SPEED CONTROL MEANS

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ABSTRACT OF THE DISCLOSURE

In a rotational speed control means for hand sustained pressure fluid driven grinding, drilling and like machines, and particularly for dental work, an upper limit is put on the number of revolutions per minute of the machine from idling and up to full working load by a control valve and a control circuit cooperating to divert or to throttle pressure fluid in the control valve in advance of the machine such as to maintain automatically under any partial load a predetermined selective upper rotational speed limit for the machine.

This invention relates to speed control means and more particularly to rotational speed control means for hand sustained machines having a pressure fluid driven rotary motor and intended for such operations as grinding and drilling preferably in connection with dental work. In such machines, in the supply conduit for leading pressure fluid to the motor is usually arranged a reduction valve by which the pressure level of the pressure fluid entering the motor may be adjusted whereby the rotational maximum idling speed of the motor and its torque under working load are influenced. Often such machines are to be used with tools which because of the working process or by reason of strength considerations must be driven with low carefully limited rotational speed, such being the case for example in special dental tools for root filling operations and in grinding disks. Efforts have been made to limit the rotational speed for such special tools by lowering the pressure level by means of the reduction valve. It is true that the idling speed can be lowered in such way, but simultaneously the maximum torque of the tool under working load is also lowered resulting in the low-speed implement being unable to work satisfactorily under load.

Another measure applicable particularly in connection with grinding machines is to provide the machine with a centrifugal regulator controlling the pressure of the working fluid. This solution, however, is inappropriate in machines with very high rotational speed because of the usually restricted working range of centrifugal regulators and the regulator furthermore causes an undesirable increase in weight which is inconvenient particularly in dental machines.

It is an object of the invention to provide an automatically servo controlled rotational speed control for hand sustained machines of the above type offering an exact regulation of the rotational speed at partial load and idling of the machine without accompanying losses in output torque when the tool is set under load and without any significant increase in weight of the machine.

For the above and other purposes there is according to the invention provided in a hand sustained machine for grinding, drilling and the like, a pressure fluid driven rotary motor, a supply conduit connected to said motor for supplying pressure fluid thereto, a pressure reduction valve in said supply conduit for adjusting the pressure level therein, and a rotational speed control means for said machine, said rotational speed control means comprising an automatic pressure control valve in said supply conduit between said reduction valve and said motor actuable for controlling the pressure before said motor, a servo element in said control valve for the actuation thereof, and a control circuit, said control circuit including a servo circuit connected to said servo element for actuating said control valve, a gauging circuit for sensing the actual value of the rotational speed of said motor, an adjusting circuit for adjusting the rotational speed of said motor to a selective reference value lower than the rotational idling speed of said motor as defined by the adjustment of said pressure reduction valve, and means in said control circuit for controlling through the medium of said servo element and said control valve the pressure before said motor such as to keep said actual value substantially equal to said reference value and to cause the instant the motor rotates idle up to the motor being under full working load at the pressure level defined by said reduction valve.

The above and other purposes of the invention will be more clearly shown from the following description of the preferred embodiment of the invention in which the accompanying drawings in which two embodiments are illustrated by way of example. It should be understood that these embodiments are only illustrative of the invention and that various modifications thereof may be made within the scope of the claims.

In the drawings FIG. 1 shows a longitudinal section through the rear portion of a hand sustained machine embodying the invention. FIG. 2 shows a diagrammatic longitudinal section through an automatic control valve embodying the invention. FIG. 3 illustrates a reduction valve for the machine shown in FIG. 1. FIG. 4 shows an end view of the line 4—4 in FIG. 1. FIG. 5 is a partial cross section and top view of the motor in FIG. 4. FIG. 6 shows diagrammatically an electrical control circuit associated with the automatic control valve depicted in FIG. 2. FIG. 7 shows a longitudinal section through a modified embodiment of the control valve. FIG. 8 is a section on the line 8—8 in FIG. 7.

The example chosen for description relates to rotational speed control of a dental machine. Thus, in FIG. 1, a composite housing 10 in the shape of a hand piece is provided with a rotatably journaled drive spindle 11 which via drive axle parts 12, not shown in more detail, in known manner drives a dental tool such as a drill, a grinding disk, or the like, received in the machine 10. The housing 10 is provided with a throttle valve 13 inserted between a supply conduit or hose 14 and an inner chamber 15 in the housing 10. From the chamber 15 pressure fluid supplied through hose 14 is led via guide openings 16 against the blades 17 in a motor in the shape of a pressure fluid driven turbine 18. After the turbine 18 the pressure fluid is expelled to the surrounding atmosphere via openings 19, 20. The turbine 18 is drivenly connected to the drive spindle 11. The throttle valve 13 is actuated manually by means of a lifter 21 which latter through the medium of a spring-loaded cam sleeve 22 can be displaced rearwardly in the housing 10 by a spring loop 23, not shown in more detail, grasping at the forward portion of the housing 10, the spring loop 23 being affixed to the cam sleeve 22.

