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(54) Method and apparatus for thermo-mechanical controlled rolling of metal plates and strips

(57) Method for thermo-mechanical controlled rolling of metal slabs to plates or strips, in which for two successively rolled slabs the time gap between the starts of their rolling phases 1 is always smaller than the sum of the duration of all rolling phases and all cooling phases of the rolling pattern, and in which during rolling the batch it occurs on at least one rolling mill stand several times that a rolling phase applied to one slab or plate or strip is succeeded by a different rolling phase applied on another slab or plate or strip. In the apparatus for thermo-mechanical rolling according to that method the number of storage positions is half the interleave depth of the performed rolling pattern rounded up to an integer.

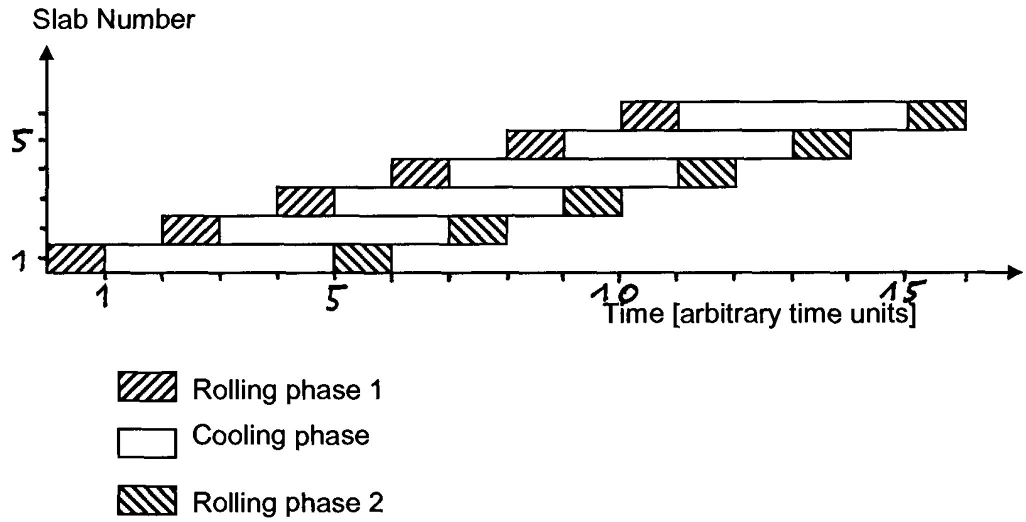

FIG. 17

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Description

FIELD OF INVENTION:

[0001] The invention relates to the general field of thermo-mechanical controlled rolling of metal slabs to plates or strips in a rolling mill, in particular to a technique known as interleaving and an apparatus for performing that technique.

BACKGROUND OF THE INVENTION:

[0002] Thermo-mechanical controlled rolling involves the rolling of metal-slabs, plates or strips at specific temperatures in order to achieve specific metallurgical microstructures and mechanical properties. It typically involves two or more rolling phases. Between two successive rolling phases the plates or strips are allowed to cool down during a cooling phase to the specific temperature which is desired for the next rolling phase. For example, when two rolling phases are performed first a number of passes are rolled at a high temperature during the first rolling phase, and then the obtained plate or strip is allowed to cool down to a specific temperature in a cooling phase before the second rolling phase starts. Analogously, in three phase rolling two cooling phases take place, a first one between rolling phase 1 and rolling phase 2, and a second one between rolling phase 2 and rolling phase 3.

[0003] To increase a thermo-mechanical controlled rolling mill's throughput the interleaving technique is employed. It consists in concurrently processing more than one metal slab, plate or strip in the rolling mill.
When no interleaving technique is employed in thermo-mechanical controlled rolling, the rolling of a plate or strip has to be completed, i.e. the plate or strip has to have passed all rolling phases, before rolling of another, new slab can start. While a plate or strip cools down between two rolling phases during a cooling phase the rolling mill is completely idle. Contrary to that, according to the interleaving technique rolling of new slabs already starts while a plate or strip previously subjected to rolling phase 1 cools down during a cooling phase. Thereby, the rolling mill is not always completely idle during the cooling phases of one plate or strip since it is processing other plates or strips meanwhile. Hence, the rolling mill's throughput is considerably enhanced by application of the interleaving technique. The interleave depth is a characteristic parameter for thermo-mechanical controlled rolling according to interleaving technique. In order to obtain a special product by thermo-mechanical rolling via interleaving technique, a special rolling pattern is applied on each slab of the batch to be processed. The rolling pattern is the sequence and duration of all rolling phases and cooling phases which are applied when processing a slab to a plate or strip. Such a rolling pattern comprises at least two rolling phases, and cooling phases between successive rolling phases. For rolling patterns with unequal durations of the rolling phases interleave depth is defined as the integer number of the smallest value from the group of values consisting of the quotients of the durations of the cooling phases and the duration of the longest rolling phase. For rolling patterns with equal durations of the rolling phases interleave depth is defined as the integer number of the smallest value from the group of values consisting of the quotients of the durations of the cooling phases and the duration of a rolling phase.
For example, for two phase rolling with equal durations of the rolling phases the interleave depth is defined as the integer number which is the duration of the cooling phase divided by the duration of a rolling phase.

[0004] Throughout the present application text, the integer number of a number which is not a whole number is to be understood as the integer number which is obtained after rounding down to a whole number. For example, the integer number of 1.95 is 1. For whole numbers the integer number is equal to the whole number.

[0005] In the most common method for interleaving the plates or strips are stored during their cooling phases on the same roller tables that are used for rolling.
Such a technique is illustrated in Figures 1- 6 for two phase rolling of plates with an interleave depth of two on a simplified plan view of a single stand rolling mill. A first slab to be rolled is heated in the furnace 1 and then discharged onto the roller table 2 and transported to the rolling mill stand 3 where a number of reversing rolling passes are carried out until its rolling phase 1 is completed. The thereby obtained plate 5 is then moved down the roller table 4 to a storage position 6 where plate 5 is stored during its cooling phase. Figure 1 shows plate 5 in storage position 6.
Then a second slab is discharged from the furnace 1 and rolled in the same way as the first slab until its rolling phase 1 is completed. The thereby obtained plate 7 is then moved down the roller table 4 to a storage position 8 where plate 7 is stored during its cooling phase. Figure 2 shows plate 7 in storage position 8.
Then a third slab is discharged from the furnace 1 and rolled until its rolling phase 1 is completed to yield plate 9. Figure 3 shows plate 9 after completion of rolling phase 1.

[0006] Then all three plates are transported by the roller tables 4 and 2 back to the entry side of rolling mill stand 3 and rolling phase 2 with a number of reversing rolling passes starts for plate 5. Figure 4 shows the position of plates 5, 7 and 9 when rolling phase 2 starts for plate 5.
Figure 5 illustrates the situation after the penultimate rolling pass of rolling phase 2 of plate 5. Figure 6 illustrates the situation after the last pass of plate 5.

[0007] A disadvantage of storing plates during their cooling phases on the same roller tables that are used for rolling is the additional length of the roller tables, and of the building housing the roller tables, that is required in comparison to thermo-mechanical rolling without interleaving technique. In the example illustrated in Figure 5 the interleave depth is two and the roller table 2 on the entry side of the rolling mill stand 3 needs to have at least a length which is equal to twice the length of plates after rolling phase 1 plus the length of a plate after the penultimate pass of rolling phase 2. The roller table 4 on the exit side of the rolling mill stand 3 needs to have a length which is at least equal to the larger one of the two following two values: three times the length of plates after rolling phase 1, length of plates after rolling phase 2.

[0008] Modern plate grades often require very long cooling times, hence interleave depth can be up to twelve or even more. In analogy with the example shown in Figures 1-6, for an interleave depth of twelve the roller table on the entry side of a rolling mill stand would need to have at least a length which is equal to twelve times the length of the plates after rolling phase 1 plus the length of the plate on the penultimate pass of rolling phase 2. With a plate length of about ten metres after rolling phase 1, of up to 48 metres after the penultimate pass of rolling phase 2 , and of up to 50 metres after rolling phase 2, handling an interleave depth of twelve would require a roller table length of approximately 170 metres on the entry side and of 120 metres on the exit side of a rolling mill stand, while about 50 metres on each side would be sufficient when thermo-mechanical controlled rolling is performed without interleaving technique.

[0009] A solution to store plates during their cooling phases in a shorter overall length of a rolling mill is shown in GB 1396946 which discloses side-shift roller table sections which can be moved transversely out of the rolling line. At the start of a cooling phase a plate is positioned on one of the side-shift roller tables and then moved transversely off-line into a storage position. This transverse movement of the side-shift roller table either brings a cooled plate ready for the next rolling phase into the rolling line or it brings an empty side-shift roller table back into the rolling line. Since the plates are not stored in a row but side by side, the required length of roller tables and building is significantly reduced. However, to cope with an interleave depth of twelve would require twelve side-shifting roller tables which would take up a very large transverse area that would not fit into a standard rolling mill building.

[0010] Another known solution to the problem of storing large numbers of plates during their cooling phases is to use one or more storing roller tables which run parallel with the mill line roller tables and moving-equipment to move plates between the mill line and the holding line. After rolling phase 1 is finished a moving-equipment moves the plates onto the storing roller tables. When the cooling period is finished the plate is moved back into the mill line for rolling phase 2. However, to handle an interleave depth of twelve according to the example described above, a storing roller table parallel to the mill-line roller table would still need to be around 120 metres long. To use two or more storing tables with moving-equipment in order to shorten the required length of each individual additional table would increase the complexity of the equipment and need more transverse space.

[0011] Another known solution to the he problem of storing large numbers of plates during their cooling phases is to lift the plates up above the mill line roller table. This works similarly to the use of the side-shift roller tables, except that the movement is vertical instead of horizontal. Again, to handle large interleave depths would increase the complexity of the necessary equipment as well as the dimensions of rolling mill's housing.

[0012] Another disadvantage of the interleaving methods of the prior art is that their furnace discharge pattern of slabs is not ideal.

Figure 7 schematically shows the timing diagram of the rolling pattern of an example of a two phase rolling prior art interleaving method with interleave depth two and equal duration of the rolling phases, the cooling phase being twice as long as a rolling phase, on a rolling mill with one rolling mill stand. A timing diagram depicts the chronological relation of the rolling phases and cooling phases applied on different slabs and the plates or strips derived from these slabs.

