An impact wrench torque limiting device having a socket member and a coaxially disposed impact wrench drive receiving member associated therewith. A resilient member connects the socket member to the drive receiving member to limit torque transmitted between the socket member and drive receiving member.
IMPACT WRENCH TORQUE LIMITING DEVICE

This application is a continuation of application Ser. No. 766,770, filed Oct. 11, 1968, now abandoned.

BACKGROUND OF THE INVENTION

Impact wrenches used in the art deliver torque to threaded fasteners by imposing a series of intermittent or impact torque impulses through a rotary hammer impacting an anvil element which is generally integral with the wrench drive. Such wrenches find particular utility in installing threaded fasteners since intermittent torque impulses or impacts impose "impulse stretching" of the bolt portion of the threaded fastener. Vibration is also imparted by the impact blows of the rotary hammer. The "impulse stretching" and vibration tend to reduce the inherent frictional resistance between the surfaces against which the nut being threaded bears, thereby permitting the nut to be rotated with respect to the bolt relatively independent of the friction resisting rotation.

In the art it is often necessary to assemble threaded fasteners with a prescribed torque imposed thereon. Such instances are dictated by various considerations such, for example, as the ultimate strength of the fastener, the expected external loading on the assembly and the like.

Hereinbefore, many devices have been proposed in connection with impact wrenches for controlling the force applied to threaded connections by controlling the torque output of the wrench. Among these mechanisms are those which employ means for shutting down the wrench or disengaging a clutch when a preselected torque output has been achieved. These prior art devices are, however, relatively expensive, are complicated and require care and skill on the part of the operator in setting and observing the prescribed torques.

SUMMARY OF THE INVENTION

This invention provides a means to adapt conventional impact wrenches to limit the torque output thereof by providing a resilient means between the drive output of the wrench and the wrench socket to thereby absorb torque energies, so that the resultant applied torque is held to a predetermined level.

The invention also provides means to limit the torque output of conventional impact wrenches without requiring modification thereof by furnishing a socket connectable to the wrench drive through a resilient member to thereby limit the torque output of the wrench to a value determined by the resistance to deformation of the resilient member.

The invention further provides means to limit the torque output of an impact wrench in a simple and economical manner by providing a socket member resiliently connected to a wrench drive engaging member to thereby provide means to absorb torque energies from the wrench drive member.

In a preferred embodiment, the objects of this invention are accomplished by providing a fastener-engaging socket coaxially aligned with an impact wrench drive receiving member and having a resilient member interconnecting the socket member and receiving member to thereby allow relative movement in a forward direction of rotation therebetween. Means are provided to bypass the resilient member in the opposite rotational direction to provide substantially direct drive for loosening of fasteners.

These and other objects of the invention will become better understood to those skilled in the art by reference to the following detailed description when viewed in light of the accompanying drawings, wherein like numerals throughout the figures thereof indicate like components and wherein:

FIG. 1a is an elevation showing an impact wrench associated with the form of torque transmitting and limiting device as shown in the sectional view of FIG. 2;

FIG. 1b is a perspective view of an impact wrench torque limiting device in accordance with the invention;

FIG. 2 is a reduced side elevational view, in section, of the wrench of FIG. 1;

FIG. 3 is a sectional view of the wrench of FIG. 2 taken along the lines 3—3 thereof;

FIG. 4 is a side elevational view, partly in section, of another torque limiting device in accordance with the invention;

FIG. 5 is a sectional view of the device of FIG. 4 taken along the lines 5—5 thereof;

FIG. 6 is a perspective view of another torque limiting device in accordance with the invention;

FIG. 7 is a side elevational view in section of the device of FIG. 6;

FIG. 8 is a sectional view of the device of FIG. 7 taken along the lines 8—8 thereof;

FIG. 9 is a side elevational view partly in section, of another torque limiting device in accordance with the invention;

FIG. 10 is an enlarged sectional view of the device of FIG. 9 taken along the lines 10—10 thereof;

FIG. 11 is a perspective view of another torque limiting device in accordance with the invention;

FIG. 12 is a side elevational view in section of the torque limiting device of FIG. 11;

FIG. 13 is a sectional view of the device of FIG. 12 taken along the lines 13—13 thereof;

FIG. 14 is a sectional view of the device of FIG. 12 taken along the lines 14—14 thereof;

FIG. 15 is a perspective view of another torque limiting device in accordance with the invention;

FIG. 16 is a side elevational view in section of the device of FIG. 15;

