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(54) **Differential cooling system for control of thermal profile of work rolls in cold reversing mill**

(57) A differential cooling system for the control of the thermal profile of work rolls in a cold reversing mill of a steel plant comprises headers (9A and 9B) for applying coolant on a top back up roll (12A) optionally, headers (10A and 10B) for applying coolant on a top work roll (3A), headers (11A and 11B) for applying coolant on a bottom work roll (3B) at the entry side (E) and delivery side (D) respectively of each said roll. Each of the headers is provided with a row of nozzles spaced along the length thereof and directed towards the surface of the corresponding roll along the length thereof and with pipe lines (4A,4B,4C) with gate valves(15A, 15B,15C) at the entry side and pipe lines (5A,5B,5C) with gate valves (16A,16B,16C) at the delivery side. The pipe lines are connected via pipe lines (17 and 18) respectively to a common pipe line (19) into which the coolant in the form of an emulsion of 2% by weight of oil in water prepared in a tank (1) having an agitator (2) is supplied by means of a centrifugal pump (3) via a pressure relief valve (4), pressure gauge (5), non-returnable valve (6), emulsion filter (7), and gate valve (8). The used coolant is collected in a pit (13) from which the same is returned to the tank (1) via a pipe (14) and an emulsion filter (19A). The nozzles have three-piece dovetail construction and are disposed along each header for producing a flat spray of coolant with the broad side lying along the length of each work roll. The inter-nozzle spacing on the headers is set to provide differential flow density of coolant in accordance with the

temperature gradient built up in the rolls. The number of nozzles provided in each header for applying coolant on the top and bottom work rolls is reduced to 13 from 18 provided in the existing system. The pipe lines are of reduced length and number of bends compared to the existing system.

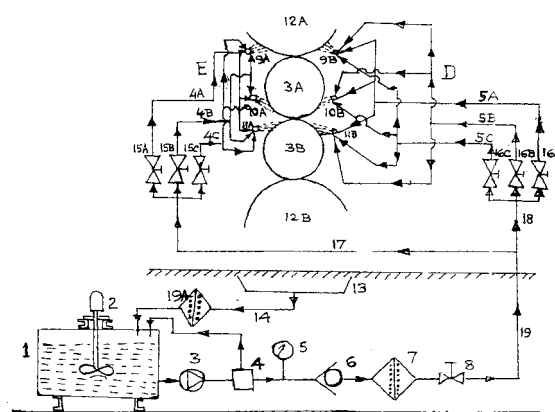


Fig.2

Description

[0001] The present invention relates to a differential cooling system for the control of the thermal profile of work rolls in a cold reversing mill.

[0002] The invention relates more particularly to a system in which the rate of cooling of the work rolls is varied along their length in accordance with the temperature gradient therein so that the rolls are cooled uniformly throughout their entire length and thereby the buckling of the rolled steel strips caused by temperature variation along the length of work rolls is prevented and the frequency of failures/spallings of the work rolls owing to the increased wear in the relatively hot parts thereof is reduced with an overall economy achieved in the operation of the mill.

[0003] In the existing system, coolant in the form of an emulsion of oil in water is applied at a uniform flow rate and pressure through nozzles producing sprays of round shape distributed at short intervals along the length of rolls by means of a centrifugal pump having the rated capacity of pumping the coolant at 4500 litre per minute (1pm) at a pressure of up to 10 bar. A total number of 100 nozzles are used, of which 18 nozzles are provided on the entry side as well as the delivery side of each of two work rolls and 7 nozzles are provided on the entry side as well as the delivery side of each of two back up rolls. Because of the use of such a large number of nozzles and application of coolant at a uniform rate along the length of each roll, the coolant is applied on the rolls at a relatively low rate of 0.8 1pm and low pressure of 4 bar and alternately on the entry side and delivery side of each roll in order that the rated capacity of the pump used is not exceeded. As a result the variation of the temperature from the hottest central part to the coldest end parts of the work rolls is found to be appreciable i.e. from 73°C to 58°C, and consequently the percentage of buckled strips produced and failures of rolls caused by increased wear at the central parts thereof is high i.e. above 40%.

