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Gasket joint tightening.

An electric drive system applies rotational force to and threadably advances a fastener in a fastener and gasket assembly. A micro processor unit continuously compares the applied torque to a torque control limit value. When the torque control limit is reached the drive system power is reduced. After a preselected time pause the drive system applies at least one retorque pulse. When a predetermined quantity of retorque pulses have been applied, the tensioning operation is terminated.

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GASKET JOINT TIGHTENING

This invention relates to fastener tightening systems for gasketed joints. More specifically it relates to electrically powered torquing and retorquing systems utilized to tighten a threaded fastener joint which includes a gasket.

A gasket of a given material has a fixed rate of compression or flow proportional to the applied pressure. Most gaskets are used as sealers between two adjoining surfaces. The two surfaces are typically secured to each other through the use of fasteners such as threaded bolts. Gasket compression occurs when the fasteners are tensioned to a specified torque thereby causing pressure to be applied to the gasket. When a fastener has been tensioned to the desired torque or rotated to a specified angle control value, the fastener driving device is turned off. Once the gasket tightening process is terminated, the gasket will continue to compress or flow until the gasket's resistance to flow under pressure equals the applied pressure. The net result is that over a short period of time, the tension originally applied to a fastener may drop to 60% or less of the original value. This loss of fastener tension results in fasteners that are loose and ineffective gasket seals.

Various methods are employed to overcome the undesirable effects of gasket relaxation. A first method is the sustained power method. This method tightens a fastener to a control limit and then maintains power on the drive system at a level sufficient to maintain the control limit level over a predetermined period of time. The method achieves success because as a gasket flows and fastener tension relaxes, the drive system will turn the fastener in order to hold fastener tension at the desired level.

Another method is a pulsating torque method where the average torque applied is slightly below the desired final torque and the pulsating peaks are equal to the desired final torque.

A third approach is to slowly bring the motor up to final torque, thus allowing the gasket to flow as the torque ramps up.

The above described sustained power, pulsating torque and power ramp methods achieve acceptable tension results. However, when used with an electric drive system, high power usage over relatively long periods of time are required.

The large power consumption over long periods of time causes undesirable heating effects. The temperatures generated and power consumed can limit the duration and therefore the overall effectiveness of the tensioning process unless special motors and controls are used.

It is accordingly an object of this invention to provide a torquing system which is capable of providing the desired tension to a gasket type joint.

It is another object of the invention to provide a system that will operate efficiently without excess power usage and heat generation.

It is a further object of the invention to provide diagnostic information related to fastener tension and gasket compression.

In accordance with the present invention, when tensioning a threaded fastener and gasket assembly, the drive system applies rotational force to and threadably advances the fastener while the monitor and control unit continuously compares the applied torque to a torque control limit value. When the torque control limit is reached the drive system power is substantially reduced, preferably to zero. After a preselected time pause the drive system is re-energized and applies a retorque pulse until the applied torque again reaches the torque control limit. When a predetermined quantity of retorque pulses have been applied, the tensioning operation is terminated.

These and other objects of the invention will become apparent from the following.

Figure 1 is a schematic illustration of a torquing system according to the invention.

Figure 2 is a graph showing applied torque over time according to the invention.

Figure 3 is a graph showing clamp force over time.

Figure 4 is a graph showing power applied to the drive system over time.

Figure 5 is a flow chart of a preferred embodiment of the invention.

Referring to the drawings and in particular Figure 1, the preferred embodiment of an electrically driven retorquing system according to the invention is illustrated.

The system includes an electric drive system 30 such as a brushless DC motor spindle module. A torque detector 32 such as a torque transducer is provided for detecting the tightening torque applied by the drive system. A turning angle detector 34 such as an angle encoder is provided for detecting the tightening turning angle. A drive socket 36 transfers torque to the fastener.