FIG. 17 is a sectional view of the device of FIG. 16 taken along the lines 17—17 thereof;

FIG. 18 is a sectional view of the device of FIG. 16 taken along the lines 18—18 thereof;

FIG. 19 is a side elevational view partly in section of another torque limiting device in accordance with the invention;

FIG. 20 is a sectional view of the device of FIG. 19 taken along the lines 20—20 thereof;

FIG. 21 is a perspective view of another torque limiting device in accordance with the invention; and

FIG. 22 is a side elevational view in section of the device of FIG. 21.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 16, 2 and 3 of the drawing, a torque limiting device, generally indicated at 30, comprises a wrench member, generally indicated at 32, and an impact wrench drive receiving member, generally indicated at 34, interconnected by a resilient member, generally indicated at 36. In FIG. 1a, this assembly
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30 is shown in association with an impact wrench 28 of a type known in the art.

Referring more specifically to FIGS. 2 and 3, the wrench member 32 comprises a wrench head 38 having a socket 40 formed in the end thereof. The other end of the head 38 is in the form of a tubular sleeve 42. The drive receiving member 34 similarly comprises a drive head 46 having a drive receiving recess 48 formed in one end thereof and a tubular sleeve 50 at the other end. A tubular shield or cover 52 is mounted to the exterior of the sleeve 50 for purposes to be described hereinafter. The resilient member 36 comprises a cylindrical shaft 53, coaxially disposed with respect to the heads 38 and 46 within the sleeves 42 and 50 and having annular resilient members 54a and 54b disposed therearound proximate either end thereof. The resilient members 54a and 54b are so dimensioned that they engage, around the outer peripheries thereof, the interior of the sleeves 42 and 50 and are bonded to the inner surface thereof and to the exterior of the shaft 53, preferably by means of a suitable adhesive, or the like.

As is more clearly seen in FIG. 16, the sleeves 32 and 34 are provided with interfitting longitudinally extending tongues 56 and 58 respectively which will permit relative rotational movement between the members 32 and 34 in a direction away from each other, but will abut and transmit torque independent of the resilient material when the wrench drives in the reverse direction.

This provides for a reverse torque, larger than the forward torque, for looseness of connections by reverse drive of the impact wrench. A space 60 is provided, as seen in FIG. 1b, to avoid return impact between the tongues when the members return to a normal relationship upon intermittent release of torque, when the wrench is operating in the forward or tightening direction. In the illustrated embodiment, these tongues are disposed substantially 180° apart, so that the maximum permissible relative rotation between members is approximately 180° less the width of the tongues. The cover 52 extends over the interfitting area between the tongues 56 and 58 to avoid damage thereto or injury to the operator.

The annular resilient members are preferably fabricated of some conventional elastomer suitable for the purpose. The primary requirements for the elastomer are durability, compatibility with the environment in which the device is to be used, and deformation characteristics suitable for providing the required resistance to relative rotation between the members 32 and 34. Such resistance can be selected by the choice of the particular elastomer and the geometrical configuration thereof and by application of the conventional spring formulas, known to those skilled in the art.

For example, the primary concern is the maximum torque which the device will deliver. Maximum torque occurs when the fastener being driven is substantially stopped and when the resilient member 36, considered as a torque spring between the wrench member 32 and the impact wrench drive receiving member 34, is fully stressed.

In a case where there is no initial compression in the resilient member 36, the initial rest position of the spring is designated by the angle θ = 0 at t = 0. From the rotary form of Newton's "Laws of Motion" the differential equation for the motion of the struck end of the spring is:

\[ I \frac{d^2θ(t)}{dt^2} = K θ(t) \]

where:
- \( I \) = the moment of inertia of the wrench drive receiving member 34 (including the associated structure not shown, i.e., the hammer, axle, etc. of the impact wrench.)
- \( θ(t) = \) the rotary position in degrees of the drive receiving member 34, measured from its rest position.
- \( K \) = the torque constant of the resilient member 36 in foot pounds per degree of rotation.

