



## Harshwardhan Gupta's Design Tips-9

### Tolerances and Fits

"Everything is in absolutely zero-zero! We did matching with your bearing only! Not going? Krishna, take it and put little polish paper on that Rajkot it is empty, tell Kaka don't do minus! If it goes minus, we will have to unnecessary send for haadcroam 3 days it will take. So what I was saying? Yes yes, we of course fully inspect 110%. You don't worry! Whatever plus minus tolerance you are giving, we are maintaining 110%. Little bit out and we are straightaway doing rejeksun. I myself full Diploma engineer, Sir. Our Quality Control is very very shtrick. Sorry, Assurance, Assurance, Quality Assurance, not Control. Quality Control is now old fashion no, hee hee. Nowadays Assurance is there in place of Control. And we are always doing best relation maintain with your purchase, inspection, everybody. But I tell you; nowadays even bearings are coming minus bore. All &^\$%@ duplicate business going on. Yesterday only I triple checked original pack SKF 50 bore with dial myself only. It was showing half thou minus!" (Which is exactly what the SKF catalog specifies, by the way.)

Familiar scenario, isn't it?

At times I wonder that, for all our rapid industrialization, are we really a manufacturing nation? Or are we essentially a nation of traders, having somehow done a diploma course, who are employing agricultural labor to work on contraptions made by next town's blacksmith, and doing industrial manufacturing business by underhand deals, rather than on quality?

And what is this tolerance business?

In the 18<sup>th</sup> century, gun-making companies in Europe, employing hundreds of gunsmiths, invented the concept of interchangeability to enable soldiers to interchange their guns' parts in the battlefield. This concept of interchangeability of parts worked so well and proved so economical that its use spread like wildfire to all gun-making factories, then to other industries, and then became the driving engine of what we today call the Industrial Revolution. The Industrial Revolution simply could not have come about without the then unique concept of interchangeability.

In stark contrast from those times, today we simply take it for granted that when a part of some machine or gadget becomes unserviceable; a new part to replace it will fit perfectly in place of the old. Therefore, the first word in the Quality dictionary is not "assurance" but "interchangeability" – or predictability, in a more general sense.

This interchangeability is central to the whole industrial World. The lifestyle we all are used to nowadays simply cannot exist even for a day without interchangeable parts, assemblies and machines. To achieve this interchangeability, the industrial World has devised a system of 'tolerances'.

Quite simply, tolerances are nothing but dimensional limits within which a part can be manufactured so that, firstly, a desired fit – tight, loose, locating, running – is achieved with the mating part (which is also made to corresponding limits), and secondly, the piece-to-piece variation in that fit remains within acceptable limits.

Most engineering handbooks contain tolerance tables and explain the method of choosing them fairly well, so I am not going to go into that part of it here. The problems lie elsewhere. I am outlining the problems – the solutions are obvious!

1. Most of the tolerances are specified on the drawings by the designers / draftsmen, who usually have absolutely no hands-on experience of either manufacturing or assembly or both. Most such guys hide behind their ignorance and try to use their handbooks as shields, throwing their "theoretical" weight around

when their parts don't assemble right or work right, blaming it on the blue-collar guys. This is the commonest point of friction between the 'upstairs' and 'downstairs' guys.

2. Some design guys, wanting to err on the safe side, specify the tightest possible tolerances, making the part unnecessarily expensive.
3. Others have no idea or experience of metrology, and specify tolerances in such a way that either they are impossible to achieve, or impossible to measure.
4. Still others completely bypass the standards, and give absolute limits by 'judgment' (All this H7 and g6 and F9 business I don't understand only!) These guys will specify  $\pm 0.02$  on  $20\phi$ , and the very same limits on  $250\phi$  also, aiming to get the same fit – which is nonsense.
5. Still others are very fond of specifying shrink fits and press fits. So, the poor shop floor guys, neither having heating and handling arrangements, nor a big press, resort to 10 Kg hammers and wooden blocks, ending up with material shavings on the floor. If a tight fit is required, often industrial adhesives can be put to good use. (See Design Tips #1, IPF November 2002, page 195) These press-fit buffs often forget to specify an entry chamfer, so the shop floor has a hell of a time assembling. At other times, the turner puts a small chamfer and the grinder removes it completely. Inspection guys are busy setting their bore gauges – what is there to inspect in chamfers?
6. Others make mistakes with capital and small letter denotations.
7. Still other will either convert the denotations (e.g. 30H7) to absolute values in the drawings, which is okay for production but creates havoc in a design review.
8. Others give only the denotations and expect the shop floor and inspection room to convert them to absolute values – recipe for a whodunit detective novel!

So much for the design office! Lets see what happens elsewhere.

1. Many vendors will invariably ask for the mating part and achieve a 'fit' by trial and error on the lathe or the boring machine. This is criminal! Such surfaces invariably become tapered, and play havoc with the bearings, etc.
2. Many factories work with worn-out or out-of-calibration measuring instruments.
3. Other places give worn-out instruments to the machinists, and a 'new' set to the inspectors.
4. Others use bearings to set dial bore gauges, or routinely set them on built-up micrometers.
5. Many don't have a Height-Master, so they can't check right angles properly. Others use 'commercial' grade try-squares.
6. In my observation for the last quarter-century, a good percentage of the people – machinists, inspectors, engineers – simply DO NOT know how to correctly put a Vernier caliper or a micrometer on the job. I have personally come across scores of people who will insert the Vernier caliper jaws just about 2mm inside a bore, then tilt it sideways, anywhere from  $15^\circ$  to  $45^\circ$ , then pronounce their verdict most confidently – Job is reject, Sir.

These individual shortcomings, going up the manufacturing ladder till we reach the national level, add up to an enormous wastage of man-hours, energy, money and materials, and results in inferior quality and unreliability. Our population is World's 22% and our total exports are World's 0.8%. Out of which, an extremely large chunk is non-industrial export. Out of this, machinery and hardware export to the First World is disgracefully negligible. Machinery export to the First World by Taiwan, Korea, China and other Southeast Asian countries put together may exceed our industrial GDP.

We are importing, using and discarding high-tech stuff – cell-phones, cars and their parts, home theatres, laptops, Laser mice, etc., at a furious rate, but we are not even mildly participating in their globalized development and production. With negligible exceptions, whatever high-tech stuff is being manufactured in India is under a foreign name, design and control.

Are we even a technical nation, leave alone being a technological nation? Well, throughout our long history, we have always placed software above hardware. We could write reams of Upanishads and invent the zero,

but could not invent and develop electricity, or the water wheel. Today, we can write billions of lines of source code, but cannot design and manufacture a hard disk drive on our own.

We Indians have a lot of tolerance! Mahatma Gandhi said so, no? But then why don't we fit into this World's sprawling manufacturing system?

*Next Month: Roller Chains*

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The author, Mr. Harshwardhan Gupta, is a graduate of I.I.T. Mumbai in mechanical engineering. He has been designing machines for the last 28 years, and has many World's First and India's First Machines to his credit. Many of his machines have very sophisticated pneumatic systems. He is the founder of Neubauplan Machine Design Studio, an independent machine-design firm in 1981 in Pune. Suggestions for topics for future pieces, questions and comments can be sent to [neubauplan@eth.net](mailto:neubauplan@eth.net). Website [www.neubauplan.com](http://www.neubauplan.com).