The apparatus consists of a suspension preheater with a calcining burner, a rotary kiln, a planetary type multicylinder precooler installed into a unitary construction with the rotary kiln and a main cooler and it aims to take away many problems and defects caused by the conventional system having production capacity more than several thousand tons per day.
ROTARY KILN APPARATUS WITH SUSPENSION PREHEATER HAVING BURNER FOR CALCINING

The present invention relates to a large capacity rotary kiln apparatus with a suspension preheater in which a secondary burner or burners (hereinafter called a calcining burner) is installed.

In order to burn raw materials in the form of powder, especially that of Portland cement clinker, an installation consisting of a combination of a rotary kiln with a suspension preheater (hereinafter called SP kiln or SP apparatus) and a grate type cooler had been employed because its thermal efficiency is high and a large production capacity could be easily obtained by one unit. Recently there has been devised and demonstrated a rotary kiln with a suspension preheater in which a calcining burner is installed and the endothermic reaction of raw materials is substantially accomplished hereafter called SCP kiln or SCP apparatus so that the burning through-put of the rotary kiln may be doubled in comparison with the conventional SP kilns. In general the bigger the size of rotary kilns becomes, the shorter the service life of refractory materials considerably, but the SCP apparatus makes it possible to double the production with a same rotary kiln in size which had been used for SP kilns.

However the conventional SCP apparatus with a grate cooler still have many problems and defects, especially on the clinker cooler and the height of apparatus as the production capacity being increased.

One of the objects of the present invention is therefore to provide an improved SCP kiln which may substantially eliminate the problems and defects encountered in the conventional SCP kilns.

The objects, features and advantages of the present invention will become more apparent from the following description of one preferred embodiment thereof taken in conjunction with the accompanying drawing.

Fig. 1 is a diagrammatic view partly in section of a conventional SCP kiln;

Fig. 2 is a diagrammatic view, partly in section, of a rotary kiln installation in accordance with the present invention; and

Fig. 3 is a graph illustrating the clinker cooling speeds attained by the kiln installation shown in Figs. 1 and 2.

Same reference numerals are used to designate similar parts throughout the figures.

Prior to the description of the preferred embodiment of the present invention, a conventional SCP apparatus with a clinker cooler will be described briefly in order to distinctly point out the problems and defects thereof.

Raw materials charged into a suspension preheater 1 from a feed port I of the uppermost stage is heated by higher temperature gas as they flow down from one stage to the next. To a calcining burner 5 installed at the lowermost stage of the suspension preheater is supplied a high temperature combustion air induced from a clinker cooler 3 through a secondary air duct 82. As a result the endothermic reaction of raw materials is substantially completely accomplished whereas in the conventional SP apparatus the reaction takes place about 40% in the preheater. Thereafter raw materials are sent to a rotary kiln 2 and burnt to cement clinker which is then discharged upon a grate 6 in the grate type clinker cooler 3. While clinker is transported toward the discharge end II by the reciprocate movement of the grate 6, it is cooled by cooling air which is sent by a blower 7 so as to pass through the clinker bed from the under side of the grate 6 of the cooling air which has been heated up by the clinker, the highest temperature air is induced into the rotary kiln 2 through the hood connecting the cooler with the kiln as combustion air of a kiln burner 4, and the next highest temperature air is induced to the suspension preheater 1 through a vent port 8 as combustion air of the calcining burner 5 by way of a dust collector 81 for clinker dust removal and the secondary air duct 82. The remaining air is discharged through a vent 9 of the clinker cooler 3 to the atmosphere after it has been treated by a dust collector (not shown).

In the conventional apparatus air velocity in the secondary air duct is generally higher than gas velocity in the kiln from the economical reasons and in addition the dust collector 81 is installed so that the secondary air flow system needs higher draft resistance than the kiln gas flow system. The kiln gas flow system of the suspension preheater 1 is provided with an orifice 83 (a narrowed gas passage) so as to keep balance of the draft between two flow systems. In place of the orifice a fan may be installed in the secondary air duct 82 but it is not practical method in view of its durability because a high temperature air with some clinker dust has to be handled. The clinker dust caught by the collector 81 is returned to cooler 3.