[0004] The aim of the present invention is to provide an improved system for cooling work rolls uniformly along their entire length to a temperature of around 58°C using the centrifugal pump of rated pumping capacity as used in the existing system.

[0005] Another aim is to reduce the percentage of buckled steel strips produced.

[0006] Yet another aim is to reduce the percentage of spallings of work rolls caused by non-uniform wear along their length.

[0007] A still further aim is to reduce friction at the nip of work rolls and save thereby the electrical energy required for driving the rolls.

[0008] According to the invention, there is provided a differential cooling system for the control of the thermal profile of work rolls in a cold reversing mill of a steel plant comprising headers (9A and 9B) for applying coolant on a top back up roll (12A) optionally, headers (10A and

10B) for applying coolant on a top work roll (3A), headers (11A and 11B) for applying coolant on a bottom work roll (3B) at the entry side (E) and delivery side (D) respectively of each said roll, each said header being provided with a row of nozzles spaced along the length thereof and directed towards the surface of the corresponding roll along the length thereof and with pipe lines (4A,4B,4C) with gate valves(15A,15B,15C) at the entry side and pipe lines (5A,5B,5C) with gate valves (16A, 16B,16C) at the delivery side, both said pipe lines being connected via pipe lines (17 and 18) respectively to a common pipe line (19) into which coolant in the form of an emulsion of 2% by weight of oil in water prepared in a tank (1) having an agitator (2) is supplied by means of a centrifugal pump (3) via a pressure relief valve (4), pressure gauge (5), non-return valve (6), emulsion filter (7), and gate valve (8), the used coolant being collected in a pit (13) from which the same is returned to the tank (1) via a pipe (14) and an emulsion filter (19A), characterized in that -

(a) the nozzles are each of three-piece dovetail construction and are disposed along each header for producing a flat spray of coolant with the broad side lying along the length of each work roll;

(b) the inter-nozzle spacing on the headers is set to provide differential flow density of coolant in accordance with the temperature gradient built up in the rolls;

(c) the number of nozzles provided in each header for applying coolant on the top and bottom work rolls is reduced to 13 from 18 provided in the existing system; and

(d) the pipe lines are made of reduced length and number of bends compared to the existing system.

[0009] In the invented system the coolant is applied at a differential flow density varying according to the temperature gradient along the length of the rolls by adjusting inter-nozzle spacing, using nozzles capable of producing flat dovetail like sprays to cover a larger length of the rolls by the individual nozzles compared with the nozzles used in the existing system and reducing thereby the number of nozzles for each work roll by about 30% of the number of nozzles used in the existing system, applying coolant optionally on the top back up roll, eliminating application of coolant on the bottom back up roll and applying coolant simultaneously on both the entry side and delivery side of each work roll.

[0010] The invention is described fully and particularly in an unrestricted manner with reference to the accompanying drawings in which :

Figure 1 is a schematic layout of pipe connections and nozzles for applying the coolant along the roll

length at the entry side and delivery side thereof;

Figure 2 is a schematic layout of the headers for applying coolant on the top back up roll and each of the top and bottom work rolls ;

Figure 3 shows the variation of coolant flow density along the length of each work roll in the invented system (A) and existing system (B) ; and

Figure 4 shows the temperature variation along the cooled work roll length in the invented system (A) and existing system (B).

[0011] Referring to Fig. 1, headers (10A and 10B), each having a row of nozzles (10C and 10D) distributed thereon and directed towards the roll surface along the length thereof, are connected to pipe lines (4A,4B,4C) on the entry side (E) and to pipe lines (5A,5B, 5C) on the delivery side (D).

