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(54) Automatic method for controlling the working speed of a weaving loom to optimise the productivity thereof

(57) An automatic method for controlling the working speed of a weaving loom, for the purpose of optimising the productivity thereof, comprises the steps of: starting the loom at the speed Viniz equal to a standard working speed; detecting the overall number of stops NF1 in a first period of time t1, and determining the value of BF1 and RM1 by the formulas:

$$BF = Vtel \cdot \Delta t / NF$$

$$RM = BF / (BF / Vtel + TF) = BF \cdot Vtel / (BF + TF \cdot Vtel);$$

in subsequent periods of time t2, t3, tn detecting in a similar way the overall number of stops NF in any period, calculating the values of BF and RM of the different periods; at the end of each period t after the first one, comparing the value RMn of period tn with a reference value RM representative of the average productivity of the preceding periods and, for the subsequent period, increasing/decreasing loom speed by a preset value ΔV, depending on the fact whether RMn is greater or smaller than the reference RM.

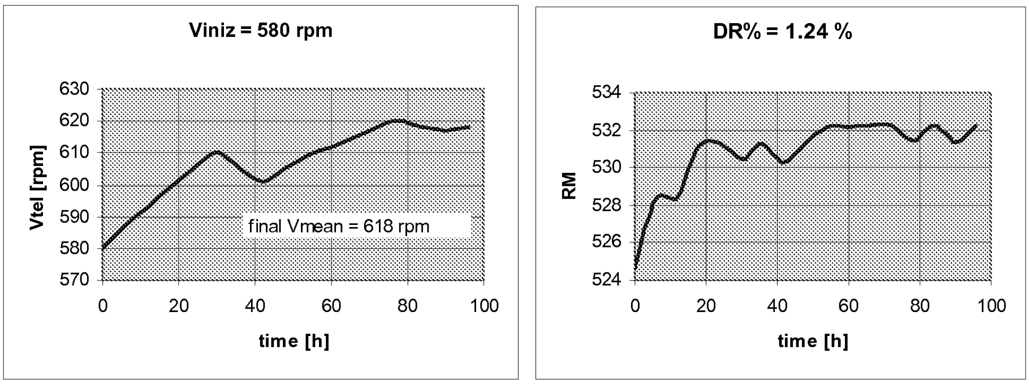

FIG. 2A

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Description

[0001] The present invention concerns an automatic method for controlling the working speed of a weaving loom, for the purpose of maximising the productivity thereof. In particular the invention concerns a fine adjustment method of the weaving speed, in the neighbourhood of a standard working speed.

[0002] As known, the productivity of a loom is normally defined as the number of weft yarns inserted in the unit of time (for example every minute). Of course it must be distinguished between maximum loom productivity - achievable in optimal weaving conditions, in the absence of stops and hence for short periods of time - and average loom productivity, i.e. productivity assessed throughout a rather long period of time (for example a few hours, a day, etc.) to take into account also the loom stops for repair actions of the weft yarns or of the warp yarns which have broken or have shown other faults during weaving. Maximum productivity is representative of the peak performance of a loom, while average productivity is a significant parameter of the actual loom performance.

[0003] In the following, average productivity will be referred to as:

RM = average productivity = wefts actually introduced per minute, over a preset period of time.

[0004] Indicating then by:

Vtel = loom speed (number of strokes per minute), one has of course the relationship, in the ideal case of a loom weaving without stops for repairs:

RM = Vtel.

[0005] Furthermore, BF indicates the average number of correctly-performed strokes (i.e. the number of wefts introduced) before a loom stop, and NF the number of loom stops, in a period of time Δt, where these two quantities are linked by the relationship:

$$BF = Vtel \cdot \Delta t / NF.$$

[0006] Finally, TF indicates the machine downtime (in minutes) for each stop, i.e. the time necessary for performing the repair and restarting the loom, which time in the following considerations will be considered, for simplicity, constant and equal to the average repair time. Better results can be achieved distinguishing between stops due to weft breakages and stops due to warp breakages and by assigning different machine downtimes to these two cases in point.

