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Harshwardhan Gupta's Design Tips–11

Fasteners, Locks, Split Clamps

A bit of classification for clarity: A fastener is (generally) something that keeps two or more parts together, which otherwise would fall apart. This therefore excludes welding, brazing, adhesives, round parts pressed into round holes, but does not exclude screws. "No giggling in the back benches! Why you have such dirty minds?" The next grouping is between threaded and non-threaded fasteners. Threaded fasteners are obviously screws, nuts, studs, bolts, helicoils, etc… There is a HUGE variety available in all qualities from superb to rubbish with any decent hardware supplier. Non-threaded fasteners are things like circlips, keys, split pins, rivets… Locks are things which lock the various fasteners against loosening, like spring washers, star washers, roller chain locks; or are devices openable by bare hand – like electrical cabinet handles or toggle latches. Split clamps are features that lock a part with a side-slit round hole onto a round bar by applying tangential clamping by a screw – worm-type hose-clamps are a variant of the split clamps.

In this article, I will not go further into classifications and definitions, but try to correct some of the bad habits and myths that surround designing / assembling / using fastening devices.

1. **Beware of duplicates and sub-standard makes of fasteners and tools!**
2. Use high-quality, *high-tensile* bolts, nuts and Allen screws, correctly called socket-head screws. With high-tensile fasteners, you do not need to use first a plain washer, then a spring washer. You can tighten high-tensile threaded fasteners sufficiently to get a virtually vibration-proof natural friction lock.
3. Go through appropriate IS / DIN / ISO standards before specifying fasteners and designing threaded / mating features. Many junior design engineers don't know that the passing hole is bigger than the screw diameter, circlip groove is wider than the circlip, there are two basic types of spring washers (one of them happens to be meant for 'Allen' screws) etc., etc…
4. Nice fat thick plain washers should be used when the bolt or screw is tightening on an adjustment slot.
5. It is criminal to make tapped holes oversize just so that tapping becomes easier. You are weakening the joint, and sooner rather than later, the ill-fitting screw will screw you in turn. "Nut screws and bolts", as the old PJ about a psycho rapist goes!
6. All threaded fasteners come loose with vibrations. Using locknuts is a poor way of preventing it. Split pins are okay but can lead to fatigue cracks. Anaerobic thread-locking adhesives are good – they can be undone by a few drops of pure toluene. Nylock nuts are good. Speith nuts – a variant of lock nuts – are excellent. These are two ring nuts, one with tapped holes in the rim, one with through holes in the rim, kept axially apart on the shaft by a millimeter and fastened together with small screws. The axial gap between the two is a MUST! No gap – no locking! The theory correctly says that if the fastener gets completely unloaded at some point of the vibration cycle, it will definitely get loose quite quickly. Spring washers prevent just this, and that's how they work so well.
7. In a machine (like a car), It pays to re-tighten ALL fasteners after a few months of use. Even better to repeat it after another 6 months. If you do this (say) to your car, for example, you will never have body noise or door rattling.
8. Talking of fastened joints, a machine's or structure's rigidity is a sum total of the rigidity of its parts AND its joints. If you join two fat castings or two heavy fabrications by insufficient number and / or insufficient size of bolts, the overall assembly will have very poor rigidity, and you will keep wondering what happened to

your rigidity calculations. This also does mean that you festoon the joint with so many big fat bolts that there is insufficient spanner space. Many hydraulics designers are experts in doing just this!