In the SCP apparatus of the type described, even when it is of a very large size, the service life of the refractory materials can be elongated so that the apparatus may be operated continuously for a long period of time because the thermal load of the rotary kiln may be considerably reduced due to the effects of the calcining burner in the preheater as compared with the conventional SP kilns. However in the grate type clinker cooler of a large size unit the impact of clinker being dropped from the rotary kiln and the thermal load are increased. Therefore the wear and abrasion of the grate at the high temperature portion thereof are remarkably increased. The width of the grate cannot be increased in proportion to the capacity of the rotary kiln because if it is increased the formation of clinker bed the grate is adversely affected. On the other hand the speed of the grate cannot be also increased in proportion to the capacity because the abrasion and wear of the grate are much enhanced. As a result the thickness of the clinker layer upon the grate must be increased gradually according to the enlargement of the size of the apparatus so that the power consumption of the blower for cooling air is increased due to a pressure loss of thicker clinker layer or bed.

Therefore the decrease of durability of a grate cooler, especially of its grate plates, presents a very serious problem when the capacity of the apparatus must be increased. A planetary type multicilinder cooler is of greater advantage to the durability, but all air which is used for cooling the clinker must be induced into a kiln from the construction view point so that it is not applicable for the SCP apparatus of the type described hereinbefore. Furthermore a planetary type multicilinder cooler is inferior in rapid and complete cooling effects of clinker to a grate type cooler. Moreover in the conventional SCP apparatus the orifice must be installed in the kiln gas flow system as described herein before so as to keep balance of the draft between two flow systems and it is indispensable that the power con-
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Assumption of the apparatus is increased regardless of the orifice.

In view of the above the primary object of the present invention is to provide a SCP apparatus with a cooler which may substantially eliminate the problems and defects encountered in the conventional apparatus and which may serve to increase the capacity of the apparatus and to decrease the height thereof. Briefly stated the apparatus of the present invention is characterized by a planetary type multicylinder precooler assembled into a unitary construction with a rotary kiln so that combustion air required by a kiln burner is induced through the cylinders of said precooler and that when the cylinders of said precooler pass the highest point, clinker in the cylinders is discharged to a main cooler.

According to one preferred embodiment of the present invention, between the precooler and the hot end of the main cooler is interposed an inclined surface for charging clinker and/or a clinker pocket, and the rotary kiln and the main cooler are disposed horizontally and in series.

The apparatus of the present invention shown in FIG. 2 is similar to the conventional apparatus shown in FIG. 1 except that high temperature clinker is cooled by a planetary type multicylinder precooler 31 assembled into a unitary construction with the rotary kiln 2 and a main cooler 32 joined to the planetary type multicylinder precooler 31. Combustion air of ambient temperature and of the quantity required for the combustion of a rotary kiln burner 4 is induced through the cylinders of the planetary type multicylinder precooler 31 so that high temperature clinker in each cylinder is rapidly cooled or quenched before it is discharged into the main cooler 32. In the main cooler 32 which is of the grate type, clinker is completely cooled, and preheated air of the quantity required for the combustion of a calcining burner 5 is induced through the dust collector 81 and the secondary air duct 82 into the suspension preheater 1 so as to improve its thermal efficiency. Of cooling air sent from the blower 7 to the main cooler 32, the remaining air is discharged to the atmosphere through the vent 9 and the dust collector (not shown).

Next the mode of operation of the apparatus of the present invention will be described in more detail hereinafter. Assuming that the ratio of the fuel oil to be supplied to the rotary kiln burner 4 and the calcining burner 5 of the suspension preheater 1 is 4:6, and clinker discharged from the rotary kiln 2 into the precooler 31 at the temperature of about 1,300°C, the clinker is cooled rapidly by air of ambient temperature, let say 20°C, induced into the cylinders of the precooler 31 due to the draft of the rotary kiln 2 at a rate of 0.3 Nm³/kg of clinker. Thus clinker may be cooled to 900°C before it was discharged into the main cooler 32, whereas combustion air preheated to about 900°C may be induced into the rotary kiln 2. Clinker discharged into the grate type main cooler 32 from the precooler 31 may be cooled completely to about 60°C by cooling air of ambient temperature supplied at a rate of about 2.4 Nm³/kg of clinker, whereas combustion air preheated to about 600°C may be induced through the second air duct 82 into the suspension preheater 1 at a rate of 0.6 Nm³/kg of clinker, and the remaining air of about 190°C may be discharged through the vent 9 at a rate of 1.8 Nm³/kg of clinker.

It is generally required that clinker discharged from a rotary kiln is rapidly cooled to 1,000°C in order to obtain clinker of better quality. In a planetary type multicylinder cooler provided with a conventional SP kiln, the cooling speed of clinker is shown by the curve a in FIG. 3 when clinker is cooled by cooling air at a rate of 0.9 Nm³/kg of clinker, whereas the air is preheated as indicated by the curve b in FIG. 3. In case of grate cooler operated by cooling air at a rate of about 2.7 Nm³/kg of clinker the cooling speed is shown by the curve c in FIG. 3. It is clear that the clinker is cooled more rapidly and completely by a grate cooler than by a planetary type multicylinder cooler.