Solving for \( θ \):

\[ θ = A \sin (wt + ϕ) \]

where:
\[ w = \sqrt{\frac{K}{I}} \]
and \( ϕ \) is the offset of the spring tool from its neutral position at the time of the blow. This offset may be due to incomplete return from deflection after the preceding hammer blow. For the purpose of this analysis it is assumed that:

\[ A = V_o \sin θ_{max} + wt \]

where \( V_o \) is the angular velocity of the hammer at moment of impact. Therefore

\[ A = V_o \sqrt{\frac{I}{K}} \sin θ \]

The maximum torque \( T_{max} \) occurs when \( θ = θ_{max} \), \( wt = π/2 \). The maximum torque is, therefore:

\[ T_{max} = V_o \sqrt{\frac{I}{K}} \]

This analysis assumes that the resilient member 36 has sufficient time to return to the rest or unstressed condition between impacts. This depends upon the magnitude of the desired torque, i.e., the stiffer resilient members will return to rest position between impacts, but in those instances where very low torque outputs (i.e., on the order of 100 inch pounds) are desired, the resilient member will be weak and discrepancies may occur between the calculated and observed torque limits. The amount of the discrepancy will depend upon the moment of inertia of the drive engaging member 34.

In a specific instance, a device of the type shown was found to deliver a maximum torque of 21 inch pounds. The spring constant of the resilient member was measured and found to require 24 inch pounds for an angular displacement of about 75°. K therefore was calculated as follows:

\[ K = T/θ \]

where \( T \) is the torque, \( K = 24/75 = 0.32 \) pounds per degree. From the equation set forth above:

\[ T_{max} = V_o \sqrt{\frac{I}{K}} \]
\[ V_o = T_{max} / \sqrt{\frac{I}{K}} \]

This quantity \( V_o \sqrt{T} \) is a property of the particular impact wrench.

To fabricate a device, therefore, to deliver a maximum torque of 50 in. pounds, with the same impact wrench, the structure will have to be designed to in-
include a resilient member 36 having a spring constant $K$ as follows:

$$V_e \sqrt{IK} = 50$$

$$\sqrt{K} = 50/37 = 1.35$$

$$K = 1.8 \text{ in.-lb/degree}$$

For the particular impact wrench utilized in this measurement, the resilient member 36 would have to be arranged to provide for a total deflection of 50/1.8 or 28° without permanent deformation.

Referring now to FIGS. 4 and 5 of the drawings, another embodiment of the device in accordance with the invention is illustrated. Components thereof, as well as components of the succeeding figures described hereinafter, corresponding to like components of FIGS. 1b through 3 are indicated by like numerals only of the next higher order. In this embodiment, one of the primary distinctions lies in the nature of the resilient member 136 which comprises a helically wound spring 154 interconnecting a wrench engaging member 132 and an impact wrench drive receiving member 134. The wrench receiving member 132 comprises a square stud 140 which is received in the square recess of interchangeable conventional sockets as is known in the art.

In this embodiment no provision is made for the application of a reverse torque larger than that which can be provided by the resilient member; i.e., there is no provision for by-passing the resilient member to achieve a larger torque when backing out a fastener.

Referring now to FIGS. 6, 7 and 8 of the drawings, a further variation of the device in accordance with the invention is illustrated. In this embodiment, the device is telescoped with a wrench member 232 disposed coaxially within an impact wrench drive receiving member 234. An annular resilient member 236 is disposed between, and attached to, the members 232 and 234 to provide resilient interconnection thereof.

A diametrically disposed pin 256 is fixed through the member 232 and extends into slots 258 in a tubular sleeve 250 on the member 234 to provide limits for the rotary mechanical interconnection between the members 232 and 234. This pin and slot serves the same function as the butting tongues in FIG. 1b, i.e., in reverse action the pin will strike the end of the slot and provide a greater torque. As in the embodiment of FIGS. 1 through 3, a space 260 is provided between the pin 256 and the end of the slots 258 to avoid impact between the structures when the members return to a normal relationship upon intermittent release of torque, in the normal tightening direction.

In the embodiment of FIGS. 9 and 10, a wrench engaging member 332 is rotatably connected to an impact wrench drive receiving member 334 through a resilient member 336 and through a rotatable interconnection formed by a stud 358 extending from one end of the member 332 and a bore 356 in the abutting end of the member 334.

As in the embodiment of FIGS. 4 and 5, a square socket engaging stud 340 is formed on the end of the member 332. The resilient member 336 comprises a helically wound spring 354 extending across the intersection between the members 332 and 334. The member 336 is affixed to the members 332 and 334 by internally ended 362 thereof, pressed into radial bores 364a and 364b formed in the outer surfaces of the latter members. In this embodiment the larger reverse torque could be obtained through the non-linear action of the spring when it is coiled tightly against member 332 and 334, or tongues could be added in FIG. 1b, if found desirable.