The system also employs a microprocessor based monitor, control and display unit 42 and a microprocessor based motor control unit 44. Motor control hardware and software has been designed to automatically distinguish between the normal (i.e. initial) tightening mode and the retorque mode of operation, thus allowing the systems use with previous systems. Finally the system includes a tightening parameter entry device 46 such as a hand held terminal for entering control commands, including limits, into the microprocessor.

During the retorque mode of operation, the hardware and software in the motor controller applies only short, controlled, torque pulses to 100% of desired torque as shown in Figure 2.

As shown in Figure 3, the clamp force or fastener tension of the fastener is a maximum about the same time as the applied torque peaks. As the gasket relaxes, the clamp force begins to decay until another application of torque is applied. With each successive applied torque pulse, the amount of gasket relaxation following the torque pulse becomes progressively less. When enough retorques have been applied, the clamp force decay is minimal. At this point the gasket has been compressed to a point where time dependent relaxation is minimal.

As shown in Figure 4, between torque pulses to the fastener, the power to the motor is substantially reduced, preferably to zero. This results in a considerable reduction of power applied to the drive system during a typical retorque fastening cycle. Along with the power reduction, a significant reduction in motor heating is realized when compared with the power ramp, pulsating torque or sustained power methods.

The microprocessor based monitor and control unit 42 has been designed to monitor and control the re-torquing process. Maximum applied torque, time between successive full torque applications and number of torque applications are user programmable parameters. This permits considerable flexibility in control of the retorquing process. Finally, peak torque and total accumulated angle of rotation are monitored and displayed for each fastener tightening application of the retorquing process. Information regarding total angle of rotation of a fastener and peak torque achieved for the overall tightening operation is made available for quality control purposes.

More specifically,as shown in Figure 5, the preferred system operates as follows. In S1, control limits for torque, pause time between torque applications, and number of torque pulse applications (or alternatively, overall total retorquing time) are entered into the monitor and control unit's memory via the hand held terminal. In S2, the drive system is energized and the tightening cycle begins. The drive system applies torque to the fastener until the torque control limit is reached, in S3. At that instant, the monitor and control unit issues a stop drive command, S4. Electronic braking is engaged on the drive system and maintained until the programmed pause time has elapsed. S5.

After the pause is completed, the number of pulses is compared to the pulse number limit in S6. (Alternatively, the total elapsed time from the initial start command may be compared to the total retorquing time limit). If the pulse number limit (or alternatively the total time limit) has not been achieved, the cycle returns to S2 and repeats through S6. If the limit is achieved, a signal is sent to the motor control that the drive cycle is complete, S7. Optionally at this point, the peak torque, total angle of rotation or other diagnostic information may be displayed.

During the pause times between torque applications, the gasket continues to flow and fastener tension relaxes. For each successive torque application, the fastener will rotate in order to achieve the tension resulting from the retightening to the torque control limit. Rotation becomes less for each subsequent torque pulse as the gasket's resistance to flow becomes greater with each torque pulse. The angle of rotation for each torque pulse is accumulated and stored as is the peak torque achieved. At the termination of the fastening process, the overall peak torque and the total accumulated angle of rotation of the fastener are stored and displayed. The ability to easily vary the torque, the number of torque pulses (or overall retorque time) and the time between torque pulses allows the user to tailor his system's performance to compensate for the flow rate of the many different gasket materials available today.

One unique feature of the system is its ability to distinguish between successive retorques and the start of a new cycle thereby providing a method for saving valuable information regarding peak torque and total accumulated angle.

Claims

1. A method of applying tension to a fastener and gasketed assembly comprising the steps of:

energising a drive system to apply rotational force to and threadably advance the fasteners;

continuously measuring and comparing the torque applied to the fastener to a preselected torque control limit value;

reducing the drive system energisation when the torque applied equals the torque control limit value; and

re-energising the drive system to apply at least one torque pulse to the fastener after a preselected time pause.