[0007] According to the definitions set forth above, during manufacture a machine downtime will arise, caused by a fault on the weft or warp yarns, after a period of time (expressed in minutes) equal to:

$$BF / Vtel$$

and hence BF wefts will be inserted in an overall time equal to:

$$BF / Vtel + TF$$

[0008] The number of wefts inserted in a minute, and hence average productivity, will hence be equal to:

$$RM = BF / (BF / Vtel + TF) = BF \cdot Vtel / (BF + TF \cdot Vtel)$$

[0009] As a confirmation of the correctness of this equation, it may easily be observed that:

- if TF = 0 (null stop time), RM = Vtel = productivity in the ideal case is obtained;

- if BF tends to infinity (i.e. NF = 0, no stops), the addendum TF·Vtel becomes negligible over BF and hence RM = Vtel = ideal productivity is obtained again.

[0010] The equation set forth above for calculating RM has been used in the optimisation study of the working speed of a loom, based whereon the method of the present invention has been devised.
[0011] EP-371483 suggests a control method of the working speed of a loom, wherein a limit frequency of loom stops is calculated in advance, depending on fabric quality and on a time sufficient for the repair action by an operator, and hence increasing/decreasing the speed when the detected error frequency is below/above said limit frequency.
[0012] However, such method is affected by the complications and the approximations introduced in the assessment step of the limit stop frequency, and the need for a simpler control method is hence perceived in the industry, allowing to search automatically for the speed capable of maximising productivity, starting from standard processing conditions preset by the operator.
[0013] The object of the present invention is hence that of providing an automatic method for controlling the working speed of a weaving loom capable of optimising the productivity of a loom, expressed in terms of wefts actually introduced over a certain period of time, varying the working speed in a preset neighbourhood of the standard working speed, with no need to define *a priori* limit quality parameters. In other words, the present invention suggests a control algorithm of the loom working speed, capable of determining an optimal working speed, capable of maximising loom productivity, according to the loom processing data in a previous processing period.
[0014] Such object is achieved, according to the present invention, through an automatic method for controlling the working speed of a loom, having the features defined in the attached claim 1.
[0015] Further features of the method of the present invention are defined in the dependent claims.
[0016] An exemplifying application of the control method of the present invention to a gripper loom, operating under the following basic conditions and assumption will now be described:

1. article change every 4 days; therefore the effect of the control method of the present invention over a 4-day period will be assessed;
2. typical working speed of 600 strokes/minute;
3. admissible range of the working speed change determined automatically by the control method of the invention, limited to a neighbourhood of ± 10% and preferably ± 5% of the initial speed; as a matter of fact, speed changes beyond this range might require the intervention of an operator to change weaving settings of the machine;
4. provided order of magnitude for loom stops due to weft or warp yarn breakages: 1 every 10,000 strokes;
5. fixed loom stop time for each stop, possibly different for weft or warp errors.

[0017] Such exemplifying application will be further illustrated with reference to the accompanying drawings, wherein:
[0018] fig. 1A, B, C and D are diagrams illustrating the trend of average loom productivity depending on working speed, with the assumption of an exponential growth of stop frequency NF with speed, and for four different duration times of the machine downtime for repair actions;
[0019] fig. 2A, B and C are diagrams illustrating the trend of the working speed and of the average productivity of a loom whereto the method of the invention has been applied, for different initial speeds.
[0020] The algorithm for the optimisation of the working speed of the method of the present invention hence requires - for the actuation thereof - solely the automatic detection of the number of stops of the loom during subsequent loom operation periods, i.e. of parameter NF. This detection must be performed carefully, dismissing for example all manual stops, i.e. stops due to an action by the operator, and all those other stops which may not be directly attributed to the loom working speed. As a matter of fact, the main assumption whereon the control method of the present invention is based is that a loom speed increase always causes an NF increase.
[0021] For this purpose, the Applicant has carried out preliminary tests, ascertaining that the field of application of interest of the method of the present invention is limited to the processing conditions wherein NF increases with working speed in a more than proportional fashion. As a matter of fact, only in these cases can the existence of a maximum point of productivity be verified in a neighbourhood of the standard working speed. In the other cases instead maximum productivity is achieved instead by simply causing the loom to operate at the maximum admissible speed.
[0022] Fig. 1 shows some qualitative diagrams of the average productivity trend of a loom depending on the working speed, with the assumption of an exponential increase of NF with speed. The different diagrams refer to different machine downtimes TF, which times have been assumed as being constant in every individual application and which, as evidenced by the diagrams, seriously affect the peak position of the average productivity curve. As a matter of fact, if TF = 1 or 2 min, starting from a Viniz = 600 rpm/min, it is necessary to increase the speed to increase productivity; if TF = 3 or 4 min, starting again from Viniz = 600 rpm/min, it would instead be necessary to decrease the speed in order to increase productivity.
[0023] In the framework of the above-said assumptions, the method for optimising working speed according to the

