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Harshwardhan Gupta's Design Tips–4

Saving on Raw-Material Costs

What ever happened to good old simple mild steel, cast iron, and aluminium? I have seen designers put in every sort of fancy alloys into their designs when they are not called for. And some go to the other extreme, and use the cheapest, crack-prone sheet metal, off-grade En-9 masquerading as M.S. and pig iron.

1. In most applications, one really chooses sections, say the shaft diameter, not by strength but by rigidity considerations. Often it is not appreciated that rigidity is a function of the material's modulus of elasticity, not its ultimate strength. What is also forgotten is that ALL steels have virtually the same modulus in ALL states of heat treatment. In other words, a mild steel shaft will not deflect any more than a fancy through-hardened shaft under similar circumstances. If the shafts or other parts are lightly loaded, even toughening is useless, and contributes only to the builder's or user's mental peace.
2. If a mildly loaded shaft is running on rolling bearings and no rolling (like needle bearings) or rubbing elements (like bush bearings) come in direct contact, there is no need to use anything other than M.S. Specifying unhardened En-24 gives good machinability and high ultimate strength. In other words, a shaft running under light load of ball bearings does not have to be hardened or toughened.
3. Very often, enormous costs can be saved by sensibly substituting unavailable and expensive materials in an imported design by commonly available materials. In 95% cases, it does not make any difference in the performance or life. Substituting plain aluminium plates for alloy aluminium plates is an exception, and all threads in the part must be designed out. Indian aluminium, unfortunately, does not take to tapped threads very well.
4. Static or lightly loaded springs need not be made from expensive En-47. En-42 or plain carbon steel works quite well.
5. Lightly loaded gears can be made from mild steel. No need to go in for case-hardened 4340 or En-36. Aluminium is a bad choice for gears, though.
6. Often designers specify (say) St-35 for ordinary parts, which just means steel of 35 Kg/mm^2 tensile strength, which is exactly same as mild steel. The price immediately goes up the moment the trader sees a number in the material specs.
7. Keys need never be made from alloy steels. They are meant to fail when overloaded. An extra-strong key will damage the shaft before it fails.
8. Most packaging machines, piece handling and many other machinery systems are very lightly loaded, and most (but not all) parts run with quite low stresses. Here, a lot can be made from simple mild steel and aluminium.
9. Many a times, if the volumes are low, castings and forgings can be replaced by stock materials. Redesign the parts accordingly.
10. Sprockets, if lightly loaded, can be made from mild steel too, and give a very long life if the sprockets are well aligned and the chain is lubricated with thin oil.
11. Substituting chains with timing belts makes the design much lighter and much less noisy.
12. Unfortunately, large tracts of the markets do not understand the rather cumbersome IS specifications. Asking for an exotic sounding nomenclature, or a DIN, or a GOST or a JIS material artificially pushes the price up. Do your homework, find out commonly available equivalents, again use your commonsense, and then specify materials in an imported design.
13. ISO 900x has made it more cumbersome to substitute materials. Do find a way and evolve a procedure for sensible substitution.

14. Excessive insistence of rigidity is often of no use. To design a rigid machine cover in, say, cast-iron may not serve any great purpose. Well-designed sheet metal can often be as good.
15. PTFE (Teflon) can often be replaced by ultra-high molecular weight (UHMW) HDPE, a far cheaper and superior material. Nylon / Delrin can often be substituted with this material too. Contrary to commonsense, recycled UHMW-HDPE has better properties all round than virgin material. It has the frictionlessness of PTFE; chemical neutrality of polyester, rigidity better than nylon; and machinability better than any other plastic, Wefapress of Germany is a good, cheap source of this material and finished parts in this material. You can find them on the net.
16. Almost all plastics, even if they are quite tough, have a very low modulus compared to metal. So the same part made in plastics will deflect much more than a metal part. Use this fact to your advantage.
17. Cutting intricate low-volume sheet metal blanks can actually be more economical if done by CNC laser cutting – a fairly cheap process itself. This is because the CNC program will optimize the sheet utilization and minimize the wastage to the absolutely bare minimum.
18. Redesigning machined parts into sheet-metal parts can often save money.
19. As machine-design textbooks always say, reduce weight by thinning sections and adding ribs. Everyone adds ribs but very few take the plunge to reduce section thicknesses and by corollary reducing the rib thicknesses too.
20. Making a fiberglass cladding for machine frames seems to be the fashion today, but it is better, cleaner, cheaper, simpler and actually more elegant to make the machine frame itself more aesthetic.
21. Using counter-bored holes with socket cap screws is often not necessary. Equivalent high-tensile hex bolts are much cheaper, sometimes as much by 50-60%. Plus you save on counter-boring costs. Make this change wherever it makes sense.
22. Choosing a cast material that flows more easily while pouring can reduce the ruling section of the casting and save a lot of weight, and therefore cost. In simple words, a 120 Kg casting @ Rs. 30 per Kg is cheaper than a 180 Kg casting @ Rs. 25 per Kg. Just a 3 mm reduction in a 20 mm ruling section can achieve this, for example.

Please understand the physics, metallurgy AND commonsense behind the use of materials, and keep the material specifications simple.

But keeping things simple is the most complicated thing, and the most terrorizing, isn't it?

Next Month: Rolling Bearings

The author is a graduate of IIT Bombay in Mechanical Engineering. He has been designing machines since 1976. He founded Neubauplan Machine Design Studio, an independent consulting machine-design firm in 1981 in Pune. He can be reached at harsh@neubauplan.com or through his website at www.neubauplan.com