Pressure fluid for driving the motor 18 of the machine 10 is supplied from a suitable source via a hose 24, FIG. 3, to a reduction valve 25 constructed in conventional way. In the reduction valve 25 is provided a ball valve 27 to be opened by means of a lifter 28 against the pressure of the fluid delivered by the hose 24. The lifter 28 is loaded by a spring 30 abutting thereagainst through the intermediary of a diaphragm 31, the spring 30 being adjustable as to its spring load by a knob 29. The diaphragm 31 is disposed in a chamber 32 connected by a
conduit 33 with an outlet conduit 34 disposed downstream with respect to the ball valve 27. By turning of the knob 29 the load of the spring 30 is set so that there will be maintained in the outlet conduit 34 a pressure level reduced to the desired degree relative to the pressure level in the hose 24.

Between the throttle valve 13 and the reduction valve 25 is inserted an automatic pressure control valve 36, FIG. 2. The pressure control valve 36 is connected by a hose 37 with the outlet conduit 34 of the reduction valve 25 and includes a throttling means or aperture 38, a central passage 39 having a widening diffuser portion 40, and a diverting portion 42 terminated by a valve seat 41. The hose 14 of the machine 10 is connected to the diffuser portion 40 of the central passage 39. The control valve 36 is provided with a solenoid 43 which actuates magnetically a servo element 44 pivotally journalled in the control valve 36.

The servo element 44 has a plate-shaped portion 45 cooperating with the valve seat 41 and rapidly adjusting itself relative thereto to automatically regulated adjusting positions defined by the largeness of the D.C. voltage energizing the solenoid 43. A piston 46 is supplied with pressure fluid from the hose 37 via a passage 47 immediately after the throttling aperture 38. As a result the piston 46 will strive to load the plate-shaped portion 45 of the servo element 44 towards the seat 41 against incoming fluid flow action in the diverting portion 42. With the valve open the pressure fluid is expelled from the diverting portion 42 via a cavity 48 in the control valve 36 to the surrounding atmosphere.

By numeral 50 in FIGS. 2 and 6 is designated an electrical unit box which together with the automatic control valve 36 and the reduction valve 25 is mounted separately from the machine 10. The electrical unit box 50 includes the main components in an automatic control circuit associated with the control valve 36.

The electrical unit box 50, FIG. 6, includes conventional transistorized components fed by a suitable voltage source, not shown. To the box 50 is connected a gaging circuit including a conductor 51 which is extended from an induction coil 52 fixed in the machine 10, in which coil 52 voltage pulses are induced by permanent magnets 53 carried by the turbine 18. In the electrical unit box 50 the conductor 51 is connected to an amplifier 54 in which the weak voltage pulses from the induction coil 52 are amplified for then being fed into a rectifying and integrating block 55, the output signal of which represents a D.C. voltage value proportional to the actual rotational speed of the motor 18. This direct current voltage value represents the actual value in the control circuit of the pressure control valve 36.

In the electrical unit box 50 is furthermore included an adjusting circuit 56 in which an adjustable potentiometer 57 fed by suitable D.C. voltage forms the main part. By the potentiometer there is set a D.C. voltage value which in the control circuit represents the desired reference value for the rotational speed. The actual value and the reference value are fed in the form of D.C. voltage values into a controlling means consisting of a servo amplifier 58 working as an integrating operational amplifier in which the actual value and the desired value are compared over resistances 59, 60 placed in series and an output signal defined as to its polarity and largeness is produced which is fed into a power amplifier 61. From the power amplifier 61 the output signal in the form of a D.C. voltage is led over a conductor 62 to the solenoid 43 of the control valve 36 for actuation of the servo element 44.

In each of the equipment according to FIGS. 1–6 the pressure reduction valve 25 is set to a pressure level resulting in a certain maximal idling rotational speed and the desired torque under full working load, respectively. When automatic rotational speed control is undesirable due to the use of sufficiently strong tools, the reference value is set to maximum at the potentiometer 57 which results in the servo element 44 keeping the valve seat 41 closed and the pressure level in the hose 14 to the machine 10 becoming substantially equal to the level adjusted at the pressure reduction valve.

