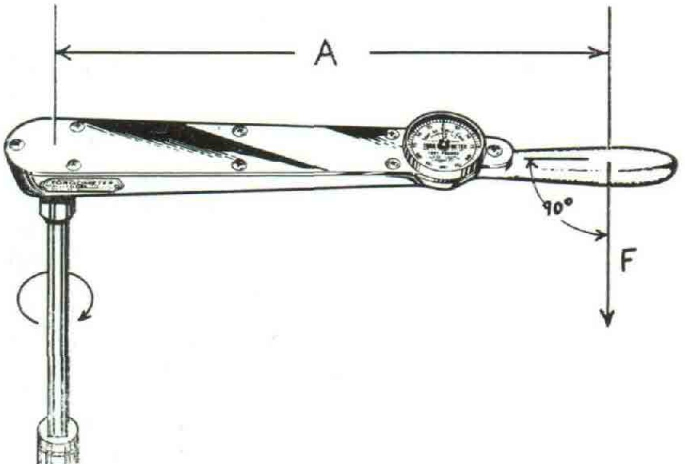
The Principles Of Thread Torque

By A. J. Schmidt, EAA 458

When a bolt is loaded in shear the function of its nut is simply to retain it against slipping out. Thus, we use thin "shear nuts" as a weight-saving expedient, the few threads in such a nut being adequate to withstand the light forces experienced. But at other places such as at cylinder hold-down studs, engine mount bolts, and many other places on engines and, less often, on airplanes, the function of the thread and nut is to create a clamping force on component parts.

Therefore when the nut is tightened, a stretching force is placed on the shank of the bolt or stud. It is often very, very important that each of several nuts should be tightened uniformly. To convey a clear and practical understanding of this a number of examples will be cited.

Suppose six bolts attach a propeller to a hub, or a dozen studs attach a cylinder to a crankcase, or several dozen short bolts attach an outer wing panel to an inner panel via mating flanges. If one nut is tightened appreciably less than those next to it, the effect will be to make the loose bolt carry little load and force its neighbors to carry more than their share. If on the other hand one nut is excessively tightened, it, and it alone, will take a much greater proportion of the load and this in addition to the tension set up by the nut may overstress it.



The amount or torque applied to the nut is determined by wrench length A times hand force F. This Snap-On Tools Corp. wrench is of the dial type.

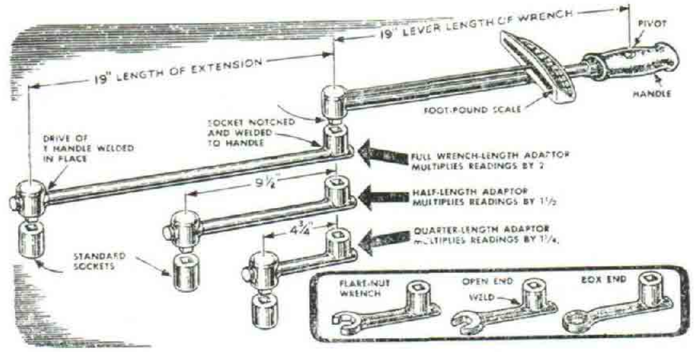
When cylinder head hold-down studs are tightened irregularly, the studs naturally put unequal pulls on the bass metal. Cylinders, cylinder blocks and cylinder heads can be distorted rather badly. Abnormal valve stem wear and burned valves have been traced to irregular stud tension. Cylinder walls can be distorted to such an extent that difficulties like loss of compression and oil pumping have resulted.

In respect to such parts as connecting rods and crankshafts, unequal tensioning of bearing caps can lead to bearing distortion and early failure. Most airmen have heard of metal fatigue but few understand how closely related it is to thread torque. If a pair of connecting rod cap bolts are tightened only lightly, with each rotation of the crankshaft they will have tension thrown on them during part of the cycle. They are thus subjected to the very kind of fluctuating load which leads to fatigue. But if the nuts are tightened so that the tension on the bolts is in excess of the amount of tension they will experience under normal running load, they will not "feel" this fluctuating tension and fatigue life will be indefinite.

When sparkplugs are poorly tensioned their gaskets are not compressed enough to do their vital job of acting as a means of transferring sparkplug body heat to the cylinder head material and hence to the cooling water or fins. If a plug is overtensioned the soft bronze or aluminum threads in the head can be stretched, carefully set electrode gap may be changed, seals may distort with consequent leakage, or porcelain may be cracked internally. When tubing connectors having tapered or flanged mating surfaces are undertensioned leakage can result, and too much tightening can lead to splitting through the powerful wedging action present. In short, torque is vitally important to safe, dependable flight.

The tensile stress set up by tightening a nut is referred to as the initial tension, and causes slight elongation of the fastener. This elongation naturally must fall within safe limits as determined by the strength of the material and sectional area of the fastener. **Torque** may be defined as a force tending to produce rotation. The amount of torque applied to a threaded fastener will govern the amount of initial stress imparted to the fastener. The amount of torque produced can be determined by multiplying the length of the lever arm by the force applied to it. This fact has led to the development of torque wrenches.

Several firms make them and they come in a variety of styles. All consist essentially of a handle of some convenient length and a dial or gage which shows the torque being generated by any given pull. Their correct use is rather fully detailed in booklets available from wrench manufacturers and covers such matters as making corrections when extensions and adaptors of varying



Length of adaptors affects method of making readings on a torque wrench. Sketches in lower right hand corner show how special adaptors can be improvised. This is a scale-type wrench made by P. A. Sturtevant Co.

length are used. Some read in inch-pounds and some in foot-pounds depending on the duty involved. In general, aircraftsmen use inch-pounds measurements, as fairly small, clean and precisely-loaded bolts and studs are used.

