INVESTIGATION OF MACHINE SCREWS

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Machine screws, bolts, and most threaded parts are usually made from material that is easily machined and not very strong. This is especially true of screws that are sold in the average hardware store. Most of the time machine screws are used in situations that do not demand strength, and this type of machine screw is perfectly satisfactory.

In a large number of the situations that do call for strong screws or threaded parts the problem is easily solved by merely using two screws instead of one, or by using a larger diameter screw.

Unfortunately the easy solution is not always possible. Sometimes space for additional or larger screws is limited or weight limitations prevent using larger parts that will take more or larger screws.

If the load on the bolts is not of the repetitive type and it is not possible to use larger screws or more of them, the only possible thing left to do is to use stronger screws. Screws and bolts made from a good grade of steel and heat treated for the greatest strength can sometimes be purchased in hardware stores, but the most likely source of supply would be an aircraft parts company. Of course, any company manufacturing screws or bolts would make any type requested. Small orders would be expensive.

If the load on the screws or threaded parts is of the repetitive type as it usually is in orthopedic work, there are a number of things that can be done to increase the life of the threaded part.

Most machine screws sold in hardware stores are made from low carbon steels. The carbon content varies from 20 points down to and below 8 points. Usually cold drawn steel is used although this is sometimes annealed. As a general rule, these screws can be strengthened by heating them until they are no longer attracted by a magnet, then quenching in water. This treatment would apply especially to low carbon parts having cut threads. The parts having rolled threads might be weakened by this treatment.

Threaded parts made of stronger steel naturally would be much better.

For repeated loadings, steel for threaded parts normally should not be harder than 300 BHN, or 150,000 psi ultimate tensile strength.

Machine screws made from austenitic stainless steel should be very good for orthopedic parts. Stainless steel machine screws have good corrosion resistance, very good fatigue strength, and are obtainable.

Any groove or sharp indentation in metal parts is very undesirable if the part is to withstand repeated loadings. Machine screws, bolts, or any threaded part automatically then have undesirable features which cannot be eliminated. Some things can be done to partially alleviate the stress raising threads. It is a well proven fact that a very sharp thread root is undesirable. The British Whitworth thread and the new Unified thread use rounded roots and many tests have been made proving their superiority over the sharp rooted threads. Every effort should be made to keep the sides of the threads as smooth as possible.

Rolled threads are becoming quite common. Tests have shown the rolled thread to be superior to any cut thread. The roots are smoothly radiused, the sides are very smooth, and the grain structure at the root of the thread is better than that of a cut thread. The stainless steel machine screws mentioned previously have rolled threads.

Threaded parts that involve the use of a nut at one end usually fail at the root of the thread level with the contact side of the nut face. In fact, most bolted connections fail at this point. There has been a lot of experimental work done in an attempt to design a nut that would eliminate this problem. The idea is to design the nut to distribute the load onto all of the engaged threads, rather than on just a few threads. The usual method of doing this is to weaken the load carrying capacity of the threads on the contact side of the nut by tapering the nut threads or by undermining the nut with a groove on its contact face. As far as the author knows, these nuts are not commercially available and the only practical thing to try, when necessary, is a nut made of a material that has a better ability to deflect than the material in the bolt. For example, use a cast iron nut with a steel bolt. Using a nut of softer steel than the bolt should also help.

Threaded parts also sometimes fail at the first thread in the shank. The reason failure occurs here rather than at any other thread is that the threads interfere with each other and actually decrease the harm done by their neighboring threads. The first thread in the shank has no adjacent thread on the one side and so can cause higher stresses than any of the other threads. It is for this reason that a completely threaded screw or bolt has more resistance to a repeated load than one which is only partially threaded. If a screw, bolt, or stud has just enough threads on it to allow complete engagement of the male and female components, then two bad features of threaded devices occur at one location; that is, the first thread in the shank, and the thread located level with the contact face of the nut. For this reason it is recommended to have as many unengaged threads as possible. This means that a stud, such as is sometimes used in ankle joints, should be completely threaded rather than just threaded at the ends.

Another thing that is sometimes done to relieve the first thread in the shank is to cut the shank diameter down to the root diameter of the threads. Sometimes this is done for the complete length of the shank, and sometimes just for a short distance.

Screws and bolts will also fail at the end of the shank just under the head. This is especially true if a sharp corner is used rather than a fillet. The fillet should be made as large as possible. Some people object to a large fillet at this point because it necessitates countersinking the hole slightly to get a flush fitting head.

Regardless of how much attention is given to making threaded parts correctly to resist failure due to repeated loadings, a large number of failures will still occur due to improper assembly. Considerable care is usually taken to make the major parts of an assembly but the bolts and screw holes are too often just rammed in with a hand drill. If the holes don't line up good enough for the screw to enter, it is very easy to enlarge the one unthreaded hole and two parts can then be fastened together. As soon as a little wear occurs, the two parts are very loose. If the holes are not drilled perpendicular to the surface, the bolt or screw is given an additional load due to uneven seating of the head.

One of the most important things to remember in assemblying bolts and screws is to draw them tight. A tight bolt will last much longer with a repeated type of loading than a loose bolt. Of course, it is very easy to tighten a small bolt or screw too much and exceed or almost exceed the strength of the screw. Very often, especially with a tight fitting screw, an additional stress due to twisting is put on the screw. This can sometimes be partially eliminated by lubricating the screw when tightening it.

Cut threads have a tendency to become loose because the rough surfaces on the sides of the thread gradually wear. Since rolled threads have smooth sides there is less tendency to become loose.