If it now is desired to drive use the machine with a tool which is to be strictly limited as to the idling rotational speed thereof, it would be possible to bring down the idling rotational speed by a substantial reduction of the pressure level in the reduction valve 25. However, with load on the tool, the low pressure level would result in a driving torque which normally would make effective use of the tool impossible. Therefore the servo circuit is actuated by setting by means of the potentiometer 57 and the adjusting circuit 56 as a reference value a calibrated voltage value which puts an upper limit on the idling rotational speed. The pressure reduction valve 25 is maintained on the pressure level which is necessary for giving sufficient torque under working load. When as a result of the high pressure level the rotational speed during idling strives to exceed the speed limit set by the reference value, the increase in the hoses 37 in from the throttling circuit 43 is limited and corresponding to a beginning increase of the actual value of the rotational speed of the motor 18, is received in the servo amplifier 58, the latter delivering an output signal via the conductor 62 which as to its polarity and largeness is adapted to adjust the servo element 44 by means of the pressure reduction valve 25 such adjustment causes a diversion of pressure fluid from the central passage 39 in the pressure control valve 36 so that the pressure before the machine 10 is regulated during idling and thus the rotational speed is controlled towards taking the adjusted rotational speed reference value as soon as a load is applied against the tool, the rotational speed tends to be reduced which is counteracted by the servo element 44 successively closing the valve seat 41 more and more until full closing has been reached, wherein the machine continues to work under overload on the pressure level to which the pressure reduction valve 25 is adjusted.

In the FIGS. 7, 8 is shown a modification of the pressure control valve. The control valve 36 in question is provided with a solenoid 65 which is fixed to a throttling valve body 66. The throttling valve body 66 projects into the main chamber 67 set in between the hoses 37, 14 for throttling therein the flow area when on the basis of voltage received in the solenoid the pressure is to be influenced in the hose 14.

It should be observed that the above described adaptation to dental machines is only to be considered as an example and that rotational speed control according to the invention also is adaptable with other types of machines intended for grinding, drilling and like operations and having pressure fluid motors. Such motors may be of other than of turbine type.

What is claimed is:
1. A hand sustained machine for grinding, drilling and the like, a pressure fluid driven rotary motor, a supply conduit connected to said motor for supplying pressure fluid thereto, a pressure reduction valve in said supply conduit for adjusting the pressure level therein, and a rotational speed control means for said machine, said rotational speed control means including an automatic pressure control valve in said supply conduit between said reduction valve and said motor, actuable for controlling the pressure before said motor, a servo element in said control valve for the actuation thereof, and a control circuit, said control circuit including a servo circuit connected to said servo element for actuating said control valve, a gauging circuit for sensing the actual value of the rotational speed of said motor, and adjusting circuit for adjusting the rotational speed of said motor to a selective reference value lower than the rotational idling speed of said motor as defined by the adjustment of said pressure reduction valve, and means in said control circuit for con-
trolling through the medium of said servo element and said control valve the pressure before said motor such as to keep said actual value substantially equal to said reference value from the instant the motor rotates idle up to the motor being under full working load at the pressure level defined by said reduction valve.

2. A machine according to claim 1 in which said control circuit is electrical and said gauging and adjusting circuits thereof are connected to feed said controlling means with electrical D.C. voltage values corresponding respectively to said actual value and to said reference value, said controlling means including an integrating operational amplifier for delivering a D.C. output signal to actuate said servo element of said control valve.

3. A machine according to claim 2 in which said gauging circuit includes inductive voltage pulse gauge means consisting of permanent magnets arranged on said motor and cooperating with induction coil means in said machine, said coil means forming part of said gauging circuit.

4. A machine according to claim 3 in which said supply conduit of said motor is a supply hose connected to said machine, said gauging circuit includes an amplifier separate from said machine, and said induction coil means is connected to said amplifier through the medium of a conductor extended through said supply hose.

5. A machine according to claim 2 in which said control valve includes a valve seat connected to said supply conduit and to passage means for diverting pressure fluid from said supply conduit, and in which said servo element includes a valve body cooperating with said valve seat for controlling fluid diversion through said passage means, and solenoid means for actuating said valve body.

6. A machine according to claim 2 in which said servo element includes a throttle valve body in said control valve actuatable for throttling fluid flow through said supply conduit, and solenoid means for actuating said throttle valve body.

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