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NEUBAUPLAN
MACHINE DESIGN STUDIO

Harshwardhan Gupta's Design Tips– 18

Problems of High Speeds

What works at 10 per minute, doesn't work at 35 per minute. What works at 35 per minute, doesn't work at 100 per minute. What works at 100 per minute, doesn't work at 300 per minute. In my observation, every tripling of speeds entails a complete sea-change of concept. The 'sensible' argument of preferring 3 'simple' machines of 1/3rd speed and 1/3rd price doesn't always work out nowadays, as the cost of space, power and (competent) manpower is increasing, and machine reliability is going up too. Unfortunately, designing conceptually-original high-speed machines from absolute scratch is one capability we woefully lack in India.

"You know such high speed machines all sophisticated high-tech but very problematic. We cannot achieve such speeds it is very danger. Our slow machine only is best." Not really! As I have said before, high-tech is nothing but attention to detail. Higher the speed, more thoroughly the designer must understand the theory and predict the behaviour of his whole concept in totality. Faster the machine, more detailed must be your design and drawings, and more precise. When you conceive the machine in your mind, you should picture the running machine – not just a static mechanism – and think how the motions, forces, inertias, momentums, vibrations, and machine elements will behave at those speeds.

"Give us *pukka* tips Sir-*jee*, not these ronnd ronnd words *jee*!" So here:

1. Gravity does not change with speed, so if something is intermittently fed by gravity into the machine, its fall time must be reduced: firstly, obstructions and sliding friction removed, and if possible, falling height reduced, so the fall takes less time. To reduce falling time to half, falling height has to be reduced to 1/4th. Not possible? Then force it down with a positive drive of some kind.
2. 3-phase AC motors can be started and stopped only so many times per hour as specified by the manufacturer's catalog, or they overheat from repeated inrush of high starting currents. So either use a bigger motor, thus de-rating it (this also increases rotational inertia), or use an electromagnetic clutch-brake (usually jerky and unpleasantly noisy), or force-cool the motor externally – uncommon but best!
3. Followers are leaving the cams as you run the machine faster? "Some loud *khata-khat* noise started coming at higher speed sir so I slowed again." Use closed-profile cams, where there is one cam surface on each side of the follower, like a groove cut in a plate or a cylinder. Now you don't need springs. Use thin, high-penetration rust-preventive oil. If you lubricate these with grease, you will only create an abstract sculpture in grease.
4. Fast pneumatics needs careful understanding and design. Put thinnest possible tubes from the valve to the cylinder, use smaller switching valves and thus try and avoid flow-control valves. Put the valves closer to the cylinder. Use faster switching valves. Use cylinders with end-cushioning. If the stroke of a 100 bore x 300 stroke cylinder should take 1 second, you don't have to put a huge 1/2" solenoid valve with fat, stiff 12mm tubing and then choke it with large flow-control valves, making everything sluggish. And is that 100mm bore really required? A hard look at the application might show you that even a 25 bore cylinder would be sufficient! Many machine-designers (we generally are a very insecure breed) believe that bigger is better, except in cell phones! Try forcing back a 25mm cylinder at 6 bars (30kg force). You can't! "Oh-ho, so much force is there, is it? I thought an average 70kg person can easily force a 25 bore cylinder!"
5. Shack-abjer… sorry, shock-absorbers are wonderful devices and they allow you to run cylinders faster than you otherwise can. Go by the book and choose the proper joules-per-stroke AND joules-per-hour rating – else you will bust them.
6. And don't use shock-absorbers as dead-stops – dead-stops have to be in parallel with the shock-absorber.

Similarly, don't use any kind of switches as dead-stops either.

7. Check your PLC. Older/cheaper PLCs work slower in processing the logic, and if it is a complex, fast cycle, then quite unbelievably, the slow PLC or even a convoluted design of the logic can make a huge difference. In the electrical engineers' mind, microprocessors work instantly, programs run through in nanoseconds. In reality they don't, especially if the logic has been written by somebody who says yes to everything. The best of system houses can easily go off on a total tangent and completely drown the job in slow speeds, and then obstinately blame the 'mak-nikal side'. "Problem was coming sir, but see I slow down the motor problem is gone…" Don't forget that you have committed for high-speeds, they haven't. "Basically Gupta sir doesn't like electrical engineers yaar, *samjha karo na*!" Nothing of the sort, but politics cannot solve electrical deficiencies.
8. Needless to say, make moving parts light, compact, and yet rigid… Come out of the casting-and-steel-plate mindset and explore sheet metal, plastics, tubular sections, etc. Parts can be made rigid by geometry also, not just by adding metal. Chamfer, cut and drill away unnecessary material.
9. For very high-speed machines, try and do things in continuous motion, and use less of pneumatics. For example, cartoning machines, processing small, soft and flimsy paper cartons, till about 100 cartons per minute, work with intermittent motion for the carton. But 300 cpm machines work with continuous motion of the carton. Form-fill-seal machines work fine with intermittent motions up to 40 packs per minute. 100 ppm necessitates continuous motion of the film. The whole concept, design and construction changes.
10. Servomotors, even today's stepper motors, are very versatile and can do a lot of things AC motors or pneumatics cannot do. Still, one should avoid over-specifying the motor size and should make sure that the electronics would definitely keep pace with the requirements. Many electronic designers are not attuned to think that way either. They think that 20 milliseconds response time at every logical step is very fast, if not same as instantaneous. "Scan time is onnly 100 microseconds, sir!" Then the solenoid valve takes 22 milliseconds to respond, contactor coil takes 40ms, clutch-brake takes 120ms… If you speed up the pneumatic cylinder, it starts hammering. If you increase the end-cushioning, the piston starts bouncing back. If you put a shock-absorber, cycle time goes up. So, this is where you have to change tracks, discard old ideas, think and design carefully, and avoid and bypass the problem, rather than fighting it. Beyond a certain speed, you have to go mechanical and do everything with linkages and cams… "Hmmm, that means we will have to copy that Germany maseen we saw in Hanovar Agjibisan. I already took out detail propojal from them with drawing. Our old pneumatic was so simpal (sigh) Sunil can you not make it work somehow?"

"*Haan-jee*, jast one more tip *jee* Sir-*jee*, make it nice ronnd figure *jee*, lakky alaven *kaar do*…"

11. Run with the machine, as I say, and imagine what will happen in real time. When you draw it out, don't get stuck with the static drawing, and don't just think of the motions alone, think of the speed too. This may sound obvious, but I have seen many designers get trapped in the static drawing. 3D real time simulations are too complex, too expensive to build, and I can tell you 'hundred and ten percent' that they are no substitute for a real prototype of your high-speed mechanism. And when things move too fast for the eye during the test run, get a strobe light – the best friend of the high-speed automator.

Duniya, yeh duniya, Toofan Mail! Iske pahiye zor se chalte… "Ai to vadda puranna ganna hai jee, aj-kaal toh jee yeh music-shoosic *bhi ekkdamm balle-balle* spper faast *chall rya hai! Mai keya Gupta-jee aaj-kaal* life *hi kitni* spper faast *ho gi hai!"*

Next Month: Surface Treatment

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