

Harshwardhan Gupta's Design Tips-19

Surface Treatment

This is not a standard informative article about conventional and new surface treatments. There is plenty of 'what' and 'how-to' information available on that. (Most authoritative is the ASM Metals Handbook, latest edition, volume on surface treatment – expensive but worth every paisa) As is usual in this column, I will go into some of the little-known facts, prevalent misunderstandings and usual screw-ups that are common in the normal gamut of surface treatments. Surface treatments are done for appearance, corrosion protection, or to get certain surface properties like wear-resistance, or all of these. This is the domain of 'The Good, the Bad and the Ugly!' "*Dekho phir se iska shining maarna shuru ho gaya!*"

Lamponing aside, do be informed of one aspect of corrosion in steel: Excess, or plentiful oxygen will deter corrosion. Limited or trapped oxygen will accelerate corrosion. Unbelievable? Believe it! Pneumatic valves and cylinders merrily work for years without corrosion on their plain steel parts, as so much oxygen (in the air) is always churning past them. Steel screws in blind oil-less holes rust within a few days as oxygen is trapped in the blind hole. Square bars lying on dry floor rust on the bottom only, where air cannot circulate freely. Bare steel parts washed with thinner, dried and sealed in plastic bags rust in a few days. *Sochne ki baat hai*. Oxygen starvation leads to more corrosion in steel, not less. This is one of the quirks of nature: you can't fight it.

People with long experience of using or providing specialized treatments usually know their field, so these tips are for the average user. *Hamaare experts ne khaas aapke liye banaya hai!*

1. Natural steel: Most steels require some or the other surface treatment, else they will merrily rust. Machine-tool design is one area where

the machines generally work in a perennially oily environment – so bare steel does not rust there. Hence, machine tool designers often leave steel parts bare. Similarly, gearbox inner parts, since they are always immersed in oil are not treated for corrosion protection. Now when their designers step into other areas like material handling, packaging, etc., they simply don't bother to specify surface protection. So please don't forget to specify surface treatment for steels!

2. Pickling: Remember ordinary pickling will not remove weld burns or mill-scale (the gray-black oxide film present on hot-rolled steel).
3. Blackodizing or blackening: This is a porous finish which adsorbs (not absorbs) oil, and will prevent rusting only when it is wet with oil at all times. Blackening and oil only give protection together – oil alone or blackening alone is no protection. Blackening does not change dimensions. High hardness or alloy content results in a reddish gray color; not black – so don't start screaming on the vendor. If you clean blackened parts with solvents like kerosene or thinner, this will remove this oil film, and rusting will start within a few hours. Wrapping blackened parts in newspaper will also draw away this oil, and the acids in the paper will immediately cause rusting. Use plastic film to wrap blackened & oiled parts. The oil used for dipping by the blackening vendor is quenching oil, and is often very badly oxidized. The free acids thus produced in that oil cause corrosion despite all above precautions. In such cases, wash the received blackened & oiled part with mineral turpentine or kerosene or diesel oil, wipe dry and again apply fresh SAE-40 oil immediately.
4. Zinc-plating / dip galvanizing: Zinc plating is the cheapest and best protection for steel. Blue, green or yellow passivation protects the zinc, which protects the steel. Dip galvanizing is extremely durable but gives a very thick, uneven coating. Best for outdoor, dirty or watery applications. Common detergents eat away zinc very quickly (so don't wash your car with household detergents). Zinc is electronegative so small scratches do not