The processed batch contains 6 slabs which yield plates 1-6. According to the rolling pattern in Figure 7 for the first three slabs rolling phase 1 starts within a period of time equal to twice the duration of a rolling phase. After the start of the third slab's rolling phase 1 a period of time, which is the sum of the durations of rolling phase 1, of the cooling phase, and of rolling phase 2, elapses until rolling phase 1 of the fourth slab starts.

That means that the furnace has to discharge the first three slabs within a short period of time, and then has to wait a long time until the next three slabs are discharged within a short period of time. Hence, the furnace discharge pattern of Figure 7 consists of three discharges at intervals of the duration of a rolling phase followed by a gap of the duration of four rolling phases during which no slabs are discharged and then another three slab discharges at intervals of the duration of a rolling phase. In the case of an interleave depth of twelve and equal durations of the rolling phases the furnace discharge pattern would consist of thirteen slab discharges at intervals of the duration of a rolling phase followed by a gap of the duration of fourteen rolling phases.

The discharge of a large group of slabs at short intervals followed by a long gap causes problems with the slab temperature control and the furnace temperature control. Due to an irregular, uneven furnace discharge pattern some slabs will stay longer in the furnace than others, uneven staying times causing different temperatures for different slabs and thereby affecting metallurgy and yield negatively.

OBJECT OF THE INVENTION:

[0013] The object of the present invention is to provide a method and an apparatus for thermo-mechanical controlled rolling by interleaving technique which permit the application of a more even furnace discharge pattern and require less space and equipment than the prior art.

DESCRIPTION OF THE INVENTION:

[0014] This object is solved by a method for thermo-mechanical controlled rolling a batch of metal slabs to plates or strips on a rolling mill comprising at least one rolling mill stand according to a rolling pattern comprising at least two rolling phases of at least one rolling pass and cooling phases between successive rolling phases, which rolling pattern is applied on each slab of the batch, an interleave depth being attributed to the rolling pattern, which interleave depth is defined for rolling patterns with unequal durations of the rolling phases as the integer number of the smallest value from the group of values consisting of the quotients of the durations of the cooling phases and the duration of the longest rolling phase, and for rolling patterns with equal durations of the rolling phases as the integer number of the smallest value from the group of values consisting of the quotients of the durations of the cooling phases and the duration of a rolling phase, characterized in that, during rolling the batch, on at least one rolling mill stand it occurs several times that a rolling phase applied to one slab or plate or strip is succeeded by a different rolling phase applied on another slab or plate or strip, and that for two successively rolled slabs the time gap between the starts of their rolling phases 1 is always smaller than the sum of the duration of all rolling phases and all cooling phases of the rolling pattern.

[0015] This method permits the application of a furnace discharge pattern that is more even than in the prior art. As can be seen in Figure 7, in the prior art the time gap between the starts of rolling phases 1 of two consecutively rolled slabs is at least once equal to the sum of the duration of all rolling phases and all cooling phases of the rolling pattern when batches larger than the rolling pattern's interleave depth are processed. Since the time gap between starts of rolling phases 1 for consecutively rolled slabs governs the discharge of slabs from the furnace, a smaller time gap permits a more even furnace discharge pattern.

[0016] Preferably, after the first rolling phase of the first slab of the batch has been completed until the beginning of the last rolling phase of the last plate or strip there is always at least one other plate or strip in its cooling phase. More preferably, this is the case for batches larger than interleave depth plus one.

[0017] In an embodiment of the invention the number of rolling phases is two, namely rolling phase 1 and rolling phase 2, which are separated by one cooling phase.

It is preferred for two-phase thermo-mechanical controlled rolling methods with rolling patterns with an even numbered interleave depth and equal durations of the rolling phases where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of a rolling phase
- and a remainder time,

that for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of twice the duration of one rolling phase and the remainder time. In this case the whole number is the integer of the quotient of cooling phase duration and duration of one rolling phase.

Expressed in mathematical terms this is:

$$Tg \leq (2 \cdot Drp) + Rt$$

$$Cpd = (Wn \cdot Drp) + Rt$$

Tg ... maximum time gap between the starts of rolling phases 1 of successively rolled slabs
Drp ... duration rolling phase
Rt ... remainder time
Cpd ... cooling phase duration
Wn ... whole number, which is the integer of (Cpd/Drp)

By limiting the maximum time gap between the starts of the rolling phases 1 of successively rolled slabs to this value a more even furnace discharge pattern becomes possible.

[0018] It is preferred for two-phase thermo-mechanical controlled rolling methods with rolling patterns with an even numbered interleave depth and unequal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of the longest rolling phase
- and a remainder time,

that for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of twice the duration of the longest rolling phase and the remainder time. In this case the whole number is the integer of the quotient of cooling phase duration and duration of the longest rolling phase.
[0019] Expressed in mathematical terms this is:

$$Tg \leq (2 \cdot Dlp) + Rt$$

$$Cpd = (Wn \cdot Dlp) + Rt$$

Tg ... maximum time gap between the starts of rolling phases 1 of successively rolled slabs
Dlp ... duration longest rolling phase
Rt ... remainder time
Cpd ... cooling phase duration
Wn ... whole number, which is the integer of (Cpd/Dlp)

[0020] By limiting the maximum time gap between the starts of the rolling phases 1 of successively rolled slabs to this value a more even furnace discharge pattern becomes possible.
[0021] It is preferred for two-phase thermo-mechanical controlled rolling methods with rolling patterns with an uneven numbered interleave depth and equal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of a rolling phase
- and a remainder time,

that for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of thrice the duration of one rolling phase and the remainder time. In this case the whole number is the integer of the quotient of cooling phase duration and duration of one rolling phase.
Expressed in mathematical terms this is:

$$Tg \leq (3 \cdot Drp) + Rt$$

$$Cpd = (Wn \cdot Drp) + Rt$$

Tg ... maximum time gap between the starts of rolling phases 1 of successively slabs
Drp ... duration rolling phase
Rt ... remainder time
Cpd ... cooling phase duration
Wn ... whole number, which is the integer of (Cpd/Drp)

By limiting the maximum time gap between the starts of the rolling phases 1 of successively rolled slabs to this value a more even furnace discharge pattern becomes possible.
[0022] It is preferred for two-phase thermo-mechanical controlled rolling methods with rolling patterns with an uneven numbered interleave depth and unequal durations of the rolling phases, where the duration of the cooling phase is equal

to the sum of

- a whole number times the duration of the longest rolling phase
- and a remainder time,

that for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of thrice the duration of the longest rolling phase and the remainder time. In this case the whole number is the integer of the quotient of cooling phase duration and duration of the longest rolling phase.
Expressed in mathematical terms this is:

$$Tg \leq (3 \cdot Dlp) + Rt$$

$$Cpd = (Wn \cdot Dlp) + Rt$$

Tg ... maximum time gap between the starts of rolling phases 1 of successively rolled slabs
Dlp ... duration longest rolling phase
Rt ... remainder time
Cpd ... cooling phase duration
Wn ... whole number, which is the integer of (Cpd/Dlp)

By limiting the maximum time gap between the starts of the rolling phases 1 of successively rolled slabs to this value a more even furnace discharge pattern becomes possible.
[0023] It is preferred for two-phase thermo-mechanical controlled rolling methods with rolling patterns with equal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of a rolling phase
- and a remainder time,

that after completion of rolling the first plate or strip of the batch rolling phase 1 alternates with rolling phase 2 during rolling the batch at an interval which is up to the sum of interleave depth times duration of a rolling phase and the remainder time.
In this case the whole number is the integer of the quotient of cooling phase duration and duration of one rolling phase.
Expressed in mathematical terms this is:

$$Int \leq (Id \cdot Drp) + Rt$$

$$Cpd = (Wn \cdot Drp) + Rt$$

Int ... interval at which rolling phase 1 alternates with rolling phase 2 during rolling the batch
Id ... interleave depth
Drp ... duration rolling phase
Rt ... remainder time
Cpd ... cooling phase duration
Wn ... whole number, which is the integer of (Cpd/Drp)

[0024] For two-phase thermo-mechanical controlled rolling methods with rolling patterns with unequal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of the longest rolling phase
- and a remainder time,

it is preferred that after completion of rolling the first plate or strip of the batch rolling phase 1 alternates with rolling phase 2 during rolling the batch at an interval which is up to the sum of interleave depth times duration of the longest rolling phase and the remainder time.
In this case the whole number is the integer of the quotient of cooling phase duration and duration of the longest rolling phase.
Expressed in mathematical terms this is:

$$Int \leq (Id \cdot Dlp) + Rt$$

$$Cpd = (Wn \cdot Drp) + Rt$$

Int ... interval at which rolling phase 1 alternates with rolling phase 2 during rolling the batch
Id ... interleave depth
Dlp ... duration longest rolling phase
Rt ... remainder time
Cpd ... cooling phase duration
Wn ... whole number, which is the integer of (Cpd/Drp)

[0025] For two-phase thermo-mechanical controlled rolling methods with rolling patterns with unequal durations of the rolling phases and a duration of the cooling phase that is equal to or longer than the sum of the durations of both rolling phases, or a whole number times that sum,
it is preferred that, after completion of rolling the first plate or strip of the batch, during a period of time equal to the duration of the cooling phase rolling phase 1 is performed as often as rolling phase 2.
In this case the whole number is the integer of the quotient of cooling phase duration and the sum of the durations of both rolling phases, i.e. in mathematical terms

Drp1 ... duration rolling phase 1
Drp2 ... duration rolling phase 2
Cpd ... cooling phase duration
Wn ...whole number, which is the integer of (Cpd/(Drp1+ Drp2))

[0026] For two-phase thermo-mechanical controlled rolling methods with rolling patterns with unequal durations of the rolling phases and a duration of the cooling phase that is equal to or longer than the sum of

- the durations of both rolling phases
- and the duration of either rolling phase 1 or rolling phase 2,

or a whole number times that sum,
it is preferred that during the duration of the cooling phase the amount of rolling phases 1 performed is equal to the amount of rolling phases 2 performed plus 1 or minus 1.
In this case the whole number is the integer of the quotient of cooling phase duration and the sum of the durations of both rolling phases and the duration of either rolling phase 1 or rolling phase 2, i.e. in mathematical terms

Drp1 ... duration rolling phase 1
Drp2 ... duration rolling phase 2
Cpd ... cooling phase duration
Wn ...whole number, which is the integer of

$$(Cpd/(Drp1 + Drp2 + (\text{either } Drp1 \text{ or } Drp2)))$$

[0027] In another embodiment of the invention the number of rolling phases is three, namely rolling phase 1, rolling phase 2 and rolling phase 3, rolling phase 1 and rolling phase 2 being separated by cooling phase 1, and rolling phase

2 and rolling phase 3 being separated by cooling phase 2.

