulating an elongaged chamber furnace in which a plurality of burners are arranged in a plurality of groups such that half the plurality of groups produce a helix of combustion gases rotating in one direction about the material to be heated in the furnace and the other half of the burner groups produce a helix rotating in the opposite direction, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letter Patent is set forth in the appended claims.

I claim:

1. A method of operating an elongated chamber furnace for heat treatment of material located in the furnace spaced from the wall thereof by high-speed burners arranged in n groups in such a manner that the impulses of the flames and combustion gases emanating from the burners of $n/2$ burner groups produce a helix of combustion gases rotating in one direction about the material to be heated and those from the remaining $n/2$ burner groups a helix rotating in the opposite direction about the material, said method comprising the steps of

operating, during full-load operation of the furnace, the burners of all burner groups simultaneously;

operating, during operation of the furnace at 50–99 percent of its full load, only the burners of $n/2$ burner groups which produce a helix in one direction for a first time interval, then operating the burners of all burner groups simultaneously for a second time interval, then operating the burners of $n/2$ burner groups which produce a helix in the opposite direction for a first time interval, then operating the burners of all burner groups simultaneously for a second time interval, the operating the burners of $n/2$ burner groups which produce a helix in the opposite direction for said first time interval, and then again operating the burners of all burner groups for said second time interval; and

during operation of the furnace at less than 50 percent of its full-load capacity, alternatingly operating the burners of said $n/2$ burner groups, each for a predetermined time interval.

2. A method as defined in claim 1, wherein during operation of said furnace at 50–99 percent of its full-load capacity, said first time interval is increased and said second time interval is correspondingly increased when the load at which the furnace is to be operated approaches 100 percent of the full-load capacity, whereas when the load at which the furnace is to be operated approaches 50 percent of its full-load capacity, said first time interval is increased and said second time interval correspondingly decreased.

3. A method as defined in claim 1, wherein n is an even number greater than 2, and wherein the load range of operation of the furnace at less than 50 percent of its full-load capacity is divided into a plurality of load ranges increasing stepwise from a minimum to a maximum load range, and wherein during operation within the smallest load range only the burners of one group are intermittently operated, and said one group is cyclically changed within the $n/2$ burner groups so as to alternatingly produce a helix in the one and in the opposite direction, wherein in the next load range the burners of one group are intermittently operated while at the same time the burners of another group which produce a helix in the same direction as the burners of the one group which are intermittently operated, are continuously operated, and wherein said one and said another group are cyclically changed within the $n/2$ burner groups, and so on, until in the highest load range $(n/2) - 1$ groups are continuously operated and only one group which produces a helix in the same direction as the $(n/2) - 1$ burner groups is intermittently operated, and wherein said $n/2 - 1$ groups and said one group are cyclically changed within the $n/2$ burner groups, and wherein the time T during which the burner groups are operated which produce a helix in the same direction is subdivided into $n/2$ time intervals

and wherein the cyclical change within the $n/2$ burner groups is performed in time intervals equalling $2T/n$.

4. A method as defined in claim 3, wherein in the load range between 50–100 percent of the full load the burners of the $n/2$ burner groups which produce a helix in one direction are operated as base load and the burners of the remaining $n/2$ burner groups which produce a helix in the opposite direction are operated as regulating load and wherein a change of operation of the burner groups as base load or as regulating load is carried out in the time interval T.

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