present invention provides hence the following steps:

a) the loom is started at the speed Viniz equal to the standard working speed for a set item (for example 600 rpm/min);
b) in a first period of time t1 (for example 3 h) the overall number of stops NF1 is detected and the values of BF1 and of RM1 are consequently calculated;
c) in subsequent periods of time t2, t3, tn similarly the overall number of stops NF is detected, calculating the values of BF and RM of the different periods;
d) at the end of each period t the value of RMn is compared with a reference value of RM and, for the subsequent period, loom speed is increased/decreased by a preset value ΔV (for example 5 rpm/min), depending on whether RMn is greater or smaller than the reference value RM.

[0024] The reference value RM may be alternatively equal to the value RM(n-1) calculated for the immediately preceding period, or to an average value RM(average) of the average productivities of all the preceding periods.

[0025] Due to what has been said above, speed changes are hence set at the end of the second period, i.e. when it is possible to make a comparison between the productivity of the current period (the second one) and that of the previous period (the first one). Of course, in the case of habitual productions wherein an average productivity value RMO is already known, it is possible to provide an increase/decrease of the working speed already starting from the end of the first period, comparing the average productivity value RM1 at the end of the first period with the above-mentioned value RM0.

[0026] The time periods t1, t2, tn normally have identical duration and the length thereof is determined experimentally depending on the number of stops which occur on average throughout a period. As a matter of fact, it is necessary for the NF for each period to be sufficiently high to make the incidence of the change of NF depending on speed change percentually small. In the opposite case the control method would imply continuous speed oscillations without providing real convergence towards an optimal value.

[0027] From the tests carried out so far by the Applicant it was possible to ascertain that when the number of stops NF is of the above-stated order of magnitude of 1 every 10,000 strokes, the optimal duration of each period of time - with the assumption of an overall processing period of 4 days - ranges between 3 and about 6 hours. Such duration must instead be proportionally reduced or increased when said order of magnitude of NF increases or decreases significantly over the one indicated above, or when the overall duration of the processing is shorter or longer than the one indicated.

[0028] The value of ΔV, i.e. of the speed increase/decrease at the end of each period of observation may be constant, as indicated above, ranging for example between 3 and 7 rpm/min, and preferably equal to 5 rpm/min. However, it has been ascertained that better and more rapid loom speed convergence towards the optimal value is achieved if ΔV progressively decreases upon each cycle, in a linear fashion or according to other kinds of law, between a predefined maximum and minimum value, for example between 7 rpm/min and 1 g/m. The ΔV decrease law can furthermore take into account also the history of the preceding changes of ΔV, increasing the progressiveness of the decrease when an alternation of opposite signs has occurred (i.e. alternation of speed increases and decreases) in subsequent periods of time, with respect to the decrease progressiveness used in the opposite case, wherein speed changes have the same sign (i.e. continuous speed increase or decrease) for multiple, subsequent periods of time.

[0029] Figs. 2A, 2B and 2C show diagrams which illustrate the weaving speed change in looms wherein the automatic method has been applied for controlling speed according to the present invention, starting from different initial speeds of the loom. In this experimentation, in the second period of time a positive, constant ΔV of 5 rpm/min has nevertheless been imparted, as visible from the speed peak of the second period. It can be noticed that in all the cases the working speed converges sufficiently quickly towards an optimal value already at the end of the first processing day.