[0028] It is preferred for three-phase thermo-mechanical controlled rolling methods with rolling patterns where the duration of cooling phase 1 is equal to the sum of

- a whole number A times the sum of the durations of the three rolling phases
- and a remainder time 1,

and where the duration of cooling phase 2 is equal to the sum of

- a whole number B times the sum of the durations of the three rolling phases
- and a remainder time 2,

that for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of the durations of the three rolling phases plus the greater of remainder time 1 and remainder time 2.
In this case the whole number A is the integer of the quotient of the duration of cooling phase 1 and the sum of the durations of all three rolling phases, and the whole number B is the integer of the quotient of the duration of cooling phase 2 and the sum of the durations of all three rolling phases.
Expressed in mathematical terms this is:

$$Tg \leq Sdr + (\text{the greater of } Rt1 \text{ and } Rt2)$$

$$Cpd1 = (WnA \cdot Sdr) + Rt1$$

$$Cpd2 = (WnB \cdot Sdr) + Rt2$$

Tg	... maximum time gap between the starts of rolling phases 1 of successively rolled slabs
Drp1	... duration rolling phase 1
Drp2	... duration rolling phase 2
Drp3	... duration rolling phase 3
Rt1	... remainder time 1
Rt2	... remainder time 2
Cpd1	... duration of cooling phase 1
Cpd2	... duration of cooling phase 2
Sdr	... sum of the durations of all three rolling phases, (Drp1 + Drp2 + Drp3)
WnA	... whole number A, which is the integer of (Cpd1/Sdr)
WnB	... whole number B, which is the integer of (Cpd2/Sdr)

By limiting the maximum time gap between the starts of the rolling phases 1 of successively rolled slabs to this value a more even furnace discharge pattern becomes possible.

[0029] It is preferred for three-phase thermo-mechanical controlled rolling methods with rolling patterns where the duration of cooling phase 1 is equal to the sum of

- a whole number C times the sum of
  - the durations of the three rolling phases
  - and the duration of rolling phase 3,
- and a remainder time 3,

and where the duration of cooling phase 2 is equal to the sum of

- a whole number D times the sum of

- the durations of the three rolling phases
- and the duration of rolling phase 1,

- and a remainder time 4,

that for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of the three rolling phase times plus the greater of remainder time 3 and remainder time 4.
In this case the whole number C is the integer of the quotient of the duration of cooling phase 1 and the sum of the durations of all three rolling phase plus the duration of rolling phase 3, and the whole number D is the integer of the quotient of the duration of cooling phase 2 and the sum of the durations of all three rolling phases plus the duration of rolling phase 1.
Expressed in mathematical terms this is:

$$Tg \leq Sdr + (\text{the greater of } Rt1 \text{ and } Rt2)$$

$$Cpd1 = (WnC \cdot (Sdr + Drp3)) + Rt3$$

$$Cpd2 = (WnD \cdot (Sdr + Drp1)) + Rt4$$

Tg	... maximum time gap between the starts of rolling phases 1 of successively rolled slabs
Drp1	... duration rolling phase 1
Drp2	... duration rolling phase 2
Drp3	... duration rolling phase 3
Rt3	... remainder time 3
Rt4	... remainder time 4
Cpd1	... duration of cooling phase 1
Cpd2	... duration of cooling phase 2
Sdr	... sum of the durations of all three rolling phases, (Drp1 + Drp2 + Drp3)
WnC	... whole number C, which is the integer of (Cpd1/(Sdr + Drp3))
WnD	... whole number D, which is the integer of (Cpd2/(Sdr + Drp1))

By limiting the maximum time gap between the starts of the rolling phases 1 of successively rolled slabs to this value a more even furnace discharge pattern becomes possible.
[0030] It is preferred for three-phase thermo-mechanical controlled rolling methods that during rolling the batch, from after completion of rolling the first plate or strip of the batch until the beginning of rolling phase 3 of the last plate or strip of the batch,
a rolling phase 1 is always succeeded by a rolling phase 2, and a rolling phase 2 is always succeeded by a rolling phase 3, and a rolling phase 3 is always succeeded by a rolling phase 1.
This pattern makes a very even furnace discharge pattern possible.
[0031] It is also preferred for three-phase thermo-mechanical controlled rolling methods that during rolling the batch, from after completion of rolling the first plate or strip of the batch until the beginning of rolling phase 3 of the last plate or strip of the batch,
a rolling phase 1 is always succeeded by a rolling phase 3, and a rolling phase 3 is always succeeded by a rolling phase 2, and a rolling phase 2 is always succeeded by a rolling phase 1.
This pattern makes a very even furnace discharge pattern possible.
[0032] It is preferred for three-phase thermo-mechanical controlled rolling methods that during a period of time equal to the duration of a cooling phase 1 rolling phase 1, rolling phase 2 and rolling phase 3 are performed equally often.
[0033] In another preferred embodiment of three-phase thermo-mechanical controlled rolling methods during a period of time equal to the duration of a cooling phase 1 rolling phase 1, rolling phase 2 and rolling phase 3 are performed unequally often.
[0034] More preferably, during a period of time equal to the duration of a cooling phase 1 the number of rolling phases 3 performed is greater than the number of rolling phases 1 performed and greater than the number of rolling phases 2

performed, and during a period of time equal to the duration of cooling phase 2 the number of rolling phases 1 performed is greater than the number of rolling phases 2 performed and greater than the number of rolling phases 3 performed.

[0035] It is further preferred that after completion of a rolling phase which is succeeded by a cooling phase the resulting plates or strips are transferred from a rolling line of the rolling mill to a storage position outside the rolling line by at least one moving-equipment, and afterwards are transferred from the storage position to the rolling line after completion of the cooling phase by the moving equipment.

Since thereby the plates or strips do not remain on the rolling line during their cooling phases, the length of the rolling line required for performing the interleaving method is reduced.

[0036] In an especially preferred embodiment, during rolling the batch it occurs at least once that while one plate or strip is transferred to its storage position or to the rolling line another plate or strip is simultaneously transferred to the rolling line or to its storage position by the same moving-equipment.

In this case two plates or strips are transferred by one movement of the moving-equipment. Thereby, the required number of movements of the moving-equipment during rolling the batch is reduced, which results in less need for supervision as well as less wearing down. In addition, less moving-equipment is needed.

[0037] The object of the invention is further solved by an apparatus for thermo-mechanical controlled rolling according to a method as claimed in claims 1 to 22,

comprising at least one rolling mill stand, a rolling line, storage positions outside the rolling line, and at least one moving-equipment for moving plates or strips from the rolling line to the storage positions, characterized in that the number of storage positions is half of the interleave depth of the performed rolling pattern rounded up to a whole number.

[0038] Compared to the prior art, where the number of storage positions required for the rolling pattern of an interleaving method is equal to the interleave depth of the rolling pattern, according to the present invention less storage positions are necessary. This results in diminished need for space and maintenance and in a less complex apparatus for thermo-mechanical controlled rolling.

[0039] The moving-equipment may be for example a side-shift roller table, lifting roller tables or cranes. The storage positions may be situated for example on one or more side-shift roller tables, lifting roller tables, or storing roller tables which may be parallel to the rolling line. In case of several parallel storing roller tables these may be staggered.

[0040] In a preferred embodiment at least one moving-equipment can simultaneously transfer one plate or strip to the rolling line or to a storage position and another plate or strip to a storage position or the rolling line.

This is for example the case for side-shift roller tables, which allow to transfer one plate or strip into the rolling line while simultaneously moving another plate or strip to a storage position.

DETAILED DESCRIPTION OF THE INVENTION:

[0041] The invention will now be described solely by way of example and with reference to the accompanying drawings in which:

> Figures 1-6 show the course of a prior art interleaving method for two phase rolling of with an interleave depth of two on a simplified plan view of a single stand rolling mill.
>
> Figure 7 schematically shows the timing diagram of the rolling pattern of an example of a two phase rolling prior art interleaving method with interleave depth two and equal duration of the rolling phases, the cooling phase being twice as long as a rolling phase, on a rolling mill with one rolling mill stand.
>
> Figures 8 -16 refer to an embodiment of the invention and show a simplified plan view of a single stand rolling mill comprising 2 side-shift roller tables with two transverse positions during the performance of a two phase rolling method with an interleave depth of four and equal duration of the rolling phases.
>
> Figure 17 shows the timing diagram of the rolling pattern described in Figures 8-16.
>
> Figure 18 shows the timing diagram of a prior art rolling pattern for an interleave depth of four.
>
> Figure 19 shows a timing diagram of a two phase rolling pattern according to the present invention with an interleave depth of 3 and rolling phases of equal length.
>
> Figure 20 shows a prior art timing diagram for a two phase rolling pattern with different durations of the rolling phases and interleave depth 1.
>
> Figure 21 shows a timing diagram of a two phase rolling pattern according to the present invention with different durations of the rolling phases and interleave depth 1.
>
> Figure 22 shows a timing diagram of a prior art two phase rolling pattern with interleave depth 3 and different durations of the rolling phases.
>
> Figure 23 shows a timing diagram of a two phase rolling pattern according to the present invention with interleave depth 3 and different durations of the rolling phases.
>
> Figure 24 shows a timing diagram of a three phase rolling pattern according to the present invention with different durations and interleave depth 2.