According to the present invention, high temperature clinker is rapidly cooled in the planetary type multicylinder precooler along the cooling curve e between the points A and B in FIG. 3 so that the discharged clinker may be cooled to 900°C. On the other hand combustion air for a kiln burner may be preheated along the curve d. Therefore it is seen that the rapid cooling efficiency of the planetary type multicylinder precooler of the present invention is substantially similar to that of a grate cooler. Furthermore according to the present invention the clinker charged to the main cooler is further cooled along the curve b from the point B to the point C where temperature may be about 60°C.

Next the construction of the apparatus of the present invention will be described in more detail hereinafter. Since clinker is rapidly cooled to 900°C by the planetary type multicylinder precooler, which is constructed with no consumable part such as a grate, before it is charged to the grate type main cooler, the thermal load of the main cooler is remarkably reduced.

There has been devised and demonstrated an inclined charging surface disposed at the hot end of the grate cooler in order to prevent the grate from being directly exposed to the impact of the clinker discharged from the rotary kiln and also to facilitate the formation of a bed of layer of clinker on the grate. However in practice clinker discharged from the kiln in liquid phase partially so that it adheres to and grows on the inclined surface thus causing troubles. However in the apparatus of the present invention which is to be discharged into the main cooler 32 is rapidly cooled by the precooler 31 to at least less than 1,000°C at which temperature clinker is already on solid phase at its surface and has no adhesive nature. Therefore an inclined surface 10 and/or a clinker pocket 11 can be disposed at the hot end of the main cooler 32 without difficulties in order to absorb the impact of clinker charged onto the grate and at the same time to uniformly spread clinker over the whole width of the grate, thereby forming a desired bed or layer of clinker.

According to the present invention a weir 12 is disposed at the discharged end of each cylinder so that clinker in each cylinder is discharged from the precooler 31 into the main cooler 32 at the highest position of the cylinder, that is the vertex of the rotation of the cylinder, and the main cooler 32 is installed substantially in horizontal relation with the rotary kiln 2 and the precooler 31 so that the overall height of the apparatus may be decreased by about 10 m in comparison with the conventional apparatus of the type shown in FIG. 1.

Furthermore in comparison with the conventional planetary type multicylinder cooler of the SP kilns, the average temperature difference between clinker and cooling air becomes 1.5 times and the heat capacity to be exchanged in the cooler is only about 40% because
clinker is cooled from about 1,300°C to about 900°C by air of ambient temperature in the planetary type multicylinder precoolor in accordance with the apparatus of the present invention. As a result the size of the cooler may be reduced from ½ to ¼ so that even when the capacity of the apparatus is increased the precoolor may be installed in a cantilever manner upon the discharge end of an extended shell of the rotary kiln without any additional support.

Next the electric power consumption will be explained. In general cooling air is sent into a grate type cooler with forced draft so as to pass through a bed of clinker. Therefore by the grate cooler having capacity of 100 to 150 tons clinker per hour the power consumption of the blower may be 5 KWH/t of clinker which is considerably greater as compared with other coolers. Furthermore the higher the temperature of clinker, the higher the permeable resistance of the clinker bed or layer becomes. However according to the present invention clinker of a high temperature zone is rapidly cooled in the planetary type multicylinder precoolor whose draft resistance is very small and the draft resistance of the precoolor which must be added to the kiln gas flow system may be well covered by the delation of a said orifice which has been installed regardlessly in the preheater of the conventional SP apparatus. Therefore the precoolor of the present invention does not bring any additional power consumption. In comparison with the conventional apparatus with a grate type cooler of a capacity mentioned above, the power consumption of the blower for cooling air in the present invention may be reduced to 1.5 KWH/t of clinker.

In the conventional grate cooler provided with the conventional SP or SCP kiln installation, the greater the capacity of the rotary kiln, the greater the thickness of the clinker bed or layer or the grate becomes as described hereinafore. However in the installation of the present invention the sloped surface 10 and/or the clinker pocket 11 is so arranged as to prevent the grate from being exposed to the impact of clinker and to facilitate the uniform distribution of clinker over the grate. Therefore the thickness of the clinker bed or layer will not be increased as the capacity of apparatus being enlarged. As a result the power consumption of the blower may be saved by the apparatus of the present invention as much as 2.0 KWH/t of clinker in case of the installation of a large capacity.

