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DRIVE MEANS FOR A CYLINDER PROCESSING MACHINE

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The present invention relates to a drive for a cylinder drying machine in which a web of material is passed over a plurality of processing cylinders, which web may undergo a change in length owing to this processing. Machines of this type are used for several purposes, such as the drying of paper webs, fabric webs, and yarn strands, the heating of webs impregnated with synthetic material up to temperature for the benefit of polymerization, the thermofusing of dyes in webs, and the like. For simplicity's sake only the use as a cylinder drying machine will be referred to hereinafter.

In the known embodiments of a drive for a cylinder drying machine it is tried to adapt the peripheral speed to the speed of the web which has changed owing to the change in length of the web, either by having the cylinder diameters vary according to a proportional ratio, or by driving the cylinders at corresponding mutual differences in the speeds of revolution. The second alternative is often realized by selecting a drive belt for the drive and by varying the diameters of the pulleys by which the cylinders are driven. This form of driving is to be regarded as the simplest attempt to adapt the revolutions of the cylinders to the altered speed of the web, it being obvious that in this manner no nearly tension-free and anti-slip web transport can be realized, because no account is taken of the torque applied by the web on the cylinder.

A drive means for a cylinder drying machine in which it is tried to adapt the number of revolutions to the speed of the relevant web portion in a different manner is known from Netherlands patent specification No. 82,379. This so-called relax-drive is based on the fact that instead of a "right" belt a flexible drive means is used. Although, superficially, this looks like a so-called tension-poor drive, this is not so in reality.

With a changed tension in the flexible drive means, and on the assumption that this drive means does not slip in the groove, which it does in actual practice, an increased torque on the cylinder will respond to said tension upon shrinkage in the cloth, which also causes an increase in the tension of the cloth. Besides there is the condition that the energy exclusively available to the transport of the web and to be fed to the cylinder must not be influenced by the loss-of-energy power that is necessary for other purposes. This condition can only be met if these losses for all drying cylinders, as well as the average diameters by which the flexible drive means run in their grooves and the associated spring constant, are precisely equal, and besides the revolutions of the driven pulleys are adapted to the alteration of the web rate. And this last-mentioned condition would in turn degrade this form of drive to the simple drying machine drive referred to above. For this to be true is more clearly understood if it is assumed that by means of this form of drive a web is to be transported of which the input rate \( v_1 \) has a specific value and the output rate \( v_2 \) reaches or approaches zero because of the shrinkage. In this case the first cylinder would have to make \( n_1 \) revolutions per minute, and the last cylinder would have to have a speed which is equal or substantially equal to nil revolutions per minute, and besides the tension in the flexible drive means of this last cylinder would have to be zero. For this example not to be so exaggerated as it may look like it is shown by the fact that in drying machines having a large number of cylinders, wherein the flexible drive means is used, there is often required a group-wise reduction of the input speed, in spite of the fact that shrinkage causes the web rate at the output end to show a value which is but a few percents lower (\( v_0=0.9 \) \( v_1 \) may usually be called a great difference already).

Also in using hydraulically operated slip couplings or electromagnetically or mechanically operated slip couplings, it is impossible to realize drying with little tension, the check test being the extreme transport instance again mentioned above for the relax machine.

It is an object of the present invention to obviate the above drawbacks. Accordingly this invention is characterized in that the drive means is composed of a plurality of hydromotors for driving the drying cylinders, and of a pump having a control and pumping yield, said hydromotors being connected to said pump in parallel relationship, and of a calibrating device provided in the path of flow of each hydromotor, and a control device which is connected to said pump and by which the feed web portion is kept nearly free of tension, the whole being so calibrated that also the web portion at the output end has little tension.

The invention will be illustrated hereinafter with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of a cylinder drying machine in illustration of the conditions this machine for substantially tension-free drying has to meet;

FIG. 2 shows a schematic diagram in illustration of the automatic differential action applied to the hydraulic drive according to this invention;

FIG. 3 is a more detailed diagrammatic view of the hydraulic drive according to this invention; and

FIG. 4 shows an embodiment of the apparatus according to this invention.

If the web is passed over a plurality of heated drying cylinders, of which seven are shown in FIG. 1, it will undergo a change in its length during the drying process. In a drying process in which it has been achieved to complete the drying entirely or substantially free of tension, the change in length \( \Delta l \), will have a negative character because of shrinkage.

To avoid tensions in the web or to prevent the peripheral speed of the cylinder from differing from the local web rate, it will have to be seen to it that the following equation is satisfied:

\[
\frac{v_0}{v_1} = \sqrt{r \cdot \frac{D}{l_0}}
\]

where \( v_0 \) represents the web rate and \( D \) the diameter of the cylinder.

As during the drying process the length may be expected to change continually, it will not only be necessary for the factor \( i \) to be selected as high as possible with a given required, total heating surface area
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\[ F_A = \frac{1}{F_e} \]

(wherein \( i \) is the number of drying cylinders and \( F_e \) the contact surface per drying cylinder), but the speed of each drying cylinder will have to be adapted to the change in the web rate caused by the change in length owing to partial drying.