[0042] Figure 8 shows a simplified plan view of a rolling mill apparatus for thermo-mechanical controlled rolling with one rolling mill stand 3, a rolling line consisting of the roller tables 2 and 4, a furnace 1 for heating the slabs prior to rolling, and two side-shift roller tables 10 and 11 which are located on the exit side of the rolling mill stand 3 in roller table 4. Each side-shift roller table can moved between two positions. Figure 8 shows the moment when the first slab of the batch to be processed has finished rolling phase 1 and the resulting plate 12 is transported onto side-shift roller table 10 which is in its down position. After that, side-shift roller table 10 is moved into its up position, thereby removing plate 12 from the rolling line and transferring it into its storage position. Figure 9 shows plate 12 in its storage position. When a period of time equal to the duration of one rolling phase has elapsed since the end of rolling phase 1 of plate 12, rolling phase 1 of a second slab starts. The resulting plate 13 is transported onto side-shift roller table 11 which is in its down position. Figure 10 shows plate 13 on side-shift roller table 11 in its down position. After that, side-shift roller table 11 is moved into its up position, thereby removing plate 13 from the rolling line and transferring it into its storage position. Figure 11 shows plate 12 in its storage position. When a period of time equal to the duration of one rolling phase has elapsed since the end of rolling phase 1 of plate 13, rolling phase 1 of a third slab starts. The resulting plate 14 is transported onto side-shift roller table 10 which is in its up position. Figure 12 shows plate 14 on side-shift roller table 10 in its up position. After that, side-shift roller table 10 is moved in its down position, thereby removing plate 14 from the rolling line and transferring it into its storage position, and simultaneously transferring plate 12 from its storage position to the rolling line. Figure 13 shows plates 12 and 14 on side-shift roller table 10 in its down position. After that, rolling phase 2 starts for plate 12. Figure 14 shows plate 12 after completion of its rolling phase 2. When plate 12 clears the rolling mill rolling phase 1 starts for a fourth slab 15, which is also shown in Figure 14, resulting in plate 16. When plate 16 completes phase 1 rolling it is moved to side-shift roller table 11 which is in its up position. Figure 15 shows plate 16 on side-shift roller table 11 in its up position. After that, side-shift roller table 11 is moved in its down position, thereby removing plate 16 from the rolling line and transferring it into its storage position, and simultaneously transferring plate 13 from its storage position to the rolling line. Figure 16 shows plates 13 and 16 on side-shift roller table 11 in its down position. Then, rolling phase 2 begins for plate 13.

If the batch of metal slabs to be processed is larger than 4, another slab will start its rolling phase 1 when plate 13 clears the rolling mill, effectively repeating the situation which is shown in Figure 14. The resulting plate would be processed in analogy to Figures 15 and 16. Also for each further slab the pattern shown in Figures 14 to 16 would be repeated analogously.

In the example with an interleave depth of four outlined in Figures 8-16 only two side-shift roller tables are required.

[0043] Figure 17 shows the timing diagram of the rolling pattern described in Figures 8-16.

For comparison the timing diagram of a prior art rolling pattern for an interleave depth of four is shown in Figure 18. According to Figure 18, for an interleave depth of four a total of four side-shift roller tables would be required to remove the first four plates from the rolling line before rolling phase 1 of the fifth slab starts. Hence, the present invention reduces the number of side-shift roller tables required.

In addition the invention as outlined in Figures 8-17 reduces the number of side-shift movements that are required because all the side-shift movements after the first two simultaneously transfer one plate into a storage position and another plate back to the rolling line. In the prior art as shown in Figure 18 no such simultaneous transfer takes place.

In addition the invention as outlined in Figures 8 -17 allows a more even furnace discharge pattern, since after the completion, i.e. the end, of a rolling phase 1 of one slab a new slab starts its rolling phase 1 always after a period of time which is equal to the duration of one rolling phase. When the rolling phases 1 start evenly, the furnace discharge pattern can be even, too. In the prior art as shown in Figure 18 the first five rolling phases 1 start one after another without time gap between the end of rolling phase 1 of one slab and the start of rolling phase 1 of the successively rolled slab, followed by a long time gap between start of rolling phase 1 of the fifth slab and start of rolling phase 1 of the sixth slab. That long time gap lasts for a time period which is equal to the sum of the durations of all rolling phases and the cooling phase.

Hence, the advantage of the present invention is that compared to the prior art it provides a possibility to use more even furnace discharge patterns, to reduce the number of storage positions needed, and to reduce the number of movements of the moving-equipment which transfers plates from the rolling line to storage positions and back.

While Figures 8 - 17 refer to a two phase rolling pattern on a rolling mill with one mill stand with interleave depth four, the abovementioned advantages can also be achieved for rolling patterns with more rolling phases, and for rolling patterns with different interleave depths, and for rolling mills with more than one mill stand.

[0044] An inventive two phase rolling pattern with an interleave depth of 3 and rolling phases of equal length is illustrated in the timing diagram of Figure 19. The maximum time gap between starts of successive rolling phases 1 is a time period equal to the duration of three rolling phases, whereas in the interleaving pattern of the prior art for an interleave depth of 3 the maximum time gap would be equal to equal to the duration of five rolling phases. Furthermore, for the inventive rolling pattern two side shift table would suffice whereas for a prior art rolling pattern three side shift tables would be necessary.

[0045] Another advantage of the invention is illustrated by Figures 20 and 21. Figure 20 shows a prior art timing diagram for a two phase rolling pattern with different durations of the rolling phases and interleave depth 1. In that rolling pattern it takes a period of time equal to eight times the duration of rolling phase 1 to produce 2 plates, and during that time the mill is only rolling for a period of time equal to six times the duration of rolling phase 1.

Figure 21 shows a timing diagram for an inventive rolling pattern with the same durations of the rolling phases and the cooling phase, and thereby the same interleave depth, as the prior art rolling pattern of Figure 20. With the inventive pattern of Figure 21, after rolling phase 2 of the first plate has been completed, the mill is operating without pause and 1 plate is produced after thrice the duration of rolling phase 1. The throughput is therefore 33% greater than is achieved by the pattern shown in Figure 20.

In practice operation of the rolling mill without pause cannot be achieved because the cooling time is not necessarily an exact multiple of the duration of the rolling phases and some time is required to move the plates to and fro their storage positions.

[0046] A similar improvement in throughput is illustrated by Figures 22 and 23 for a two phase rolling pattern with interleave depth 3. In these figures the duration of the cooling phase is 6 times the duration of rolling phase 1 and the duration of rolling phase 2 is twice the duration of rolling phase 1. With the prior art rolling pattern illustrated in Figure 22 four plates are produced in a period of time equal to 15 times the duration of rolling phase 1, and during that time the mill is operating for a period of time equal to 12 times the duration of rolling phase 1. With the inventive rolling pattern illustrated in Figure 23 the mill operates continuously after the first two plates and one plate is produced after thrice the duration of rolling phase 1.

[0047] Figure 24 shows a three phase rolling pattern with equal durations of the rolling phases, different durations of the cooling phases and interleave depth 2. After the completion of rolling phase 3 of the first plate according to this rolling pattern 4 plates are produced in every period of time equal to 13 times the duration of a rolling phase. A conventional interleaving pattern of the prior art would produce 3 plates in every 11 periods so the interleaving pattern of the invention results in a 13% increase in throughput.

[0048] In Figures 17 - 24 timing diagrams are only shown for small batches to be processed. If the batches were larger, the timing diagrams would continue in the same regular manner as shown for the small batches.

Claims

1. Method for thermo-mechanical controlled rolling a batch of metal slabs to plates or strips on a rolling mill comprising at least one rolling mill stand according to a rolling pattern comprising at least two rolling phases of at least one rolling pass and cooling phases between successive rolling phases, which rolling pattern is applied on each slab of the batch,
   an interleave depth being attributed to the rolling pattern,
   which interleave depth is defined
   for rolling patterns with unequal durations of the rolling phases as the integer number of the smallest value from the group of values consisting of the quotients of the durations of the cooling phases and the duration of the longest rolling phase, and
   for rolling patterns with equal durations of the rolling phases as the integer number of the smallest value from the group of values consisting of the quotients of the durations of the cooling phases and the duration of a rolling phase,
   characterized in
   that, during rolling the batch, on at least one rolling mill stand it occurs several times that a rolling phase applied to one slab or plate or strip is succeeded by a different rolling phase applied on another slab or plate or strip,
   and **that** for two successively rolled slabs the time gap between the starts of their rolling phases 1 is always smaller than the sum of the duration of all rolling phases and all cooling phases of the rolling pattern.

2. Method according to claim 1, **characterized in**
   that after the first rolling phase of the first slab of the batch has been completed until the beginning of the last rolling phase of the last plate or strip there is always at least one other plate or strip in its cooling phase.

3. Method according to claim 1 or 2, **characterized in**
   that for batches larger than interleave depth plus one after the first rolling phase of the first slab of the batch has been completed until the beginning of the last rolling phase of the last plate or strip there is always at least one other plate or strip in its cooling phase.

4. Method according to any of claims 1 to 3, **characterized in**
   that the number of rolling phases is two, namely rolling phase 1 and rolling phase 2, which are separated by one cooling phase.

5. Method according to claim 4, **characterized in that** for rolling patterns with an even numbered interleave depth and equal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of a rolling phase
- and a remainder time,

for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of twice the duration of one rolling phase and the remainder time .

6. Method according to claim 4, **characterized in that**, for rolling patterns with an even numbered interleave depth and unequal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of the longest rolling phase
- and a remainder time,

for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of twice the duration of the longest rolling phase and the remainder time.

7. Method according to claim 4, **characterized in that**, for rolling patterns with an uneven numbered interleave depth and equal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of a rolling phase
- and a remainder time,

for successively rolled slabs the-maximum time gap between the starts of their rolling phases 1 is up to the sum of thrice the duration of one rolling phase and the remainder time.

8. Method according to claim 4, **characterized in that**, for rolling patterns with an uneven numbered interleave depth and unequal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of the longest rolling phase
- and a remainder time,

for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of thrice the duration of the longest rolling phase and the remainder time.

9. Method according to any one of claims 4, 5 or 7, **characterized in that** after completion of rolling the first plate or strip of the batch for rolling patterns with equal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of a rolling phase
- and a remainder time,

rolling phase 1 alternates with rolling phase 2 during rolling the batch at an interval which is up to the sum of interleave depth times duration of a rolling phase and the remainder time.

10. Method according to any one of claims 4, 6 and 8, **characterized in that** after completion of rolling the first plate or strip of the batch for rolling patterns with unequal durations of the rolling phases, where the duration of the cooling phase is equal to the sum of

- a whole number times the duration of the longest rolling phase
- and a remainder time,

rolling phase 1 alternates with rolling phase 2 during rolling the batch at an interval which is up to the sum of interleave depth times duration of the longest rolling phase and the remainder time.