The literature survey revealed that most of the fatigue tests done on threaded parts covered the range from one-quarter inch diameter and larger. The smaller size machine screws, namely, numbers six, eight and ten. apparently have not been investigated too thoroughly. Since these sizes are used quite frequently in orthopedic work it was decided that an experimental investigation would be made.

The first phase of the investigation was to find the ultimate static breaking load of the screws.

Four different makes of No. 6-32 machine screws were purchased from regular hardware stores. The ultimate static breaking load of these screws ranged from a low of 620 pounds corresponding to a stress of 68.800 pounds per square inch to a high of 850 pounds corresponding to a stress of 94,400 pounds per square inch.

Three different makes of a better grade of No. 6-32 machine screws were purchased from wholesale hardware stores. Local hardware stores do not as a rule stock these makes. The ultimate static breaking loads ranged from 1,660 pounds with a corresponding stress of 184,400 pounds per square inch to an ultimate breaking load of 1,840 pounds with a corresponding stress of 204,400 pounds per square inch.

One make of No. 6-32 stainless steel screws was obtained with an ultimate breaking load of 1,000 pounds corresponding to a stress of 111,000 pounds per square inch.

A No. 6-32 brass machine screw had an ultimate breaking load of 640 pounds with a corresponding stress of 71,000 pounds per square inch.

None of the machine screws tested have the recommended strength of 150,000 pounds per square inch ultimate tensile strength for repeated types of loading.

In the second phase of the test, it had originally been planned to run a complete fatigue test on the machine screws in direct tension. Since time was limited and a comparison of the different makes of screws was desirable, it was decided to run a partial fatigue test and test all of the screws with just one loading: a loading high enough to produce quick results.

All of the machine screws were tested in direct tension with a load varying from zero to 432 pounds corresponding to a stress of 48,000 pounds per square inch.

It was originally planned to test the screws with no preload and also with varying amounts of preload. Lack of time prevented running any tensile tests with preloads.

The test results were fairly well scattered. It was quite obvious, though, that the group of three makes of screws with an ultimate tensile stress of around 200,000 pounds per square inch were not as well suited for alternating tensile loads as the group of four makes of screws with an ultimate tensile strength around 90,000 pounds per square inch.

The one type of stainless steel machine screw tested gave the largest variation in results, from very good to very poor. Apparently this can be expected of stainless steels in general.

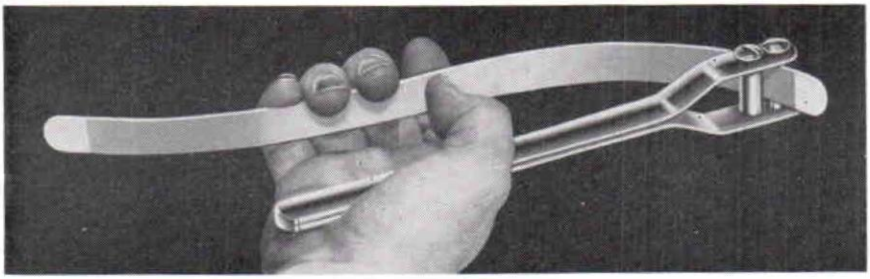
The brass screw gave the lowest results, as expected. No plated brass screws were tested, but these would undoubtedly give lower results.

The third phase of the investigation consisted of testing the machine screws in single shear with the same loading used in the alternating tension test. This phase consisted of two parts; with preload and without preload.

The results from the single shear fatigue test were also fairly well scattered. The group of four makes of screws with an ultimate tensile stress around 90,000 pounds per square inch were not as well suited for single shear as the group of three makes of screws with the higher ultimate tensile stress. This lower tensile group failed in pure shear while the higher tensile group failed in tension due to bending.

Placing a preload on the screws increased the life. The amount of increase was quite variable but was consistent enough to definitely say a preload should be placed on all screws if long life is desirable.

"WHAT'S NEW(S)"



"Stay-Shaper" for Surgical Fitters.

• *Truform Anatomical Supports* has designed a surgical fitters' "stay shaper" for ease in the shaping of heavy steel or duraluminum to proper body contours. The new instrument is made of aluminum. No adjustments are required, the stay shaper being so set that the steel is inserted to the point desired. Hand pressure shapes it readily, even to the very end.

• *Howard Hollander* has been named by the Pope Brace Division as its representative in the Southwest area. Mr. Hollander will be calling on brace establishments in the states of Arizona, New Mexico, Texas, Oklahoma, Arkansas, Louisiana and Colorado. In announcing his appointment, Ralph Storrs, Manager of the Pope Brace Division, emphasized that the Pope Division would continue its efforts to ship orders the same day received. Mr. Hollander was formerly with the U. S. Public Health Service. He has represented several different companies and has a wide knowledge of brace establishments.

• 1956 is a key year in the life of *Konrad Hoehler*, OALMA member and Certified Prosthetist in New York City. It's the fiftieth anniversary of his work in artificial limbs and braces—it's the fortieth anniversary of his graduation from the German Orthopedic Training Program—and it marks a quarter of a century that he has spent in the United States in the orthopedic and prosthetic field.

• "*Care of Your Realastic Restoration*" is the title of a new booklet prepared for patients by Prosthetic Services of San Francisco. The booklet and an accompanying sheet of instructions, "How to Care for it" has been prepared for patients who are wearing cosmetic restorations such as gloves, leg coverings and facial prostheses.