[0012] Referring to Fig. 2, headers (9A and 9B) are provided for applying coolant on the top back up roll (12A) when required, headers (10A and 10B) are provided for applying coolant on the top work roll (3A) and headers (11A and 11B) are provided for applying coolant on the bottom work roll (3B) from the entry side (E) and the delivery side (D) respectively of the rolls, through pipe lines (4A,4B and 4C) via gate valves (15A,15B and 15C) at the entry side and through pipe lines (5A,5B and 5C) via gate valves (16A,16B and 16C) at the delivery side, through pipe lines (17 and 18) respectively, which are connected in turn to a common pipe line (19) into which the coolant in the form of an emulsion of water and 2-3% by weight of oil prepared in a tank (1) having an agitator (2) is supplied by means of a centrifugal pump (3) via a pressure relief valve (4), pressure gauge (5), non-return valve (6), emulsion filter (7) and gate valve (8). The used coolant is collected in a pit (13) wherefrom the same is allowed to return to the tank (1) via a pipe (14) and an emulsion filter (19A). The pipe lines used are of reduced length and number of bends compared to the existing system for lowering the resistance to the flow of coolant therethrough and thereby increasing the flow density of the coolant applied on the rolls without increasing the rated pumping capacity of the pump used.

[0013] The nozzles provided in each header are capable of producing flat sprays having their broad sides directed along the length of each roll. Each nozzle is of three piece dovetail construction and capable of producing a spray of the coolant at 45° angle, 63.25 lpm flow rate and 5 bar pressure. Because of the flat shape of the sprays produced by each nozzle the separation between the adjacent nozzles on a header is increased, requiring thereby a lesser number of nozzles, say, 13 in each of the four headers used for the two work rolls, instead of 18 as used in the existing system for applying the coolant on the work rolls.

[0014] In the invented system, the headers on both the entry and delivery sides of the work rolls are operated simultaneously instead of alternately as in the existing system. Because of the reduced number of nozzles used in the invented system and adjustment of inter-nozzle spacing, the coolant can be applied at an increased flow density of up to 1.6 lpm/mm at the central part, 1.4 lpm/mm at the intermediate part towards each end and at 1.2 lpm/mm at each end part along the length of each work roll, by means of a centrifugal pump of rated pumping capacity i.e. a flow rate of 4500 lpm and pressure of 10 bar. The central hottest part of each work roll is thereby cooled at the fastest rate, the intermediate part towards each end having lower temperature than the central part is cooled at a lower rate and each end part having the lowest temperature is cooled at the lowest rate. Because of this differential cooling rates for different parts of the roll length, the roll is cooled to attain a uniformly low temperature along its entire length.

[0015] Referring to Fig. 3, the variation in the coolant flow density on each work roll in the invented system is illustrated in line (A) from which it is noted that the central zone (1) is cooled by applying the coolant at a flow density of 1.6 lpm/mm, each of two intermediate zones (2 and 3) is cooled by applying the coolant at a flow density of 1.4 lpm/mm and each of two end zones (4 and 5) is cooled by applying the coolant at a flow density of 1.2 lpm/mm, each of said three zones i.e. central, intermediate and end having varying proportion of the roll length. Line (B) in Fig. 3 illustrates that all of the said zones (1,2,3 4 and 5) of a work roll are cooled in the existing system by applying the coolant at a uniform flow density of 0.8 lpm/mm which is appreciably lower in comparison with even the lowest flow density 1.2 lpm/mm used in the invented system.

[0016] The pressure at which the coolant is applied on the work roll is 6 bar which is appreciably higher than the pressure of 4 bar at which the coolant is applied on the work roll in the existing system.

[0017] Referring to Fig. 4, the temperature of the roll cooled in the invented system shown by line (A) is uniform at about 58°C along almost its entire length except near the two extreme ends thereof where the temperature drops to around 55°C. The temperature of the roll cooled in the existing system shown by curve (B) is appreciably non-uniform along the roll length, being around 73°C at the central part and 58-60°C near the two ends. Because of this relatively wide variation in temperature along the roll length cooled in the existing system the buckling of the rolled strips and wear of the rolls in the hottest part thereof are appreciable, leading to a high percentage of subgradation of the buckled strips and failures/spallings of the differentially worn work rolls with an adverse effect on the economy of the mill.