[0030] On the right-hand side of the pictures the change of average productivity RM in the same period is shown, as well as the value DR% of the productivity percentage increase, calculated as the percentage ratio between actual productivity and the theoretical productivity which would have been achieved operating for the entire processing period, in the same conditions as the initial period t1. In all cases an increase of such coefficient has been detected.

[0031] The control method of the present invention has been illustrated with reference to some exemplifying applications, but it is clear that multiple variants may be introduced without departing from the scope of protection of the invention, which is limited exclusively by the attached claims.

Claims

1. Automatic method for controlling the working speed of a weaving loom comprising the steps of:

a) starting the loom at the speed Viniz equal to a standard working speed;
b) detecting the overall number of stops NF1 in a first period of time t1, and determining the values of BF1 and

RM1 by the formulas:

$$BF = Vtel \cdot \Delta t/NF$$

$$RM = BF / (BF / Vtel + TF) = BF \cdot Vtel / (BF + TF \cdot Vtel);$$

c) in subsequent periods of time t2, t3, tn detecting in a similar way the overall number of stops NF in each period, calculating the values of BF and RM of the different periods;
d) at the end of each period t subsequent to the first one, comparing the value RMn of the period tn with the value RM(n-1) of the period t(n-1) and, for the subsequent period, increasing/decreasing loom speed by a preset value ΔV, depending on whether RMn is greater or smaller than RMn-1.

2. Automatic method for controlling the working speed of a weaving loom comprising the steps of:

a) starting the loom at the speed Viniz equal to a standard working speed;
b) detecting the overall number of stops NF1 in a first period of time t1, and determining the values of BF1 and RM1 by the formulas:

$$BF = Vtel \cdot \Delta t/NF$$

$$RM = BF / (BF / Vtel + TF) = BF \cdot Vtel / (BF + TF \cdot Vtel);$$

c) in subsequent periods of time t2, t3, tn detecting in a similar way the overall number of stops NF in each period, calculating the values of BF and RM of the different periods;
d) at the end of each period t subsequent to the first one, comparing the value RMn of the period tn with the value RM(average) of the preceding (n-1) periods and, for the subsequent period, increasing/decreasing loom speed by a preset value ΔV, depending on whether RMn is greater or smaller than RM(average).

3. Automatic method for controlling loom speed as claimed in claim 1) or 2), wherein the speed change occurs already at the end of the first period t1 following a comparison of RM1 with an average productivity value RM0 relating to similar previous processes.

4. Automatic method for controlling loom speed as claimed in claim 1) or 2), wherein the duration of periods t is constant and ranging between 3 and 6 hours, for a loom stop frequency of the order of magnitude of 1 stop every 10,000 strokes.

5. Automatic method for controlling loom speed as claimed in claim 1) or 2), wherein the speed increase/decrease value throughout each period is constant.

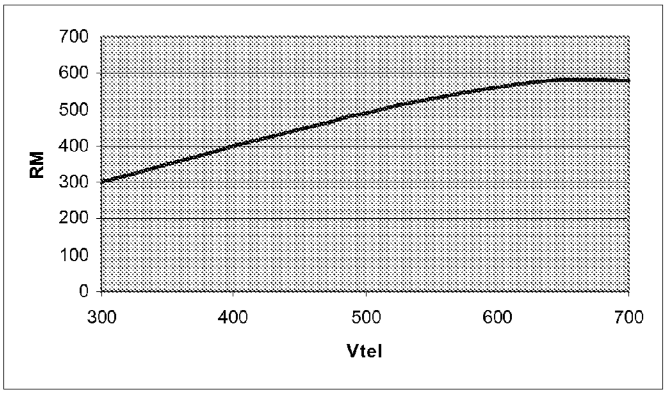
6. Automatic method for controlling loom speed as claimed in claim 5), wherein said value ranges between 7 and 3 rpm/min.

7. Automatic method for controlling loom speed as claimed in claim 1) or 2), wherein the speed increase/decrease value in each period decreases according to the number of periods.