2. A method according to claim 1, characterised by the steps of:

counting and comparing the number of re-energising torque pulse steps to a preselected pulse limit number; and

terminating application of torque to the fastener when the counted number equals the preselected number.

3. A method according to claim 1 or 2, characterised by the steps of:

measuring and comparing the elapsed time from the initial drive energisation step to a preselected time limit; and

terminating application of torque to the fastener when the measured elapsed time equals the preselected time.

4. A method according to claim 1, 2 or 3, characterised in that the reducing step further comprises reducing the drive system energisation to essentially zero power.

5. A method according to any one of the preceding claims, characterised by the step of:

preselecting a torque control limit and a time pause limit.

6. Apparatus for applying tension to a fastener and gasketed assembly comprising:

a drive system for applying rotational force to the fastener;

means for energising said drive system;

means for continuously measuring and comparing the torque applied to the fastener to a preselected torque control limit value;

means for reducing the drive system energisation when the measured torque equals the torque control limit value; and

means for re-energising the drive system to apply at least one torque pulse after a preselected time pause.

7. An apparatus according to claim 6, characterised by:

means for counting and comparing the number of re-energising torque pulses to a preselected pulse limit number; and

means for terminating application of torque when the counted number of torque pulses equals the preselected number.

8. An apparatus according to claim 6 or 7, characterised by:

means for measuring and comparing the elapsed time from the initial drive energisation to a preselected time limit; and

means for terminating application of torque when the measured time equals the preselected time.

9. An apparatus according to claim 6, 7 or 8, characterised by:

means for entering a preselected torque control limit value and a preselected time pause limit respectively, into said measuring and comparing means and said re-energising means.

10. An apparatus according to claim 9, characterised in that said entering means further comprises means for entering one of a preselected pulse number limit and total time limit into said terminating means.