11. Method according to any one of claims 4, 6, 8 and 10, **characterized in that**, for rolling patterns with unequal durations of the rolling phases and a duration of the cooling phase that is equal to or longer than the sum of the durations of both rolling phases, or a whole number times that sum,
after completion of rolling the first plate or strip of the batch,
during a period of time equal to the duration of the cooling phase
rolling phase 1 is performed as often as rolling phase 2.

12. Method according to any one of claims 4, 6, 8 and 10, **characterized in that**, for rolling patterns with unequal durations of the rolling phases and a duration of the cooling phase that is equal to or longer than the sum of

- the durations of both rolling phases
- and the duration of either rolling phase 1 or rolling phase 2,

or a whole number times that sum,
during the duration of the cooling phase the amount of rolling phases 1 performed is equal to the amount of rolling phases 2 performed plus 1 or minus 1.

13. Method according to any of claims 1 to 3, **characterised in that** the number of rolling phases is three, namely rolling phase 1, rolling phase 2 and rolling phase 3, rolling phase 1 and rolling phase 2 being separated by cooling phase 1, and rolling phase 2 and rolling phase 3 being separated by cooling phase 2.

14. Method according to claim 13, **characterised in that**, for rolling patterns where the duration of cooling phase 1 is equal to the sum of

- a whole number A times the sum of the durations of the three rolling phases
- and a remainder time 1,

and where the duration of cooling phase 2 is equal to the sum of

- a whole number B times the sum of the durations of the three rolling phases
- and a remainder time 2,

for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of the durations of the three rolling phases plus the greater of remainder time 1 and remainder time 2.

15. Method according to claim 13, **characterised in that**,
for rolling patterns where the duration of cooling phase 1 is equal to the sum of

- a whole number C times the sum

of the durations of the three rolling phases and the duration of rolling phase 3,

- and a remainder time 3,

and where the duration of cooling phase 2 is equal to the sum of

- a whole number D times the sum

of the durations of the three rolling phases and the duration of rolling phase 1,

- and a remainder time 4,

for successively rolled slabs the maximum time gap between the starts of their rolling phases 1 is up to the sum of the durations of the three rolling phases plus the greater of remainder time 3 and remainder time 4.

16. Method according to any one of claims 13 to 14, **characterised in that** during rolling the batch,
from after completion of rolling the first plate or strip of the batch until the beginning of rolling phase 3 of the last plate or strip of the batch,
a rolling phase 1 is always succeeded by a rolling phase 2, and a rolling phase 2 is always succeeded by a rolling phase 3, and a rolling phase 3 is always succeeded by a rolling phase 1.

17. Method according to claim 13 or 15, **characterised in that** during rolling the batch,
from after completion of rolling the first plate or strip of the batch until the beginning of rolling phase 3 of the last plate or strip of the batch,
a rolling phase 1 is always succeeded by a rolling phase 3, and a rolling phase 3 is always succeeded by a rolling phase 2, and a rolling phase 2 is always succeeded by a rolling phase 1.

18. Method according to claim 14 or 16, **characterized in that** during a period of time equal to the duration of a cooling phase 1
rolling phase 1, rolling phase 2 and rolling phase 3 are performed equally often.

19. Method according to any one of claims 15 or 17, **characterized in that** during a period of time equal to the duration of a cooling phase 1
rolling phase 1, rolling phase 2 and rolling phase 3 are performed unequally often.

20. Method according to claim 19, **characterized in that** during a period of time equal to the duration of a cooling phase 1 the number of rolling phases 3 performed is greater than the number of rolling phases 1 performed and greater than the number of rolling phases 2 performed, and **that** during a a period of time equal to the duration of cooling phase 2 the number of rolling phases 1 performed is greater than the number of rolling phases 2 performed and greater than the number of rolling phases 3 performed.

21. Method according to any one of claims 1 to 20, **characterized in that** after completion of a rolling phase which is succeeded by a cooling phase the resulting plates or strips are transferred from a rolling line of the rolling mill to a storage position outside the rolling line by at least one moving-equipment, and afterwards are transferred from the storage position to the rolling line after completion of the cooling phase by the moving equipment.

22. Method according to claim 21, **characterized in that** during rolling the batch it occurs at least once that while one plate or strip is transferred to its storage position or to the rolling line another plate or strip is simultaneously transferred to the rolling line or to its storage position by the same moving-equipment.

23. Apparatus for thermo-mechanical controlled rolling according to a method as claimed in claims 1 to 22 comprising at least one rolling mill stand, a rolling line, storage positions outside the rolling line, and at least one moving-equipment for moving plates or strips from the rolling line to the storage positions, **characterized in that** the number of storage positions is half of the interleave depth of the performed rolling pattern rounded up to a whole number.

24. Apparatus according to claim 23, **characterized in that** at least one moving-equipment can simultaneously transfer one plate or strip to the rolling line or to a storage position and another plate or strip to a storage position or the rolling line.

25. Use of a method according to any one of claims 1 - 22 for thermo-mechanical controlled rolling a batch of metal slabs to plates or strips on a rolling mill comprising at least one rolling mill stand.