8. Automatic method for controlling loom speed as claimed in claim 7), wherein the reduction progressiveness of the working speed increase/decrease in each period - when the speed changes made in the previous periods have an opposite sign - is higher than when the speed changes in the previous periods have concordant sign.

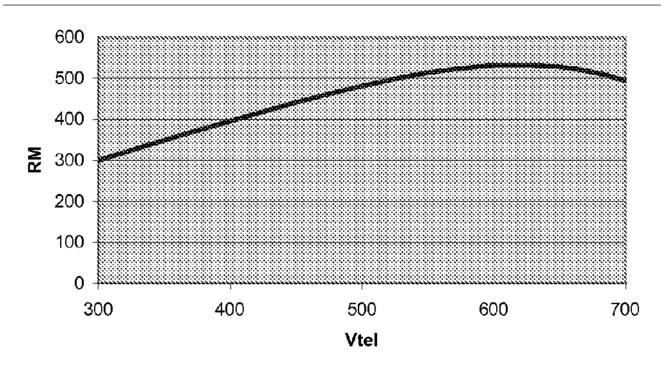
9. Automatic method for controlling loom speed as claimed in claim 7) or 8), wherein said speed increase/decrease, in each period, ranges between 7 and 1 rpm/min.

10. Automatic method for controlling loom speed as claimed in any one of the preceding claims, wherein the admissible speed change range is limited to ± 10% by the initial working speed.