So the cylinder speed \( n_c \) will in general have to vary with each cylinder. In the case of the embodiment shown in FIG. 1, \( n_1 \neq n_2 \neq n_3 \neq \cdots \neq n_i \) applies, because

\[ \nu_1 \neq \nu_2 \neq \nu_3 \neq \cdots \neq \nu_i \]

these web rates again differ from the input and output web rates \( \nu_i \) and \( \nu_o \), respectively.

The total change of length \( \Delta l \), is not caused by the relation:

\[ 1 = l \cdot \Delta l \]

because the change in the relative moistness of the web varies from cylinder to cylinder. Therefore, with a manner of driving wherein

\[ R = n_1 \cdot R_2 = n_3 \cdot R_4 = \cdots = n_{i-1} \cdot R_i \]

slip and tensions in the web will be inevitable.

From the aforesaid can be derived the conditions which an ideal drive for a cylinder drying machine has to meet.

(A) A cylinder speed must be entirely adapted to the local web rate affected by the change in web length.

(B) The energy \( A_i \) exclusively available to the web transport and to be fed to the cylinder must not be influenced by the loss-of-energy power required for other purposes.

The total energy \( A = A_1 + A_2 \) required for the cylinder can be a multiple of \( A_1 \cdot A_2 \) is caused by journal friction, stuffing box friction and other such drive losses.

Consequently, a substantially tension-free web transport is not very well possible if a cylinder is driven by means of another cylinder or through the web to be transported.

This leads to the following conditions:

(C) Each cylinder must be separately driven.

(D) A driven cylinder must not be influenced by the drive of another cylinder.

It should be understood that, for example, drawing rollers at the output end of the drying machine, or a winding device on which the web is wound under tension, or other similar devices, adversely affect the operation of the machine. For by means of such devices energy is fed to the machine through the web, as a result of which there will not only arise a cloth tension in the last web portion, but the above-mentioned condition that the cylinders must not be driven through the web to be transported will not be met.

(E) The discharge of the web at the output end of the machine must take place nearly free of tension.

The web supply at the input end of the machine must be in synchronism with the web rate on the first cylinder. As can be easily seen, too low a feed rate not only causes a cloth tension in the input web portion and/or slip on the cylinders, but the drying machine drive is forced to produce a higher energy than is required for the web transport alone, which again results in tensions in the web portions between the respective cylinders.

(F) The feed of the web to the input side of the machine must take place nearly free of tension.

To satisfy the above conditions, according to this invention a hydraulic drive having an automatic differential action is applied. The principle of such drive is known per se, but will be briefly discussed hereinbelow, after which a reflection will be given to what extent such drive is useful for the transport of a web through a cylinder drying machine.

If, as shown in FIG. 2, two absolutely identical and parallel connected hydro-motors are fed by a pump, the speeds of the motor will likewise be equal, it being assumed that the internal resistance and the pipe resistances are also equal for both of the motors. If one of the motors is delayed by braking so as to come to a standstill, the entire flow of oil from the pump will try to find its way through the other, unloaded, motor, as a result of which the latter is going to run, naturally, at a number of revolutions twice the original number.

Only if the second motor is loaded with the same torque as the former, will the two motors run at the same, original, speed. If the two motors are loaded with different torques, they will accordingly run at different speeds, and this as follows:

\[ n_1 = n_2 \]

\[ n_1 \neq n_2 \]

\[ n_1 = 2 \cdot n_2 \cdot M_2 \left( M_1 + M_2 \right) \]

\[ n_2 = 2 \cdot n_1 \cdot M_1 \left( M_1 + M_2 \right) \]

wherein \( n_1 \) is the no-load speed and \( M_1 \) and \( M_2 \), respectively, the torques occurring under loaded condition.

If the number of motors is extended (see FIG. 3), a similar differential action is created, with the sum total of all motor speeds being invariably constant.

On variations in the pumping yield, corresponding variations will occur in the sum total of the speeds of revolution.

A drive of this type is in itself certainly not worse than any other one of the equipment discussed before. Yet an additional, not to be neglected, advantage is obtained by the simple speed control across a wide range by means of the control of the pumping capacity.

FIG. 4 shows a nearly tension-free hydraulic drive for a cylinder drying machine according to this invention.

Upon reflection of the hydraulic drive according to the scheme shown in FIG. 3 it appears that in a practical embodiment differences in resistance and accordingly in speed are unavoidable. Besides, this equipment does not satisfy the above condition B.

One of the characteristic features of this invention is that each hydro-motor is provided with a known-per-se throttling device. This throttling device, which may, for example, consist of a tap or a needle valve, may be disposed either at the input end or at the output end, though from a practical point of view the outlet end is mostly preferred, as is shown by S in FIG. 4.

If the preferably dynamically balanced drying cylinders, after the assembly, must be set into motion by means of pump P without a web being passed through the machine, it will turn out that not only the various hydro-motors will start turning at different speeds, but one or more of the motors will continue to stand still, owing to the differences in the required energy \( A_n \), as referred to under condition B. The throttling device S allows of a change in the various resistances so that each cylinder in the unloaded condition set rotating at exactly the same speed.