An accompanying table shows recommended torque values for fasteners in aircraft sizes and materials. Following are some useful notes on torquing.

1. Maximum torque values are to be used only when materials and surfaces being mated have sufficient area, thickness and strength to resist breaking or warping.

2. The tilt under bolt heads created by surfaces which are not parallel, and the gap under flush-head fasteners, shall not exceed .005 in.

3. When installing castle nuts, tighten them to the low side of the selected range and snug up until slot and hole are in alignment. Never back off nuts to make cotter pin holes align.

4. Threads should be clean, dry and free from oil, grease or rust.

5. When tightening a nut, use table values, but when tightening a bolt or cap screw by its head go a little to the high side, but not more than 10%, to allow for the extra friction involved.

6. Do not merely "test" nuts with a torque wrench after snugging them up with a plain wrench. Bring it up to tension with the torque wrench.

7. If nuts inside engines must be oiled before assembly, use about 10% less torque than given in the table.

8. Never use torque wrenches for **loosening** nuts and bolts!

9. When using stainless steel nuts, use figures given for shear nuts.

10. To obtain equivalent values in foot-pounds, divide inch-pound values by 12.

11. When aluminum, bronze or other soft metal is used in the mating parts, the strength of the metal involved would determine limits rather than the strength of the bolts. Aluminum and brass are in the 30,000 P.S.I. stress range.

12. Sometimes the type, hardness, compressibility etc. of the gaskets being used influences torque specifications.

NOTE: The Torque Values shown are to be used for installing ALL the tubings and fittings indicated and apply regardless of fitting or nut mat.

— FLARED TUBE AND FLEX HOSE TORQUE VALUES —
(Except Oxygen Lines)

Tube O.D. In Inches	5052-0 Alum. Alloy Tubing		Flex. Hose Assy. & 6061-T6 Alum. Alloy Tubing		Mil T-6845 Stainless Steel Tubing	
	In Lbs. Min.	In Lbs. Max.	In Lbs. Min.	In Lbs. Max.	In Lbs. Min.	In Lbs. Max.
1/8	20	25				
3/16	25	35	30	70	90	140
1/4	40	65	70	120	135	185
5/16	60	80	70	120	180	230
3/8	75	125	130	180	270	345
1/2	150	250	300	400	450	525
5/8	200	350	430	550	650	750
3/4	300	500	650	800	900	1100
1	500	700	900	1100	1200	1400
1 1/4	600	900	1200	1450	1500	1800
1 1/2	600	900	1550	1850	2000	2300
1 3/4	700	1000	2000	2350	2600	2900
2	800	1100	2500	2900	3200	3600

Table 1.

Torque Values in Inch-Pounds for Tightening Nuts

Bolt, Stud or Screw Size		On Standard Bolts, Studs & Screws Having a Tensile Strength of 125,000 — 140,000 PSI		On Bolts, Studs & Screws Having a Tensile Str. of 140,000—160,000 PSI	On High Str. Bolts, Nuts & Screws with a Tensile Str. of 160,000 PSI +
Coarse Thread	Fine Thread	Shear-Type Nuts (AN-320, AN-364, or Eqv.)	Tension-Type Nuts (AN-310, AN-365, or Eqv.)	Any Nut Except Shear-Type	Any Nut Except Shear-Type
8-32	8-36	7-9	12-15	14-17	15-18
10-24	10-32	12-15	20-25	23-30	25-35
1/4-20		25-30	40-50	45-59	50-68
	1/4-28	30-40	50-70	60-80	70-90
5/16-18		48-55	80-90	85-117	90-144
	5/16-24	60-85	100-140	120-172	140-203
3/8-16		95-110	160-185	173-217	185-248
	3/8-24	95-110	160-190	175-271	190-351
7/16-14		140-155	235-255	245-342	255-428
	7/16-20	270-300	450-500	475-628	500-756
1/2-13		240-290	400-480	440-636	480-792
	1/2-20	290-410	480-690	585-840	690-990
9/16-12		300-420	500-700	600-845	700-990
	9/16-18	480-600	800-1,000	900-1,220	1,000-1,440
5/8-11		420-540	700-900	800-1,125	900-1,350
	5/8-18	660-780	1,100-1,300	1,200-1,730	1,300-2,160
3/4-10		700-950	1,150-1,600	1,380-1,925	1,600-2,250
	3/4-16	1,300-1,500	2,300-2,500	2,400-3,500	2,500-4,500
7/8-9		1,300-1,800	2,200-3,000	2,600-3,570	3,000-4,140
	7/8-14	1,500-1,800	2,500-3,000	2,750-4,650	3,000-6,300
1"-8		2,200-3,000	3,700-5,000	4,350-5,920	5,000-6,840
	1"-14	2,200-3,300	3,700-5,500	4,600-7,250	5,500-9,000
1 1/8"-8		3,300-4,000	5,500-6,500	6,000-8,650	6,500-10,800
	1 1/8"-12	3,000-4,200	5,000-7,000	6,000-10,250	7,000-13,500
1 1/4"-8		4,000-5,000	6,500-8,000	7,250-11,000	8,000-14,000
	1 1/4"-12	5,400-6,600	9,000-11,000	10,000-16,750	11,000-22,500

Table 2