In FIGS. 11 through 14, an embodiment of the invention is illustrated wherein the resilient member 436 comprises an annular metallic sleeve 454, interconnecting the members 432 and 434. The sleeve 454 has formed therein a longitudinal slot 466 and is attached to the members 432 and 434 by pins 468 and 470 disposed on opposite sides of the slot 466 as illustrated. Spaced, parallel circumferential slots 472 and 474 extend in opposite directions from the ends of the slot 466 substantially one half the circumference of the sleeve. Through the pinning arrangement as illustrated and the above described slotting, the annular sleeve 454 is elastically deformable due to the reduced cross section provided by the slotting when torque is applied in the direction of the arrows in FIG. 11.

FIGS. 15 through 18 illustrate an embodiment of the device wherein the resilient member 536 comprises a helical spring 554 disposed around a cylindrical extension 542 of the wrench member 532 and enclosed within a tubular sleeve 550 extending from the wrench drive receiving member 534. The spring 554 is provided with internal and outturned portions 562a and 562b at the ends thereof, which are received in bores 564a and 564b formed in the members 532 and 534 respectively. Rotational support between the members 532 and 534 is provided by a shoulder 576 disposed to receive the end of the extension 542 and a ring 578 threaded into the open end of the tubular portion 550 of the member 534 as illustrated. Opposed, spaced teeth 556 and 558 extend from the members 532 and 534, respectively, to provide an increased reverse torque which may be necessary in the loosening operation.

The embodiment disclosed in FIGS. 19 and 20 comprises a wrench member 632 and a wrench drive receiving member 634 rotatably interconnected by an interfitting socket-stud structure 656 and 658. A resilient member 636 is mounted on the wrench member 632 and is attached through a radially extending arm 680 to the wrench drive receiving member 634. The resilient member comprises an annular spring steel disk 654 having a spiral cut 682 extending from the inner periphery through an arc of 360° to the outer periphery thereof. In this embodiment the increased reverse torque arises due to closing of the slot.

In the last illustrated embodiment of this invention, FIGS. 21 and 22, a wrench engaging member 732 is disposed within a recess formed within a tubular sleeve 750 extending from an impact wrench drive receiving member 734. An annular resilient member 736 is disposed around the member 732 to fit within the recess formed by the sleeve 750 and is attached to both surfaces to provide resilient interconnection therebetween. The member 732 is provided with a socket receiving stud 740 extending therefrom. In this embodiment there is no provision for increased reverse torque.

It should be obvious from the many embodiments illustrated and described herein, that the invention may be practiced in many forms. What has been illustrated herein is intended primarily to enable those skilled in the art in the practice of the invention. It should therefore be understood that, within the scope of the ap-
An impact wrench in combination with a torque transmitting and limiting device, said combination comprising:

1. An impact wrench having drive means;
2. A wrench drive engaging means coaxially disposed in constant axial relation to said fastener engaging means and in operative association with said drive means;
3. A resilient member directly interconnecting said fastener engaging means and said drive engaging means and providing the initial and sole drive connection therebetween in one direction at each impact, said resilient member deforming when said members are rotated relative to one another in said one direction to absorb the entire torque energies applied thereto and thereby limiting the torque transmitted between said members to a maximum torque desired of said device.

A combination in accordance with claim 1, wherein said fastener engaging means and said wrench drive engaging means are disposed in longitudinally adjacent relationship to one another.

A combination in accordance with claim 3, wherein said fastener engaging means and said wrench drive engaging means are provided with axially disposed recesses in the adjacent ends thereof, and wherein said resilient member is attached to each of said means and is disposed within the area defined by said recesses.

A combination in accordance with claim 1, wherein said resilient member comprises a helically wound spring.

A combination in accordance with claim 1, wherein said resilient member comprises an elastomer.

A combination in accordance with claim 1, wherein said wrench drive engaging member is provided with a recess formed in one end thereof and wherein said fastener engaging means is telescopically received in said recess.

A combination in accordance with claim 7, wherein the recess provides an annular space between the wrench drive engaging member and the fastener engaging member with the resilient member disposed in said space.

A combination in accordance with claim 1, wherein the resilient member comprises an annular sleeve of elastomeric material substantially filling said space.

A combination in accordance with claim 1, wherein said wrench drive engaging means is provided with a recess formed in one end thereof and wherein said fastener engaging means is telescopically received in said recess which provides a space between the wrench drive engaging means and the fastener engaging means with the resilient member in the form of a helical spring disposed in said space.

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