If, subsequently, a machine calibrated in such a manner has to transport a web, the speed of the motor, and with it the speed of the cylinder, will only be influenced by the local web rate, provided there are no special web tensions in the input and output portions, so that the above conditions E and F have been met.

This can be accounted for as follows. If the local web rate should tend to adopt a value higher than the peripheral speed of the respective cylinder, the relevant hydromotor would meet with a lower resistance than would the other motors, so that, as it were, it would be driven. In consequence thereof the flow of oil to this motor would automatically increase, as a result of which the number of revolutions of this motor would increase again, and this at the expense of the other motors. As it is, the total number of revolutions must be constant to realize the desired adaptation in this way. The reverse occurs if the web rate should tend to adopt a value lower than the peripheral speed of the respective cylinder, as a result of which the resistance will increase, which again results in a stabilizing effect.

A second characteristic feature of the apparatus according to this invention is that there are provided at the input
end of the drying machine two photo-electric cells \( ph_1 \) and \( ph_2 \) for controlling the web feed in such a manner that with too high a web rate in the drying machine relative to the feed rate the photocell \( ph_1 \) emits a signal through an amplifier to the control mechanism \( r \) of the pump \( P \) so as to adjust the pumping yield at a lower value. Conversely, with too low a web rate relative to the feed rate the control mechanism will receive a signal from the photocell \( ph_2 \) so as to increase the pumping yield. If desired, a dancer control roller could be used for this, although it would cause some tension in the web.

It will be understood that for this photocell receiver there may be used a converter of ultrasonic sound waves into electric signals.

In this manner the hydraulic drive according to the invention is entirely automatically adapted to each feed rate, without web tensions occurring at the input end, while the machine, even from a condition of standstill, could be controlled at the proper web rate.

The hydraulic drive discussed hereinbefore satisfies the conditions referred to under A through F. Besides it will be quite obvious that the above-mentioned extreme transport problem can also be solved by the drive system according to this invention.

I claim:

1. Drive means for a cylinder processing machine in which a web of material is passed over a plurality of processing cylinders, comprising a plurality of hydro-motors for driving said processing cylinders, a pump having a controllable pumping yield, said hydro-motors being connected to said pump in parallel relationship, calibrating means provided in the path of flow of each hydro-motor, and control means connected to said pump for maintaining the feed portion of the web substantially free of tension, and said calibrating means being so calibrated that the web portion at the output end of the machine is under relatively little tension.

2. Drive means as claimed in claim 1 wherein said control means comprises an electric control device including a receiver responsive to the slackness at the feed portion of the web for providing an electrical signal representative of such slackness and said receiver being mechanically separated from the feed portion of said web.

3. Drive means as claimed in claim 2 wherein said receiver comprises a plurality of photocells and associated light sources, a first of said photocells being responsive to slackness in the feed portion of the web for providing a signal and a second of said photocells being responsive to excess tension in the feed portion of the web for providing a signal.

4. Drive means as claimed in claim 2 wherein said receiver comprises converter means for converting ultrasonic sound waves into electrical signals in response to the condition of the web at the feed portion thereof.

5. Drive means as claimed in claim 1 wherein said calibrating means comprises throttling means disposed in the path of fluid flow through said hydro-motor.

6. Drive means as claimed in claim 5 wherein said throttling means comprises a needle valve.

7. Drive means for a cylinder processing machine of the type employing a plurality of cylinders over which a web is entrained, said drive means comprising a plurality of fluid driven motors for driving said plurality of cylinders, pump means for supplying fluid to said fluid driven motors, said motors being connected in parallel across said pump means, calibrating means in fluid communication for restricting fluid flow therethrough whereby actuation of said fluid driven motors imparts differential speeds to said cylinders to provide a low tension level in said web, and web sensing means responsive to the degree of tension in said web at the input to said cylinders and connected to said pump means for varying the output of said pump means in response to variations in the tension in the web.

8. Drive means according to claim 7 wherein said calibrating means comprises valve means in fluid communication with said number of fluid driven motors for sequentially decreasing the output speeds of said fluid driven motors.

9. Drive means according to claim 8 wherein said calibrating means comprises valve means in fluid communication with said number of fluid driven motors for sequentially decreasing the speed imparted to said cylinders.

10. Drive means for a cylindrical processing machine of the type employing a plurality of cylinders over which a web is entrained, said drive means comprising a plurality of fluid driven motors for driving said plurality of cylinders, pump means for supplying fluid to said fluid driven motors, said motors being connected in parallel across said pump means, calibrating means in fluid communication with a number of said motors for restricting fluid flow therethrough whereby actuation of said fluid driven motors imparts differential speeds to said cylinders to provide a low tension level in said web, said pump means comprising a variable pump for varying the amount of fluid supplied to said fluid driven motors, said drive means further comprising control means for controlling the output of said variable pump in response to increases and decreases in tension in said web where said web enters said cylinders.

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