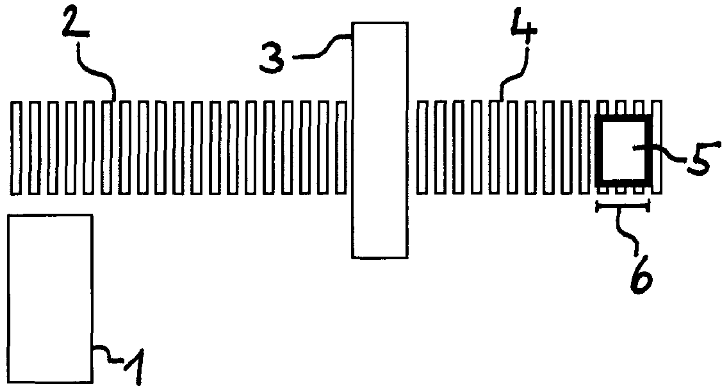

FIG. 1

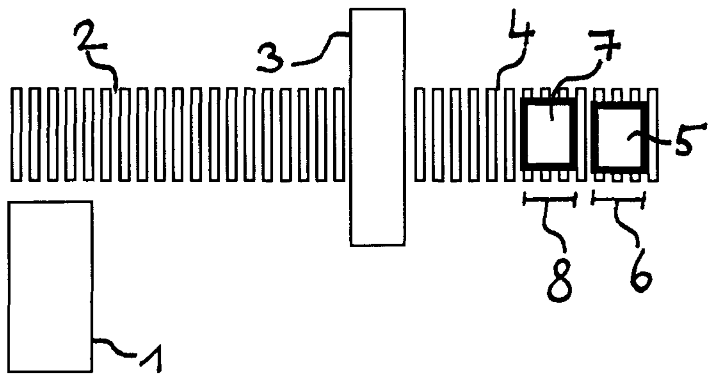

FIG. 2

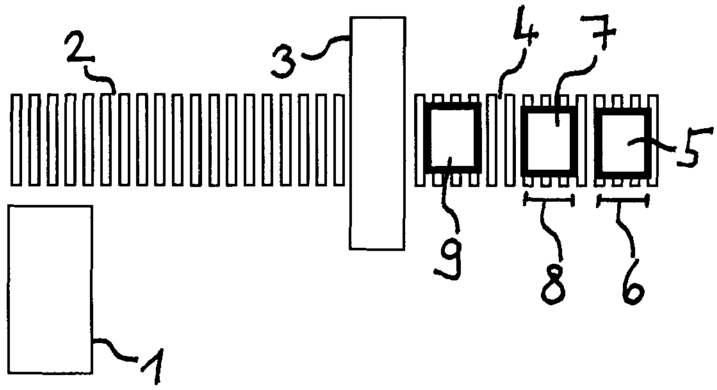

FIG. 3

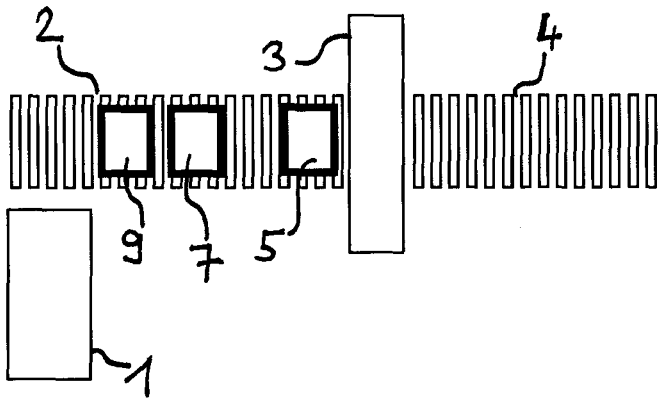

FIG. 4

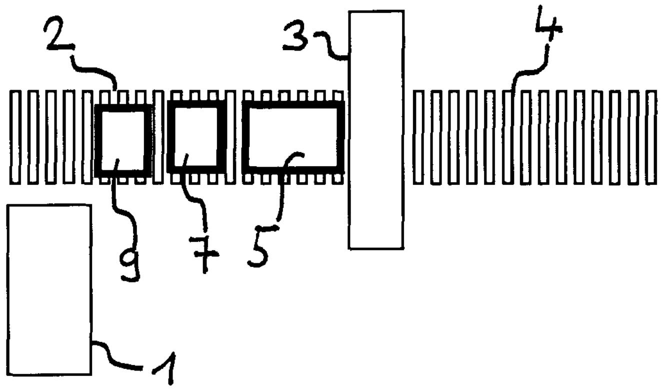

FIG. 5

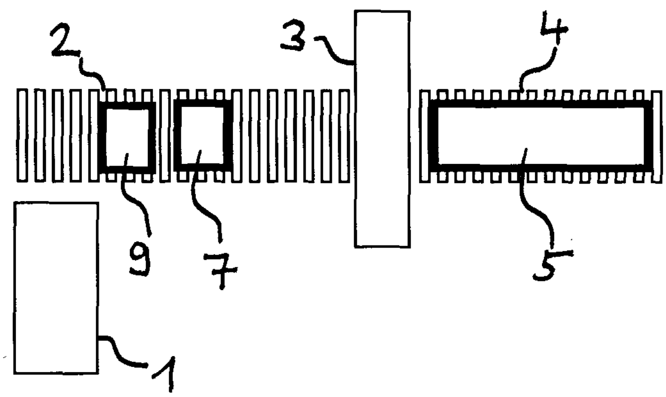

FIG. 6

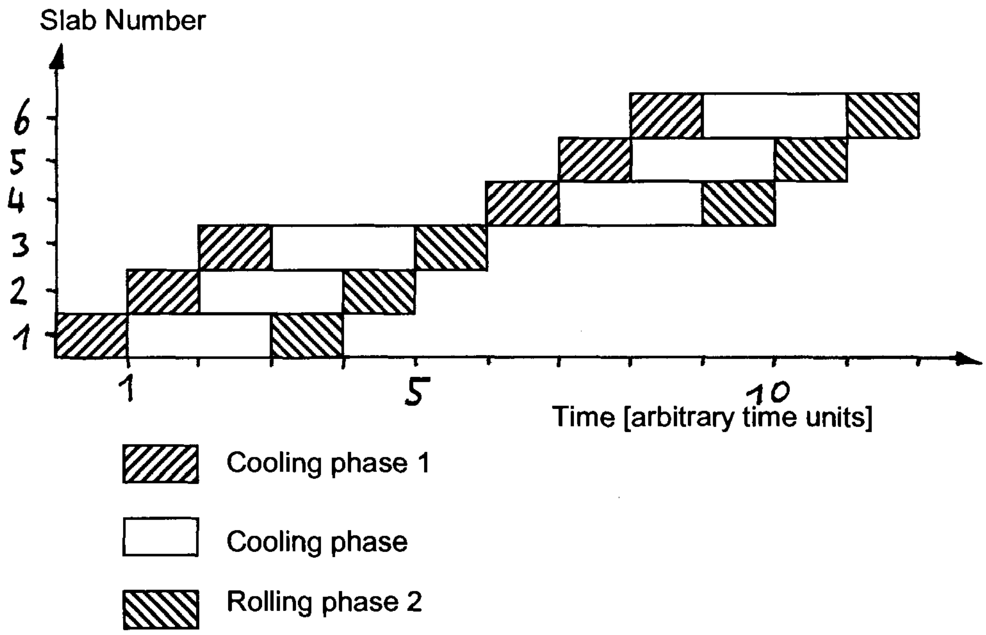
Slab Number
6
5
4
3
2
1
1
5
10
Time [arbitrary time units]
Cooling phase 1
Cooling phase
Rolling phase 2