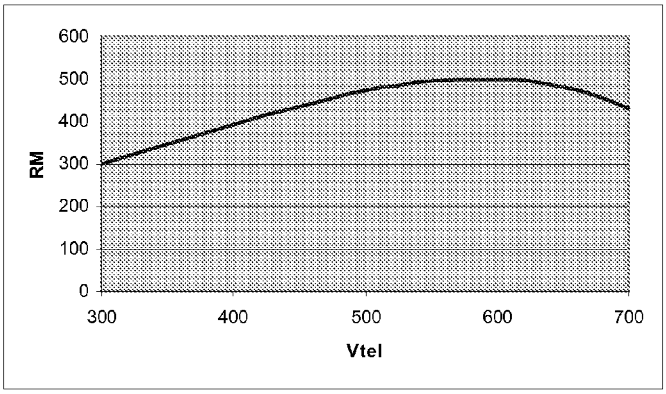
TF = 1 min

FIG. 1A



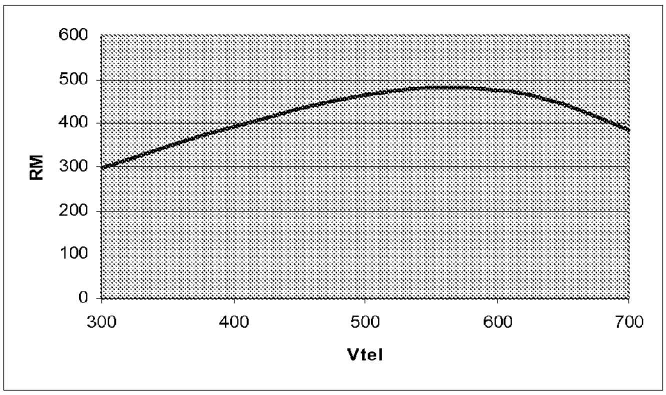
TF = 2 min

FIG. 1B



TF = 3 min

FIG. 1C



TF = 4 min

FIG. 1D

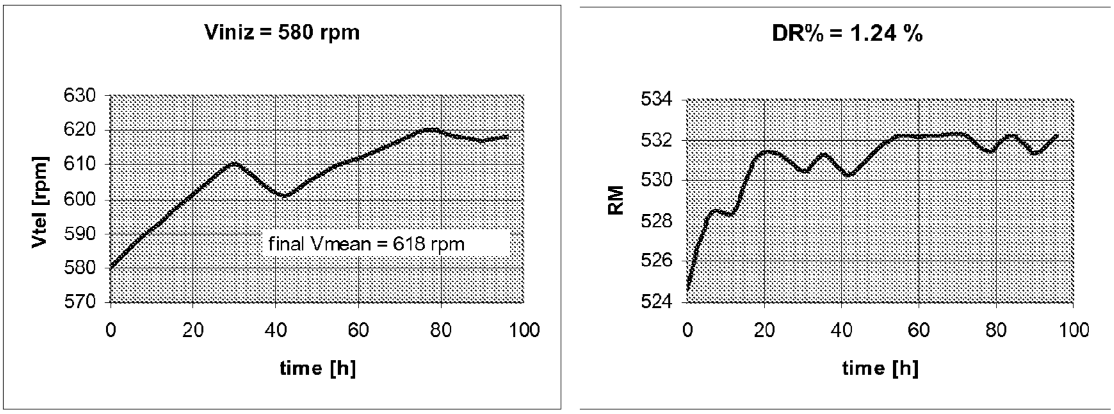


FIG. 2A

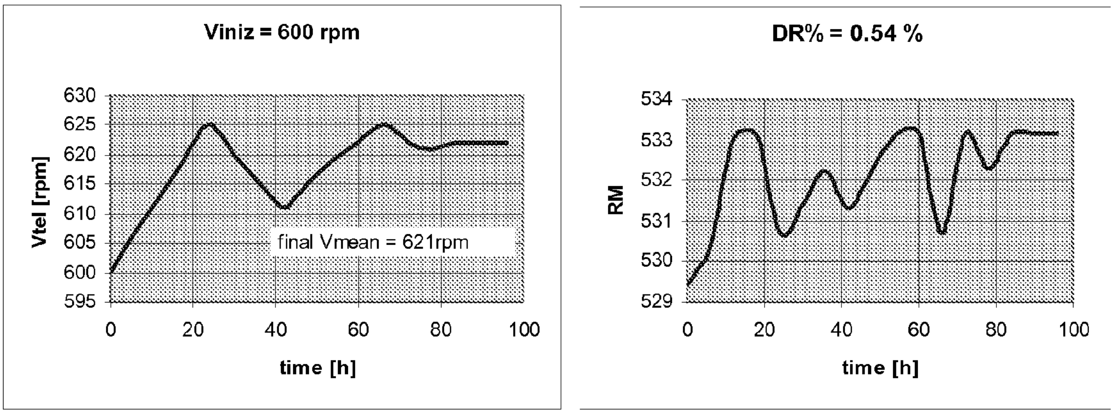


FIG. 2B

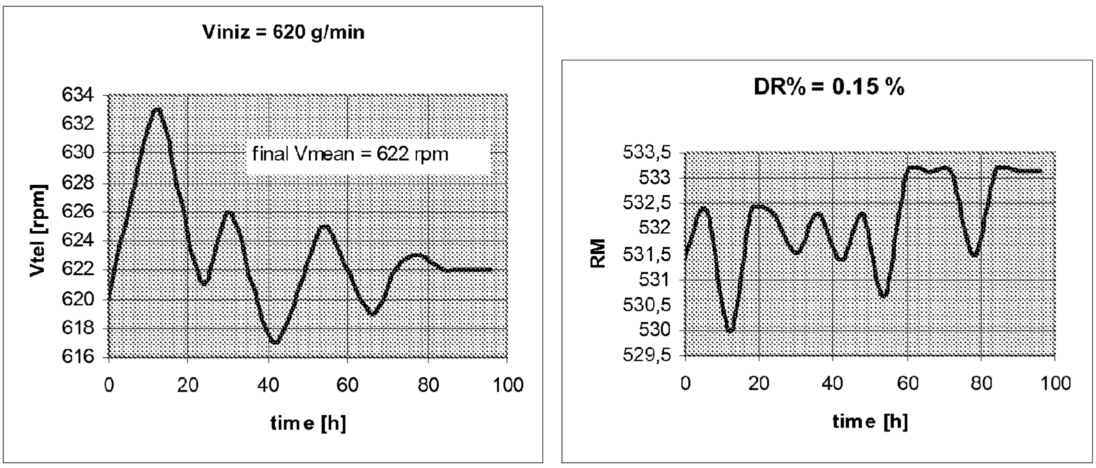


FIG. 2C

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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