Furthermore when it is not required to cool clinker to a temperature of less than 100°C, a double pass method can be applied for the main cooler as a preferred embodiment of the present invention. In this case the cooler chamber above the grate is divided into two zones, i.e. a high and a low temperature zones, and cooling air is supplied to respective zones by two independent fans. Cooling air supplied to the low temperature zone is vented from a vent port and sent to the suction side of the cooling air fan for the high temperature zone by way of a dust collector. Thus clinker of high temperature zone is cooled by vent air from the low temperature zone. By the double pass method, a heat recuperative efficiency is raised and air pollution caused by wasting vent air can be solved completely, so it has been devised and demonstrated also by the conventional SP kilns but it was not practical because the grate at the high temperature zone had been overheated and service life of the grate had been shortened remarkably. In the present invention, however, clinker which is cooled to about 900°C by the precoolor is supplied to the main cooler so that the grate will not be overheated and thus features and objects of said method can be fully displayed. Under the said criteria of clinker temperature a counterflow type rotary cooler may also be used instead of the grate type cooler so that the power consumption may be further decreased and the wasting of vent air to the atmosphere may be eliminated. When the double pass method of the grate type cooler or the counter flow rotary cooler is used as the preferred embodiment of the present invention the effects, herein mentioned, such as mitigation of thermal load of the main cooler, the overall height of the apparatus, etc. may be fully achieved.

The features and advantages of the present invention may be summarized as follows:

1. The planetary type multicylinder precoolor, which is installed into a unitary construction with the rotary kiln, may rapidly cool clinker below 1000°C only by air which is used as preheated combustion air for the rotary kiln. The precoolor is simple in construction and adapted to be used with a rotary kiln installation of a large capacity.

2. The inclined surface and/or the clinker pocket are provided at the hot end of the main cooler so as to prevent the grate from being directly exposed to the impact of clinker and also to facilitate the uniform distribution of clinker over the whole width of the grate. Furthermore the thermal load of the main cooler is reduced because of the installation of the precoolor. As a result the durability of the grate type main cooler is not lowered even when the capacity of the rotary kiln installation is increased.

3. The weir is attached to the discharge end of the precoolor so that clinker may be discharged into the main cooler only when each cylinder of the precoolor reaches the highest position or the vertex of the rotation. Therefore the rotary kiln and the main cooler may be installed horizontally and in series so that the overall height of the rotary kiln installation of the present invention may be reduced by about 10 meters as compared with the conventional installation.

4. Since the average temperature difference between clinker and cooling air in the precoolor is large and the quantity of heat exchange is less, the precoolor may be mounted upon the discharge end of the extended shell of the rotary kiln in a cantilever manner. Therefore opposed to the planetary type multicylinder cooler used in the conventional SP kilns of a large capacity it is not required to provide any support for the precoolor.

5. Clinker of high temperature whose permeable resistance is high is rapidly cooled in the planetary type precoolor, so that even when the grate type main cooler is employed the economy of the power consumption of 1.5 – 2 KWH/t of clinker may be attained.

6. When it is not required to cool clinker to a temperature of less than 100°C, a double pass method of the grate type cooler or a counter flow rotary cooler can be applied so as to improve the heat recuperative efficiency and to eliminate the wasting of cooler vent air.

Thus the present invention may provide a SCP rotary kiln installation with precoolor which may eliminate the problems and defects encountered in the conventional installations when its capacity must be increased and which may decrease the overall height thereof.
What is claimed is:
1. Apparatus of the type having a suspension pre-heater to which powdery raw materials are supplied and also having a calcining burner, a rotary kiln for receiving the raw materials and including a burner for burning the raw materials to cement clinker and also including a discharge end for the clinker, and a planetary type multicylinder pre-cooler associated with said discharge end comprising a plurality of cylinders arranged in a circle concentric with the kiln, said cylinders extending parallel to the kiln longitudinal axis and having means at its outlet ends to provide direct communication with the atmosphere and having its inlet ends communicating with said discharge end, the outlet ends of each cylinder being provided with an upstanding weir means arranged to allow discharge of clinker only when the cylinders approach the highest position of rotation and a main cooler having an inlet for receiving clinker from the outlet ends of the cylinders and a vent port connected with the calcining burner.
2. Apparatus as set forth in claim 1 wherein an inclined surface and a clinker pocket are arranged at the inlet of the main cooler.
3. Apparatus as set forth in claim 2 wherein the rotary kiln and main cooler are arranged horizontally and in series and clinker is discharged into the main cooler when each cylinder of the pre-cooler passes the highest position of rotation.