

Harshwardhan Gupta's Design Tips-12

Adjustment-free Machines

Kindly adjust – the quintessential Indian way of life! Learn to adjust; we are reprimanded in our childhood. *Marriage ke baad sab adjust ho jaata hai* – our parents counsel us! We bring the same philosophy into engineering and design.

Everything was adjustable in old, pre-WW2 European and American machines. The reason to keep everything adjustable was to compensate for errors and deviations in manufacturing, where today's precision was impossible or prohibitively expensive to achieve. Then in India, we got our freedom and firmly shut our access to technological developments in the West. This created a bizarre situation. Throughout the 60s and 70s, people (usually enthusiastic craftsmen teamed up with equally enthusiastic entrepreneurs) merrily copied machines designed and built in Europe and USA, which at that point in time were anywhere between 20 to 50 years old. Many did a creditable job of copying, yet never gave a thought to eliminating adjustments. On the contrary, they went on festooning their machines with even more adjustments. With operating manuals in India being sketchy and badly written at best, and non-existent at worst, adjusting a machine became the most well-kept secret by the workmen involved – both of the machine-builder and user – one training the other. So much so, that even their bosses, the "service" engineers and the owners never quite knew how to do these "critical" adjustments. This situation still prevails with thousands of machine-builders in material-handling, packaging, printing, pharmaceutical, food, canning, bottling, cigarette-making, jewelry making, SPM industries... virtually everywhere.

In many typical cases from these First-World industries, (Manestey, IWKA, Grafo, Heidelberg, Stannco, etc...) the original old – really old – machines had quite a few adjustments, and

subsequent Indian copies went on making more and more parts and assemblies adjustable, as the makers encountered problems, and the resulting product became uglier and increasingly troublesome, and needed an accomplished artist to adjust it right, even at the operator level (But I tell you, since that Harkisan fellow adjusted it is running very fine for last 4-5 months 70-80% production we are taking out!). In the same period, these very First World companies went on to making increasingly sophisticated machines, removing most of the adjustments as precision manufacturing became more the norm, and labour became more expensive.

So where does that leave us? Why do we need adjustments? Well, some adjustments are required to set the machine up for different sized products. This is usually accompanied by a change of tools too. It is a sobering thought that many European companies (Uhlmann, Dividella, IMA, Manestey...) are now supplying 100% pre-adjusted tool-change – mechanical engineers' answer – no, forerunner – to "plug-and-play" devices! In 1990, I myself have seen cartoning machines, specially designed for very short runs of a wide variety of cartons, made by Harro Hofliker of Germany, where all adjustments were motorized with position feedback, and a menu-driven program adjusted the machine to the chosen settings, and the machine got ready to run a new product within 3-4 minutes! This is not at all difficult to achieve by any good machine-builder in India – it only needs a change of attitude, and a good designer. The machine tool industry has been doing it for many years: in the form of Automatic Tool-Changers for CNC machines!

Back to our topic – the rest of the adjustments simply exist to hide the machine-builder's / designer's shortcomings. This is what the machine builder and his designer have to put their minds to. An obvious but oft-forgotten pre-requisite is willingness to change, as I just said. Assuming that is present, where does one start? With a 1:1 scale drawing, on paper or more likely in AutoCAD nowadays! This drawing must first be audited if it has been made by measuring and drawing parts of another older machine. The drawing by itself must be really accurate, VERY detailed, to scale in every detail, (Always keep that "Ortho" and "Snap"

on, my CAD-using comrade!) and must make sense by itself. It should not rely on the basis that “if it works in the actual machine, even the obviously wrong design must be taken as okay”. Check for things like whether gear center-distances are theoretically correct, whether the bearings come into the right place with right axial locations / floats, whether the toggle geometry is correct, whether the cam geometry makes sense, etc...

Once this design drawing is thoroughly audited, part drawings should be reviewed next. Main thing to check for is: what dimensional variation (tolerance, that is) can the design accept, rather than with what tolerance can the part be “conveniently” manufactured. If all documentation makes sense, then patterns / castings / fabrications (Quality is little bad but he is doing very cheap you know!) and other manufactured parts should be checked if they conform to the drawings. If you are in the habit of not making parts as per drawings in this 21st century, or worse, you make parts without having drawings for them, then I am at a complete loss of words!