FIG. 7

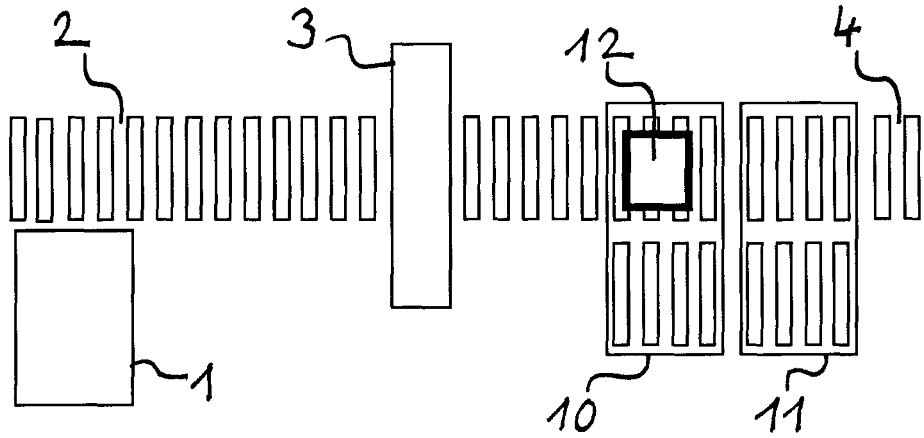

FIG. 8

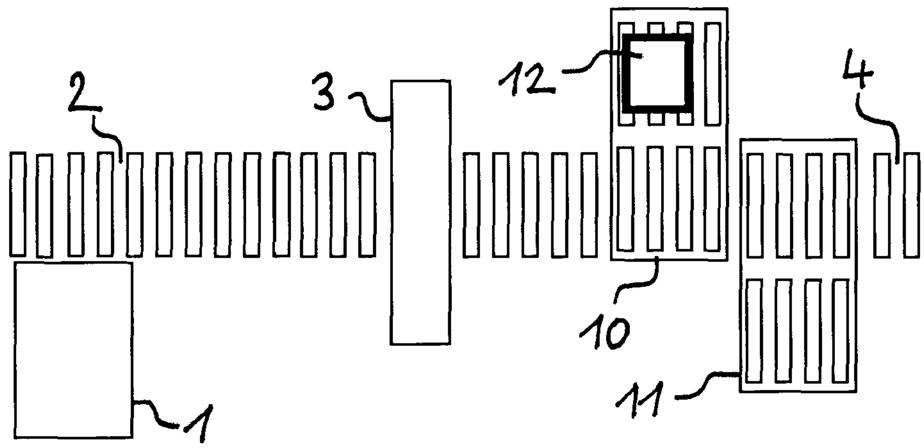

FIG. 9

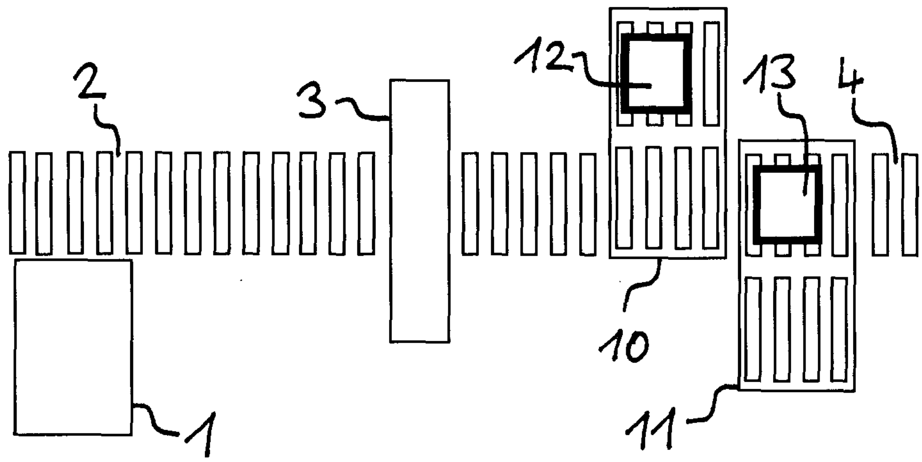

FIG. 10

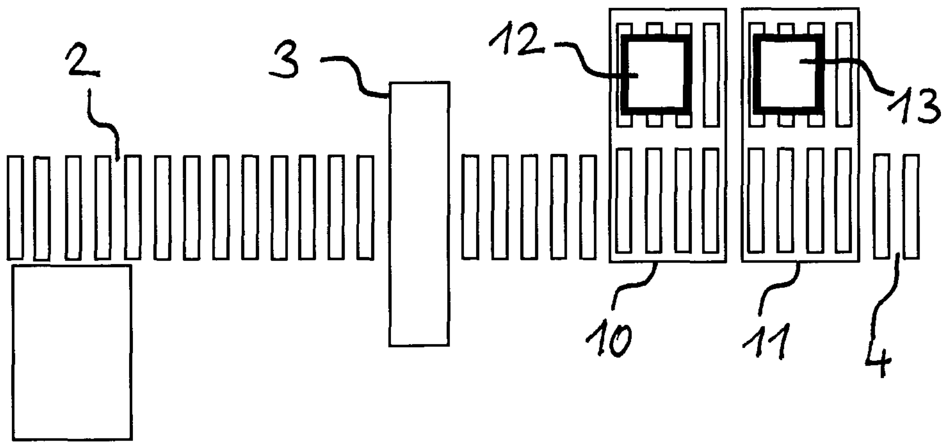

FIG. 11

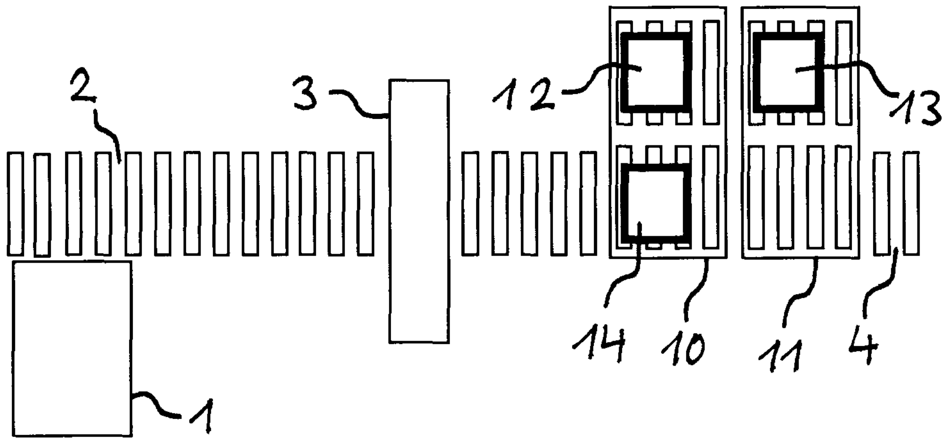

FIG. 12

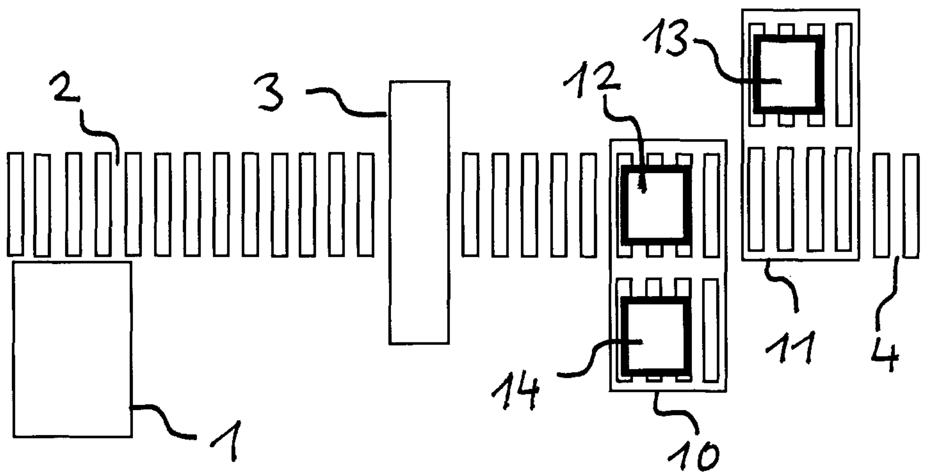

FIG. 13

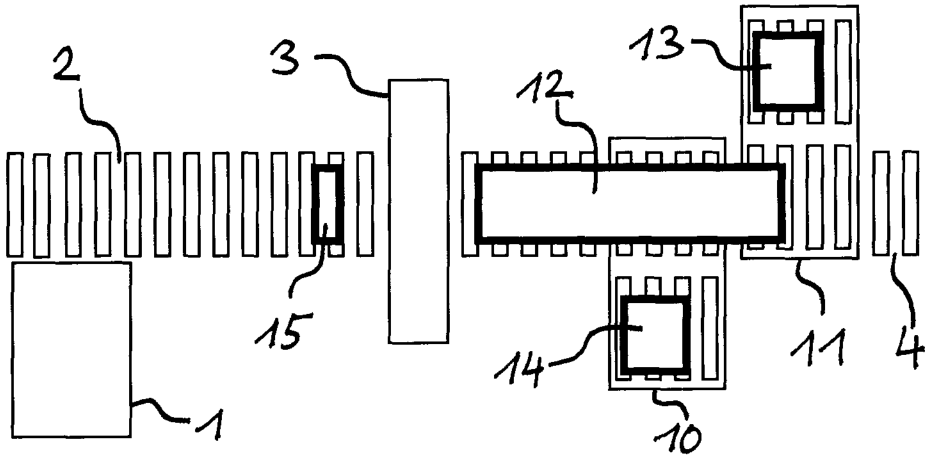

FIG. 14

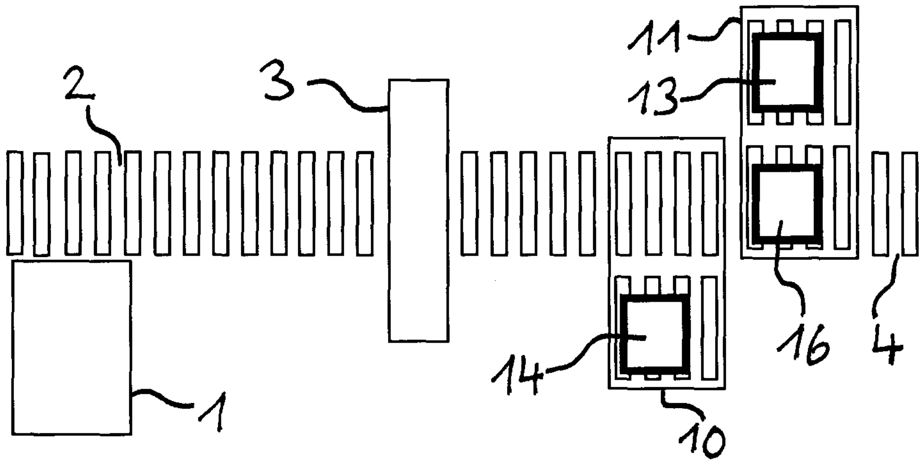

FIG. 15

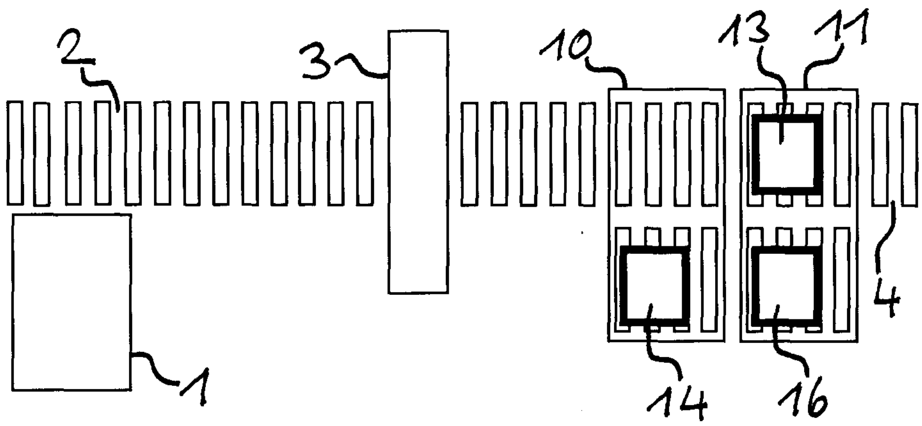

FIG. 16

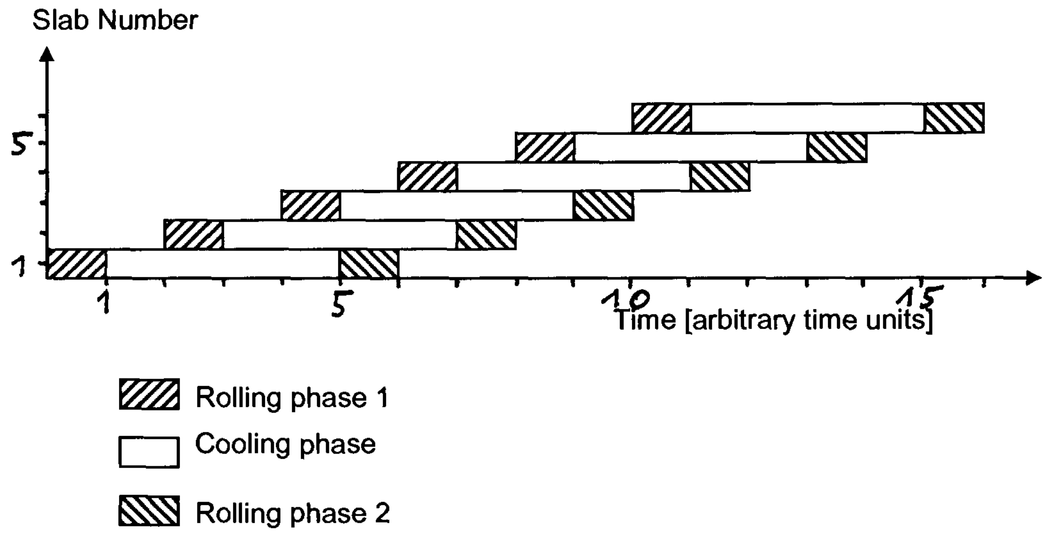
Slab Number
5
1
1
5
10
15
Time [arbitrary time units]
Rolling phase 1
Cooling phase
Rolling phase 2

FIG. 17

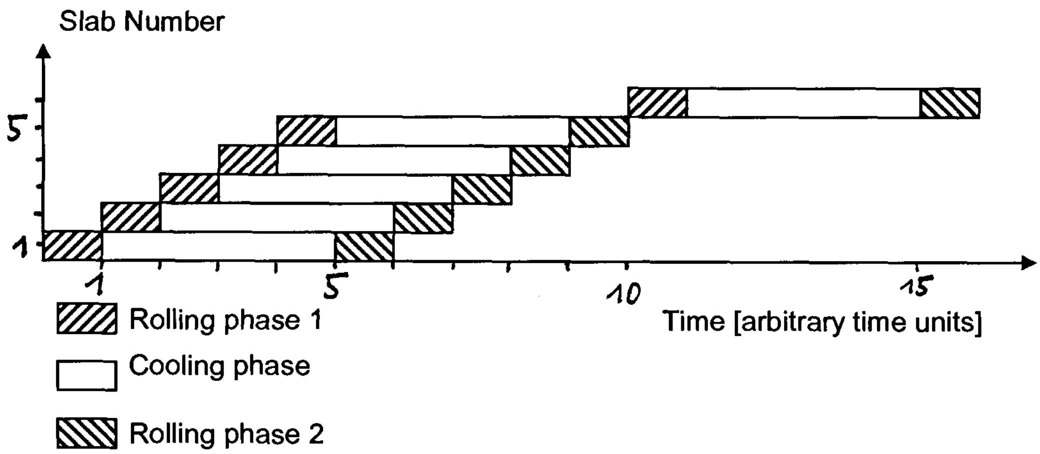
Slab Number
5
1
1
5
10
15
Time [arbitrary time units]
Rolling phase 1
Cooling phase
Rolling phase 2

FIG. 18

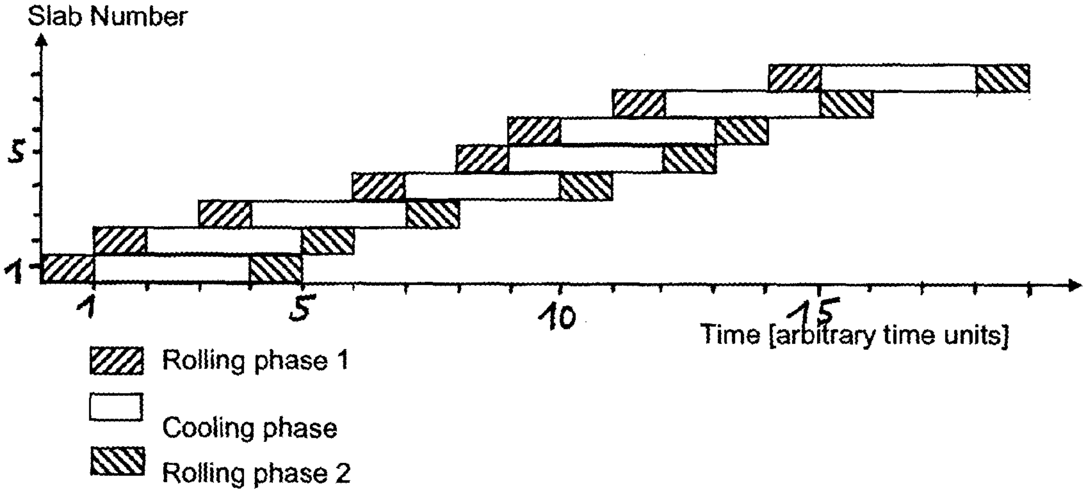
Slab Number
5
1
1
5
10
15
Time [arbitrary time units]
Rolling phase 1
Cooling phase
Rolling phase 2