9. In all my professional life, I have met very few designers who can properly proportion a split clamp. To give you an idea, for a 40ϕ shaft, the width of the slimmest portion of the clamp should be about 4-5mm, bolt should be M8 or M10, and the thickness should be 20-30mm. More width will stress the screw too much by the time sufficient clamping is achieved, and less width will stretch the material. Too much clearance (my ideal is H7-f6) will make the slit shut. Too little thickness will cause insufficient rigidity. More width than 30 (in this example) will need more than one screw. Anything beyond 40 is functionally useless. The slit should be 2-3mm in this case. The bolt should be as near the shaft as possible. I would only keep 2mm minimum material! Any material along the slit and beyond the bolt head is useless. If properly designed and made, a split clamp can surpass a shrink-fit in performance.
10. As far as possible, design keyways in shafts close-ended on both ends. It is not only neater, but physically the key cannot come out with vibrations. The key should be retained by a setscrew right on it. From 6x6mm onwards, it should also have a tapped hole to pull it out of the shaft. Follow other guidelines for keys in the standards. If the torque a key carries is not critical, you can safely (and not at all inappropriately) use a smaller size key than one specified in the standards. Avoid very long keys.
11. Keep appropriate space for entry and turning of spanners AND for the human hands using the spanners in the machine. This may be stressing the obvious, but I have seen some real boo-boos here.
12. Keep sufficient thread engagement. Though the standards say 1.5 times screw diameter, I recommend 2.5 to 3 times, as our fasteners are always grossly undersized, and female threads are oversized, or tapered, and the materials have a real low yield point, so threads often strip off with 1.5-times type design.
13. Keep sufficient tap drill depth, as our workmen are experts in stopping at the first or the second tap after they have bottomed it, so you are cheated out of the available tapping depth.
14. Machinists, especially lathe operators, are past-masters in merely starting the thread, and reporting the job as complete. It is left to the poor assembly fitters to complete the half-done job. If after tapping, the job has been hardened and ground, get ready to fill out the rejection report / rework note. Some Brave Hearts try to tap a half-tapped hardened job, and break the tap inside. Then the oldest fitter in the factory gets a chance to show his skills.
15. It is usually below the dignity of a machinist to tap the holes he has drilled. A job worth tens of thousands of Rupees is done on a CNC machine and then undone by the ITI apprentice by tapping it “cross” – the tap not having gone in at right angles. For some inexplicable reason, it is completely alien for a vast majority of our machine-shops to have the MACHINE run the tap after having drilled the tap hole. They think a great saving is achieved by manual tapping, and they think it is “safer”(?!?) – if a machine breaks a tap, it is the machine’s fault; if a man breaks a tap, it is the material’s of the tap’s fault!
16. Do not tighten hex-head bolts using an adjustable spanner. That tool is for emergencies in a remote roadside. It has no place in the assembly or the maintenance shops.
17. The pipe wrench is for working with pipes, not with big nuts or other fasteners.
18. Work circlips with good imported circlip pliers, not with hand-filed bright-chrome plated pieces of utter shit that are sold in India in the name of circlip pliers. (I am ashamed to say that Chinese circlips pliers are far better than ours, and German ones are perfect)! If you are travelling abroad, please get a good set of circlip pliers for your shop.
19. When you are rummaging through that sexy German hardware store, please also get a set of ball-ended Allen drivers. These are Allen keys with a garlic-like hexagon-faceted ball at the useful end, and a screwdriver-like handle at the other end. It can drive Allen screws even at 30°angles from normal. You do get long ball-ended keys in India (better than the common or garden variety, but nowhere as handy as these Allen drivers) but none of our resourceful importers have yet thought of importing this extremely useful tool.
20. When you can use a box spanner, don’t use a ring spanner. When you can use a ring spanner, don’t use an open spanner. When you can use an open spanner, don’t use an adjustable spanner. When you can

use an adjustable spanner, don't use a monkey wrench. When you can use a monkey wrench, don't use a pair of pliers. When you can use a pair of pliers, don't use a chisel or screwdriver, and a hammer… That's the mark of the callous and the uncaring.

21. Please don't paint fasteners. Remove jammed and rusted fasteners with good old WD-40. Many recent products are better.
22. Zinc plating with passivation is fine but the fatigue-strength is definitely reduced unless you do dehydrogenation after plating. Never ever electroplate spring washer, circlips, Belleville washers or any stuff made of spring-steel.
23. Don't add a 3-foot pipe to increase your leverage on a 200mm long hexagonal wrench (allen key). And I beg you to not to work with broken, modified or damaged tools / fasteners. I especially beseech you to not to use "duplicate" tools like spanners. You are only spitting on yourself.

Writer ka screw thoda saa loose hai shayad!

Next Month: Adjustment-free machines

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