[0018] The comparative performance tests conducted on the invented and existing systems of cooling work

rolls have shown the following advantages of the invented system over the existing system :-

1. The temperature of the rolled strips is reduced to 65-80°C against 100-140°C.
2. The roll failure is lowered by about 44%.
3. Diversion of buckled strips is less by 50%.
4. Consumption of electrical energy for driving work rolls is reduced by 10%.

Claims

1. A differential cooling system for the control of the thermal profile of work rolls in a cold reversing mill of a steel plant comprising headers (9A and 9B) for applying coolant on a top back up roll (12A) optionally, headers (10A and 10B) for applying coolant on a top work roll (3A), headers (11A and 11B) for applying coolant on a bottom work roll (3B) at the entry side (E) and delivery side (D) respectively of each said roll, each said header being provided with a row of nozzles spaced along the length thereof and directed towards the surface of the corresponding roll along the length thereof and with pipe lines (4A, 4B, 4C) with gate valves (15A, 15B, 15C) at the entry side and pipe lines (5A, 5B, 5C) with gate valves (16A, 16B, 16C) at the delivery side, both said pipe lines being connected via pipe lines (17 and 18) respectively to a common pipe line (19) into which coolant in the form of an emulsion of 2% by weight of oil in water prepared in a tank (1) having an agitator (2) is supplied by means of a centrifugal pump (3) via a pressure relief valve (4), pressure gauge (5), non-return valve (6), emulsion filter (7), and gate valve (8), the used coolant being collected in a pit (13) from which the same is returned to the tank (1) via a pipe (14) and an emulsion filter (19A), characterized in that -

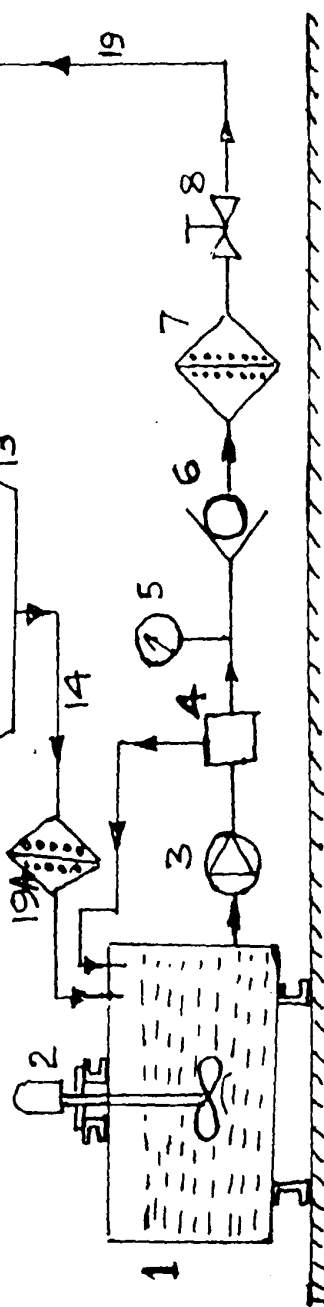
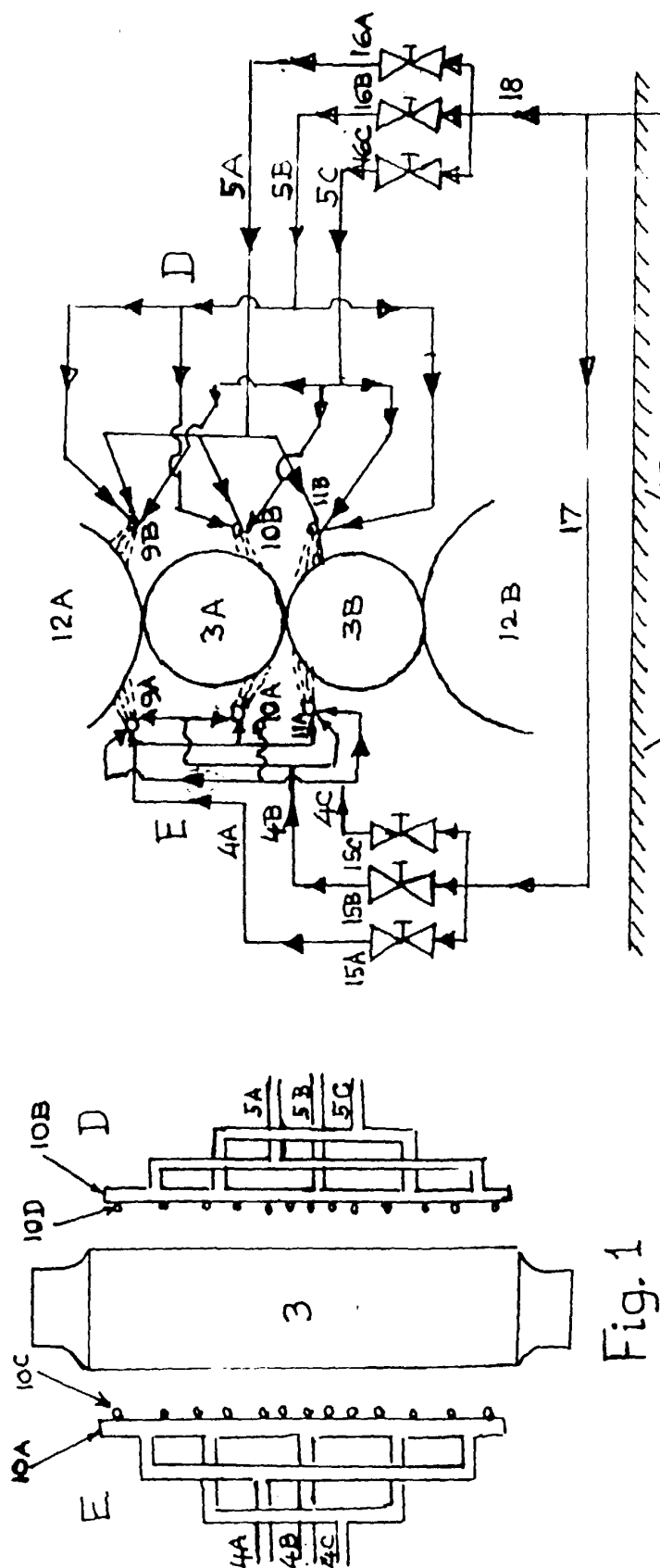
(a) the nozzles are each of three-piece dovetail construction and are disposed along each header for producing a flat spray of coolant with the broad side lying along the length of each work roll;