FIG. 19

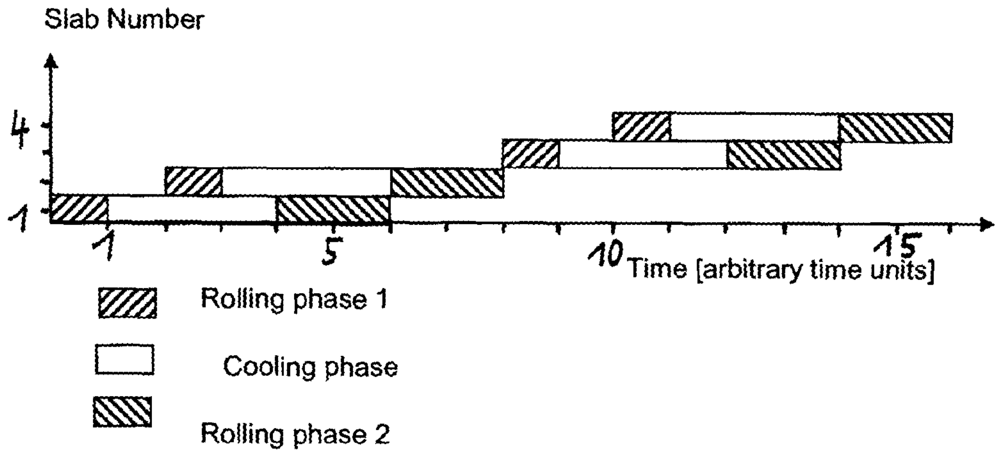
Slab Number
4
1
1
5
10
15
Time [arbitrary time units]
Rolling phase 1
Cooling phase
Rolling phase 2

FIG. 20

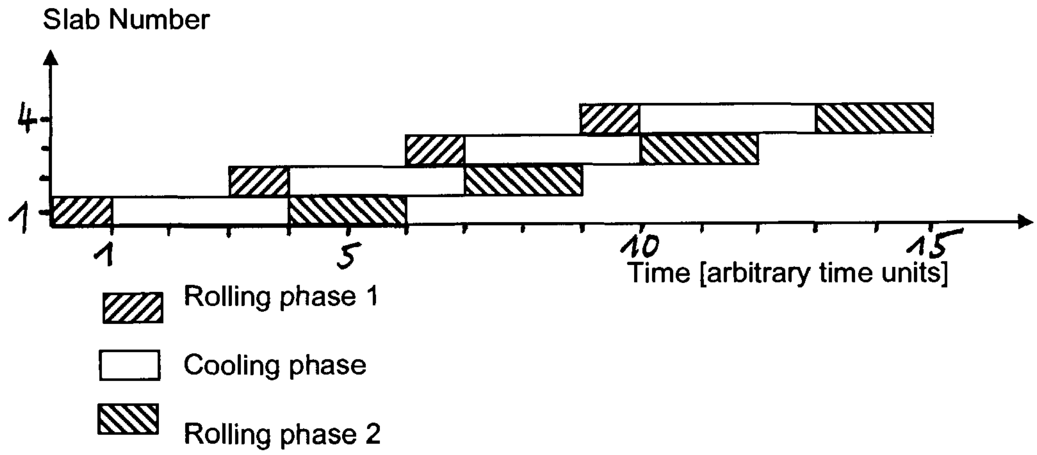
Slab Number
4
1
1
5
10
15
Time [arbitrary time units]
Rolling phase 1
Cooling phase
Rolling phase 2

FIG. 21

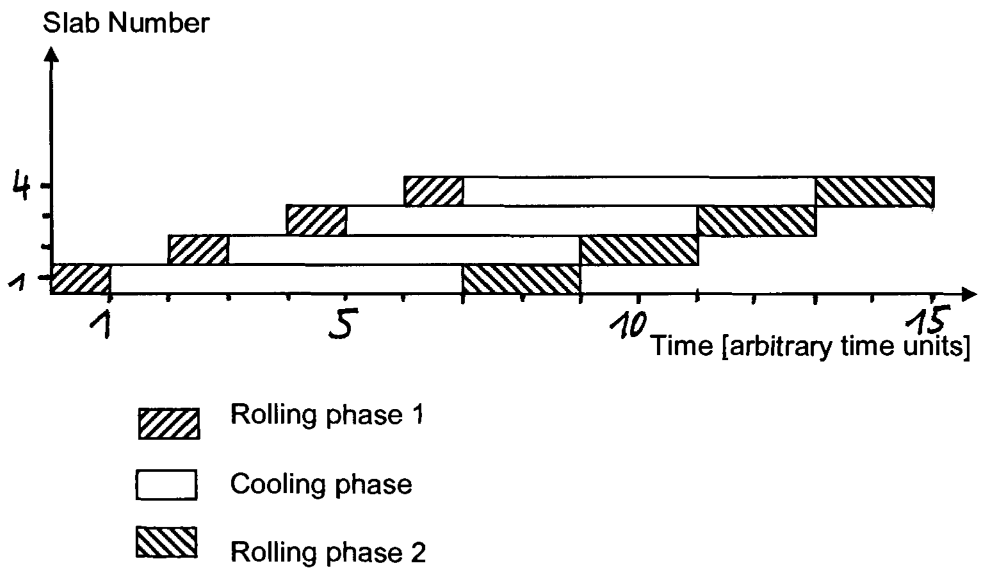
Slab Number
4
1
1
5
10
15
Time [arbitrary time units]
Rolling phase 1
Cooling phase
Rolling phase 2

FIG. 22

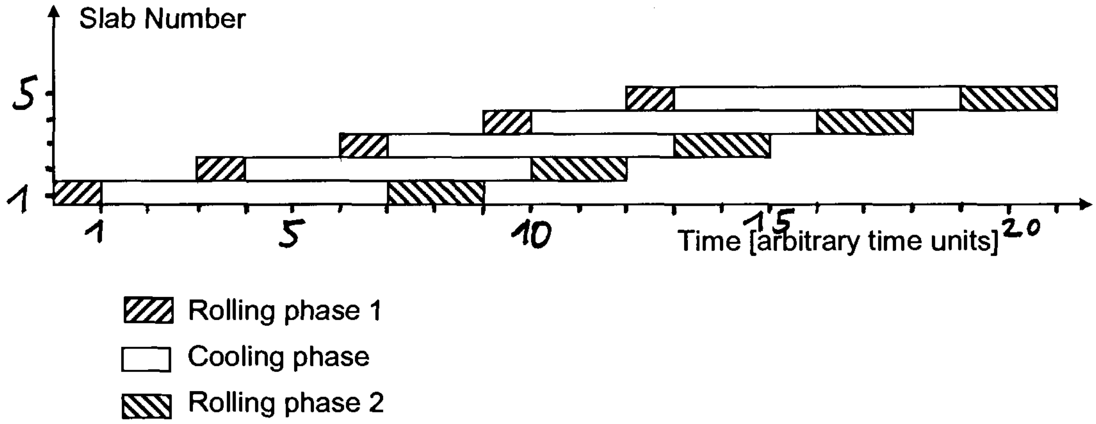
Slab Number
5
1
1
5
10
15
20
Time [arbitrary time units]
Rolling phase 1
Cooling phase
Rolling phase 2

FIG. 23

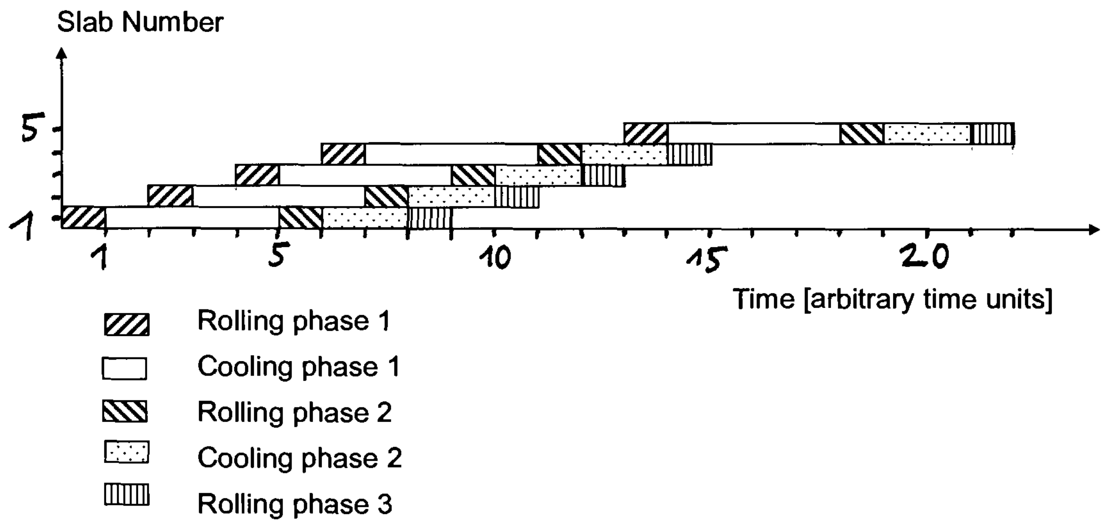
Slab Number
5
1
1
5
10
15
20
Time [arbitrary time units]
Rolling phase 1
Cooling phase 1
Rolling phase 2
Cooling phase 2
Rolling phase 3

FIG. 24

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 27 0012

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 1 396 946 A (MANNESMANN ROEHREN WERKE AG) 11 June 1975 (1975-06-11) * page 2, line 49 - line 89; figures 1,2 * -----	1-25	INV. B21B39/00 C21D8/02
A	WO 2006/063839 A (SMS DEMAG AG [DE]; MODROW WILFRIED [DE]; SKODA-DOPP ULRICH [DE]) 22 June 2006 (2006-06-22) * page 6, line 29 - page 7, line 27; figures 1,2 * -----	1,23	
A	EP 0 885 974 A1 (SCHLOEMANN SIEMAG AG [DE] SMS DEMAG AG [DE]) 23 December 1998 (1998-12-23) * figure 1 * -----	1,23	
			TECHNICAL FIELDS SEARCHED (IPC)
			B21B C21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 June 2007	Forciniti, Marco

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

2

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 27 0012

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