On the other end of the spectrum, there are those who put a tolerance on every single dimension and clutter the drawing with form tolerances. This only makes everyone’s life miserable and pushes the cost up. For dimensions and features where no special tolerance is needed, but which do contribute to the overall quality, there is something called open tolerances (defined in IS-2102). This is often misunderstood as no limits at all (Tolerance *kahan diya hai, dikhao?*). Many think open tolerance simply means $\pm 1\text{mm}$ universally, whether it applies to 20mm or 2000mm. Others argue that 20mm without tolerance must mean 20.000mm. Still others make everything “within tolerance” but the right-angle is off by a whole degree, without realizing the havoc that can cause. “Happens *bhai*, what to do? You have to adjust! How many times you will do reject reject reject?”

This is where precision manufacturing comes in. Are you accepting medium-sized castings that are badly warped and are dimensionally off by many millimeters? Are you matching shafts to bearings? Are you machining off a cheap part to save an off-size expensive part? This is where you need to

stand up and reject dimensionally unacceptable parts. Please also remember that good finish and good tolerances are two different things.

In well-made components, very often the passing (clearance) holes for fasteners, when made as per IS-1821 / ISO R/273, provide sufficient adjustment opportunity to compensate for acceptable manufacturing errors. In simple language, 7mm hole for M6, 22mm hole for M20, etc. You don’t have to make the holes any bigger or make them oval, then cover them with big ugly washers.

If you have to provide valid adjustments, don’t keep a (say) 50mm range – just to be on “safe side” – when geometry + calculation says only 22mm is required. This can actually make your design more compact.

Where locations must be frozen in place after careful alignments, as in machine-tools, dowel pins are the obvious answer. Threaded and hardened tapered dowels are the best.

Now, assuming that you have a proper design and are assured of properly made parts, *have a good look at each adjustment provided in the design and review it. Is it REALLY necessary?* Be ruthless, and be sure of your geometry and your fundas. What will happen if that adjustment is removed and the part made to fit in one given place? Something else may go out of synch? And is that adjustable too? So, remove both adjustments! Now the keyway must be in a given orientation compared to the PCD holes? Then say so in the drawing, it’s not such a big deal! Check again – are you afraid of removing those uncalled-for adjustments because... The boss will not approve? Something “unknown” might go wrong? You believe your customers like them? You are too lazy? You think that might increase the cost? You think it might need going to more expensive vendors? You are too busy with other problems? You don’t want to experiment? A known devil is better than an unknown devil? You are not sure how to do it... Well, there are very sound economical and management reasons to design-out adjustments:

1. Increased component cost usually gets offset in reduced assembly and try-out time, which is when all the investment has already been made and the machine on the assembly floor

is just that much money sitting idle for long weeks producing no financial returns!

2. Removing adjustments simplifies the design, reduces number of parts and thus reduces cost too. The design effort goes in only once, adjustments cost you extra in each single machine.
3. Erection and commissioning is much easier after delivery, thus shortening installation time and expenses.
4. Assembly-fitter / user training time and cost is reduced.
5. Critical skills are not lost when an experienced fitter leaves your organization. Or when you have to retire him.
6. Heavy use and vibrations don't put the machine out of alignment, so MTBF improves.
7. Parts like gears (especially bevel gears) normally don't wear out so easily; they do if someone adjusted them wrongly, because someone else made them adjustable. Change-gears, Timing belt drives, roller-chain drives, can ALL be designed for fixed centers.
8. It makes the machine much more fool-proof, and much less person-dependent.
9. Service calls during warranty period are reduced, as there are lesser adjustments to go 'out'. This in itself is a HUGE saving. Please realize that just because you kept everything

adjustable, a few unintentional screw-ups by the user can wipe out your entire margins on that particular machine just in making 2-3 avoidable service calls 1200 km away.

10. Assembly fitters / machine operators / unions can't hold you to ransom (Fully open this fellow is writing! One has to be diplomatic no?)

Remember the days when every single part in the old Premier Padmini "dikky" and door latches, locks and hinges was adjustable, and every few months there HAD to be "thoda aijusment by apna Balbir Singh Mechanic? Very good he is, *ekdum* best but charging much too much nowadays, very busy also he is nowadays! Just 2 year old and doors are giving trouble again again, all because so many @#\$%& potholes in the roads! Very bad you know, when we sit in car whole building knows, so much door banging is there Sheela Auntie from fifth floor regular asking morning evening where who was going in car!"

What you are talking all rubbish don't adjust don't adjust? How much I have to adjust everyday you don't know! Nowadays even Saas has to adjust to *Bahu!* Our old time it was not like that!

Next Month: Designing silent machines

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