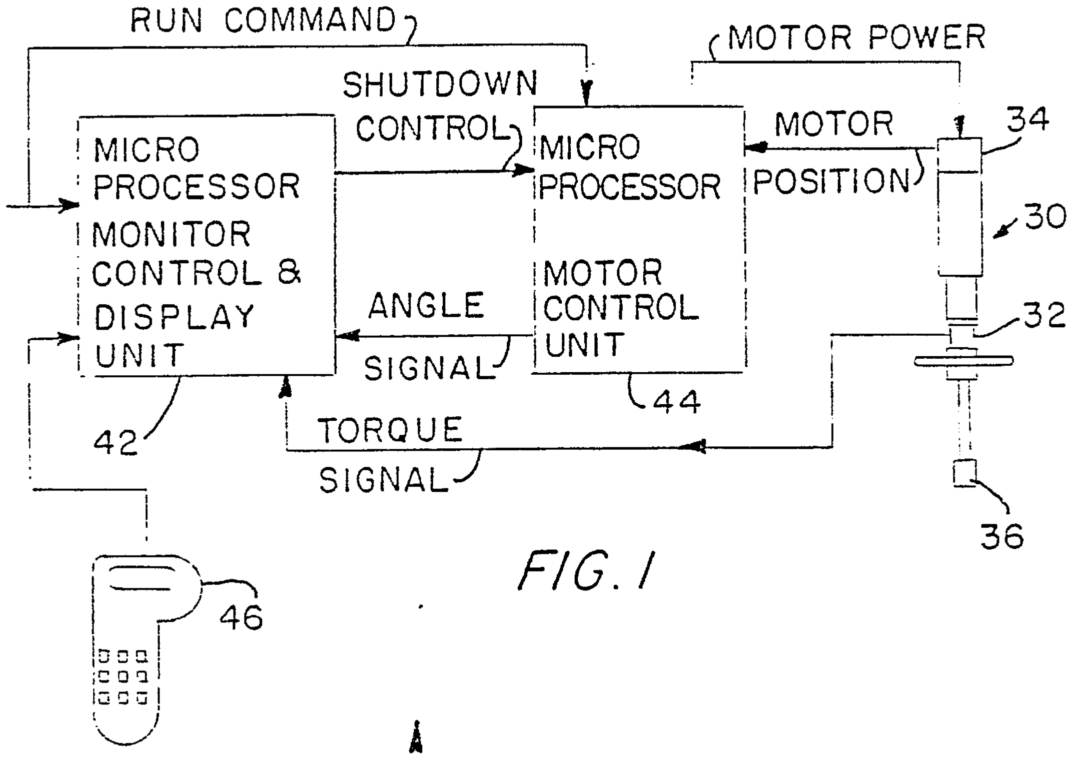

FIG. 1

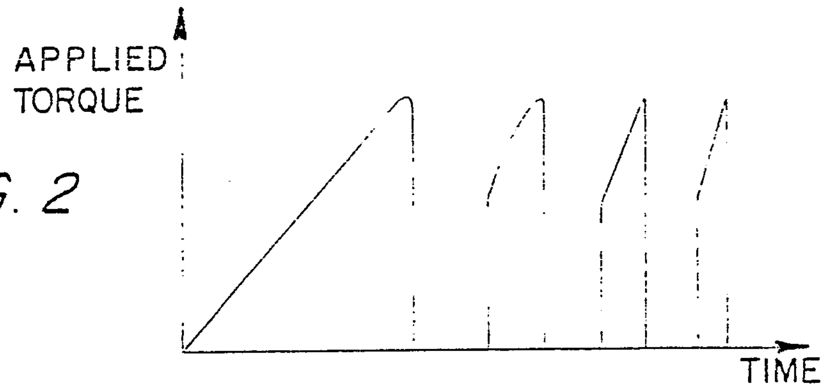

FIG. 2

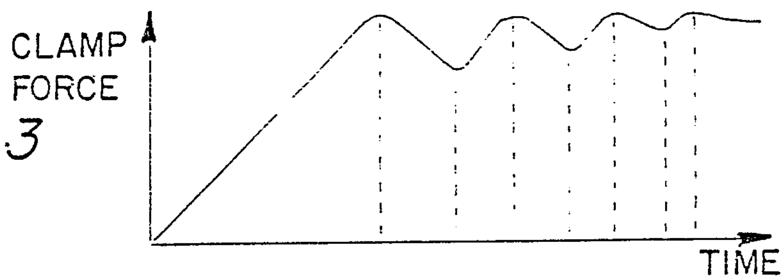

FIG. 3

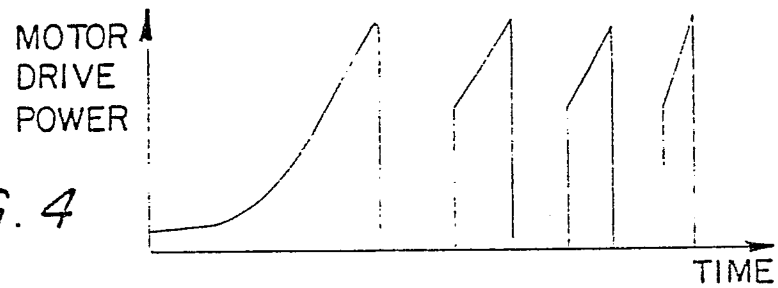

FIG. 4

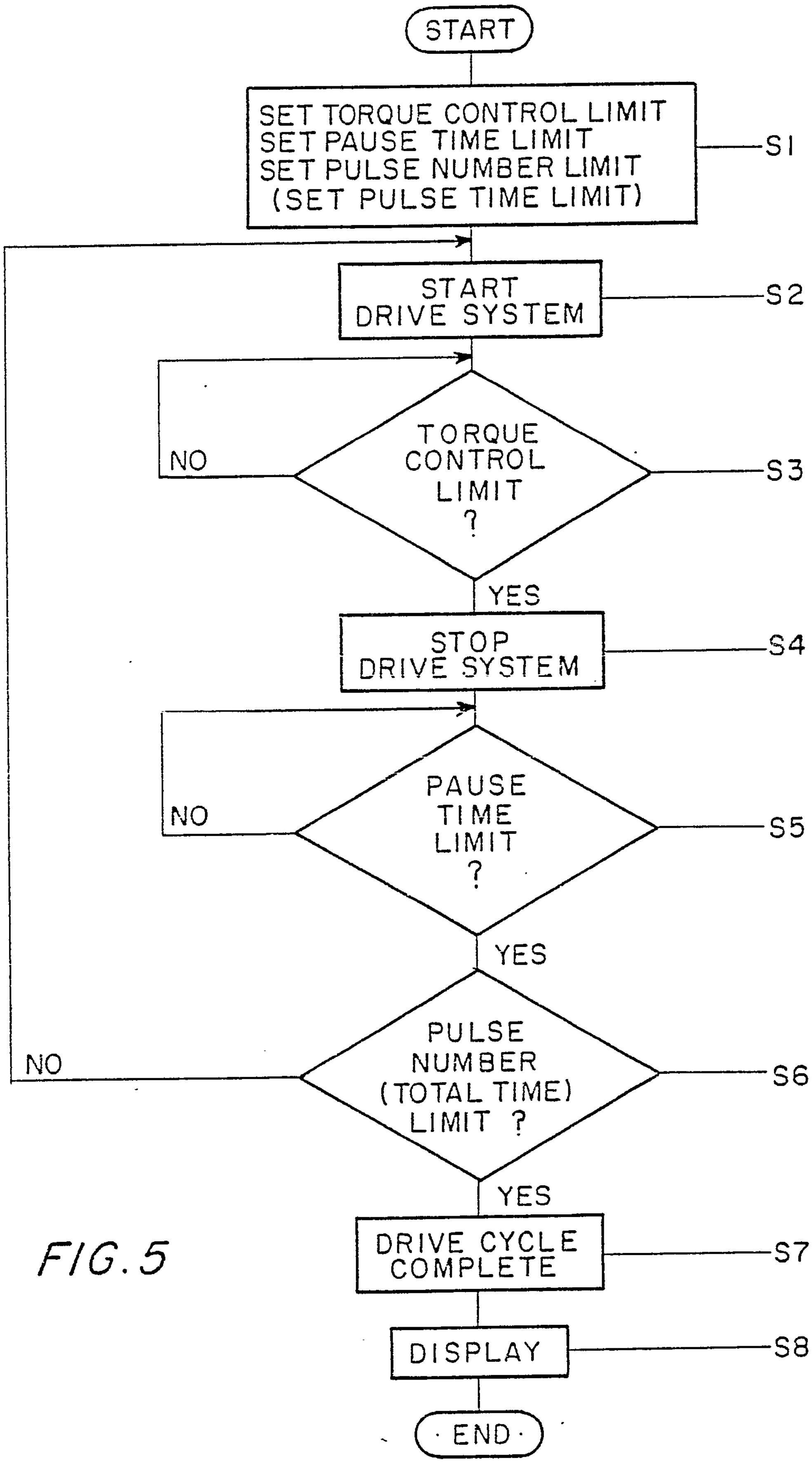
START
SET TORQUE CONTROL LIMIT
SET PAUSE TIME LIMIT
SET PULSE NUMBER LIMIT
(SET PULSE TIME LIMIT)
S1
START DRIVE SYSTEM
S2
TORQUE CONTROL LIMIT ?
NO
YES
S3
STOP DRIVE SYSTEM
S4
PAUSE TIME LIMIT ?
NO
YES
S5
PULSE NUMBER (TOTAL TIME) LIMIT ?
NO
YES
S6
DRIVE CYCLE COMPLETE
S7
DISPLAY
S8
END

FIG. 5