- cause rusting.
5. Cadmium plating: Better than zinc but more expensive. Never use it in pharma- and food-processing machinery, as it is toxic. It is also electronegative.
 6. Electroless Nickel: More expensive than cadmium but electropositive, so any discontinuity will result in rusting. Color is difficult to control. Applied without any electric current, it gives a very uniform layer thickness all around compared to any other type of electroplating. Electroless Nickel plating drastically reduces the coefficient of friction, so it can easily make screws and nuts come loose even under mild vibrations. Spring washers will cause rusting where they bite into the base part.
 7. Phosphating: This is a very porous coating, used to increase adherence of paint. It can also be used for lubricant film retention (in gears, etc.), or for avoiding welding of surfaces under high local loads. Used by itself, it needs a heavy oil film to protect the steel. Unless its acid is thoroughly washed off, it can start corrosion.
 8. Hard chrome: Most hardened steels and spring steels are prone to hydrogen embrittlement, resulting in the chrome layer flaking off. This is directly deposited, and is different from bright chrome, which is chrome plating on nickel-plating on copper plating on steel – thus building up quite an unevenly thick layer.
 9. Glass-bead blasting: Evident from the name – blasting not with sand or shot, but with fine round glass beads. Gives a uniform matt finish without scratching or gouging the surface the way sand or shot do. Used as preparatory finish for Electroless nickel or satin chrome, or as a matt finish on stainless steels.
 10. Anodizing of aluminium: Do not try to anodize aluminium castings – the necessary high silicon content in cast alloys will ruin it. Do not buff machined parts before or after anodizing (see below). Do not bead-blast either – the resulting part will become very prone to stains. Anodizing does not alter size.
 11. Buffing: *Chamak ka dost, quality ka dushman*. Buffing distorts and ruins all geometric accuracies of the part. Use bead blasting and flash-chrome (thin hard-chrome) instead. This gives a very durable, attractive matt finish, and is popularly called ‘satin-chrome’. Bright-chrome with buffing is the most abusive treatment of machined (not sheet-metal) parts, and it implies poor quality and carelessness to a discerning buyer. All that shines is not gold, as the saying goes.
 12. Electropolishing: Running the job on the anode. It removes high spots at a microscopic level, and gives a far cleaner shiny surface (seen under a microscope) than buffing. Best for medical, food and pharma applications, as the microscopic smoothness results in a bacteria-resistant surface too. It takes a skilled plater to do a good job.
 13. Painting: Hammertone finish paints imply poor quality, and suggest an attempt to hide poor basic finish. The need to clean, de-rust (best is the brushing-type phosphating solution) cannot be overemphasized. Please don’t try to cut corners by avoiding the primer coat. And please paint your machine parts before assembly, not after! The latter again conveys carelessness. Don’t tell me that you can carefully disguise that, as anyone with a sharp eye can catch you right away, and then you convey an even worse image of your quality. Alternately, don’t attempt to paint beforehand, and then ‘only’ give one final coat after assembly – that also is obvious to a discerning eye. If you want your product to look like some wonderfully shabby Indian Railways equipment, then follow their dictum – ‘If it moves, lubricate it generously; If it doesn’t move, paint it liberally’. The ubiquitous aluminium paint used on oven and furnace exteriors is often put without any special treatment, and the surface below starts rusting within weeks. “Excuse, sir, for paint and rubber parts, company not giving any gerantee!”
 14. Hydrogen Embrittlement: Running the job on the cathode makes the job absorb the hydrogen ions which are also attracted to the cathode along with plating metal ions.

Hydrogen ions are nothing but high-velocity protons, far smaller than even the tiny hydrogen atom. These penetrate deep into the material, just like bullets, then gain an electron and become immensely larger, thus stressing the metal crystals, making the metal brittle. Plate a circlip and see for yourself how it snaps off as you stress it for mounting.

15. Plating in holes: No electroplating will enter holes, as the electric field there is very weak, unless you put a specially designed bar anode in the hole itself. Electroless nickel will enter holes too.
16. Traditional Marathi wisdom says very rightly, *Ati titha maati!* Excess leads to perdition, to downfall! Excessive plating thickness, excessive plating current density, excessive pickling, excess production from a given bath, excessive buffing, excessive paint thickness, excessive electropolishing, will all lead to ruin!
17. All the same, keep away from platers who will take out the part as soon as it has got 'color' all over. And if you yourself have insisted on ultra-thin plating at ultra-cheap rates, then you yourself are on your road to perdition!

Do not use ANY surface build-up treatments (plating, painting) in these situations:

- a. On rolling bearing elements of any kind – including shafts on which steel balls, rollers or needles are running, and even on steel wheels on steel rails under high loads. Any build-up treatment would either flake off (chrome) or wear out soon (zinc), and ruin the bearings.
- b. On stainless steel, except surface removal treatments like polishing, bead blasting, electro polishing, and texturing – like brush finishing.

- c. Where close tolerances must be maintained. Unfortunately, no commercial electroplater will give you consistent thicknesses. So, watch out for uneven, unrepeatable plating layer build-up. If you specify tolerances before plating, you are damned, and if you specify them after plating, you are doomed. Blackening and zinc plating are safe to use as blackening does not build up any thickness, and excess zinc gets burnished or peeled off during tight assembly.

For all our global aspirations, you can still buy all sorts of brand-new “*peti-pack*” industrial maseens / missions / mesheens: lathes, shapers, milling machines, large motors, compressors, power hacksaws, pillar drills, bench grinders, machine vices, surface plates, you name it (“In small items full thermacoll pecking is coming sir!”) – liberally smeared with ugly daubs of tacky “rust preventive” creosote oil on wherever there is bare steel, with plastic sheets stuck on, and the whole machine unceremoniously tied into more layers of plastic sheets just the way a corpse is bundled into cloth, packed in a damp termite-eaten wooden coffin lined with blotchy tar-paper. Rest In Peace!

“Sanwla rang aur oily skin? Pimples se pareshaan hain? Chehre par kaale dhabbe? Naina-ji, aapne zinc-plating try kiya? Sirf doe dinon mein hi paiye kamaal kaa goraa-pun! Belt-sanding aapke pimple-marks jad se mitaa degaa, pickling aapki twacha ke dhabbe door karegaa, aur yellow-passivation aapko degaa poora humidity protection! Aur yeh sub kewal saat rupaye kilo mein! Ab marks se no marks! Ladke waale bus dekhte rah jayenge!”

Next Month: Gears

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