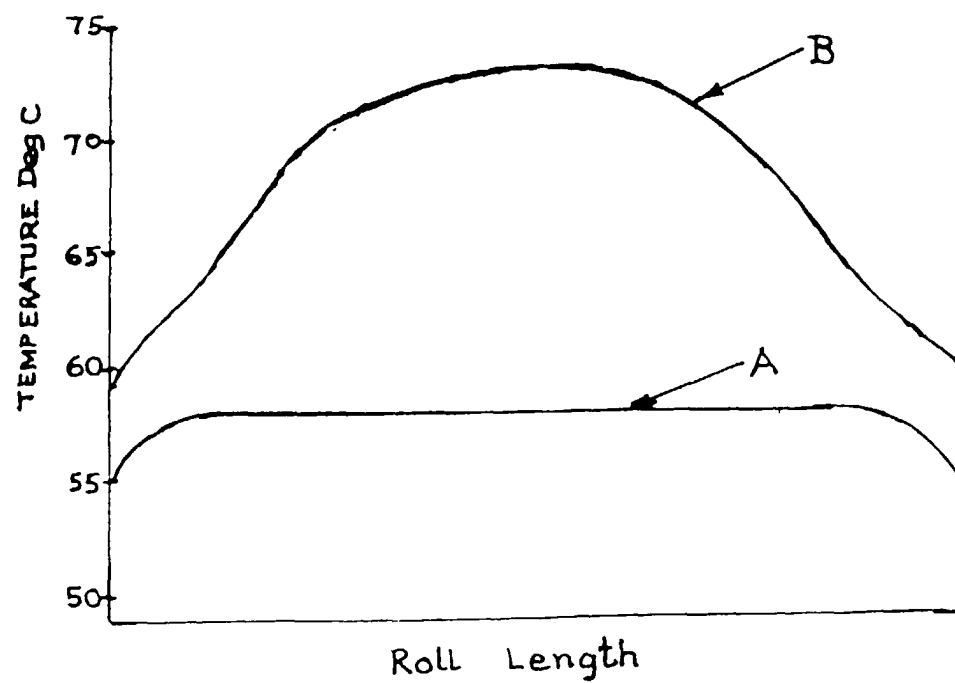
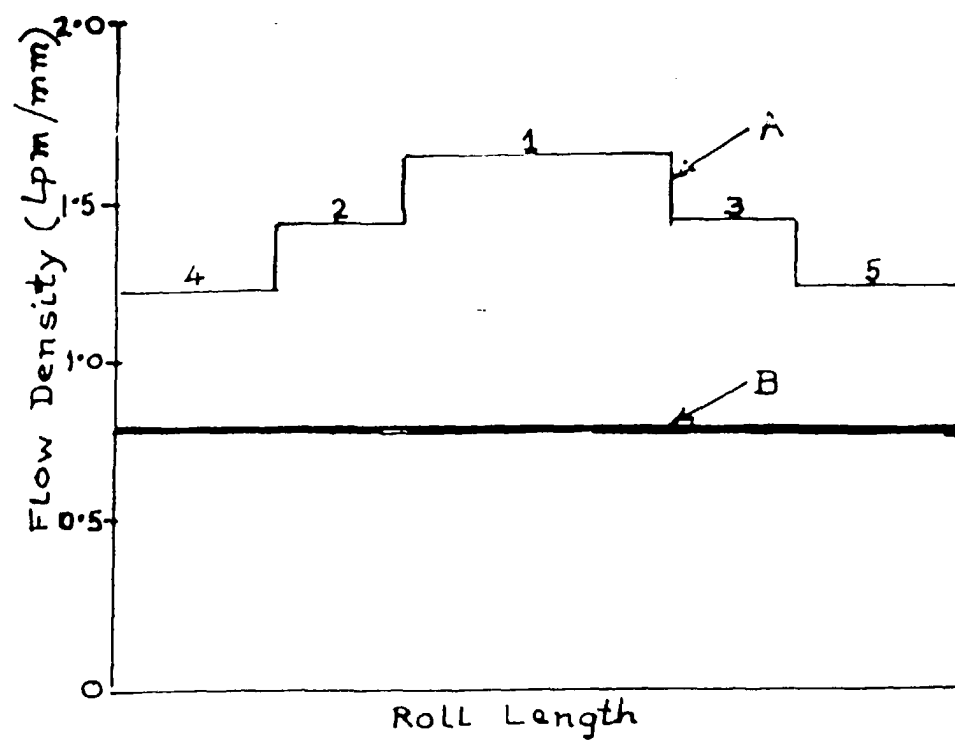
(b) the inter-nozzle spacing on the headers is set to provide differential flow density of coolant in accordance with the temperature gradient built up in the rolls;

(c) the number of nozzles provided in each header for applying coolant on the top and bottom work rolls is reduced to 13 from 18 provided in the existing system; and

(d) the pipe lines are made of reduced length and number of bends compared to the existing system.

2. The system as claimed in claim 1, characterised in that the nozzles are each capable of producing a coolant spray at 45° angle, 63.25 lpm flow rate and 5 bar pressure.
3. The system as claimed in claim 1 or claim 2, characterised in that the inter-nozzle spacing on the headers is set to produce a flow density of 1.6 lpm/mm at the central zone, 1.4 lpm/mm at each of two intermediate zones towards the end and 1.2 lpm/mm at each of the two end zones of each work roll, each said zone constituting approximately one-third of the total length of a roll.







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EUROPEAN SEARCH REPORT

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Place of search THE HAGUE		Date of completion of the search 31 August 1999	Examiner Plastiras, D
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EUROPEAN SEARCH REPORT

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CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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