Variation on CNC Chassis Design

Purpose

This paper focuses on the varying methods of chassis design and fabrication for CNC machines. Further, it is intended to help with comparative evaluations within the microtooling CNC niche. This will be done, first, by explaining why machines designed for microtooling should not be compared to other conventional CNC machines designed to run large tools, and second, by providing information on each of the primary methods of chassis fabrication used in the manufacture of microtooling CNC machines.

The tale of the tape

With such a wide range of CNC machines on the market and an even larger number of applications for those machines, it's logical that there's a relative number of methods for chassis construction. The type of construction employed in the manufacture of a particular machine should be the direct result of extensive engineering and design — taking into account the physics involved in the applications the machine will be called upon to perform. So, when comparing CNC machines, it's not always an apples-to-apples scenario. Just like you'd never see George Foreman vs. Oscar de la Hoya on the "Tale of the Tape", a CNC machine intended to muscle through dense substrates with durable large tools should never be compared to machines intended for high-speed, micro-tooling. Nonetheless, machine comparison can be problematic when certain manufacturers try to be everything to everyone. For example, some makers of large-tool CNC machines tout the added capability of being able to run small microtools ... and they can. But, if you manufacture mostly small parts, this paper should prevent you from paying for both weight and bulk that you simply don't need.

Let there be light

Small tools > Small Spindles > Less Force > Lighter Construction > Agility & Flexibility

With a trend towards miniaturization in many types of manufacturing, mills and drills with a diameter of 0.250" or less are the norm rather than the exception. To achieve superior surface finishes and avoid tool breakage, small tools require low-force and therefore high-speed that can only be delivered by spindles specifically designed for them. Conventional CNC machines, with hulking, high-horsepower spindles, simply cannot run small tools without breaking them or sacrificing both the cycle-time and the surface finish of the end product. That's because RPM and feed rates must be slowed down to a snail's pace in order to reduce the force on these fragile, small tools — and this results in burring and slow production times. So, as mentioned above, large-tool CNC machines can run microtools, but at what cost?

The smaller spindle designs for microtooling inherently produce less force and therefore allow for a "light" chassis construction that ultimately provides manufacturers with added agility and nimbleness. In particular, consider weight alone. Conventional CNC machines frequently weigh in at a whopping 25,000 lbs. while microtooling CNC machines can be as light as 1,500 lbs. which provides manufacturers with increased flexibility to adjust manufacturing cells to fit their changing needs.

Microtooling CNC machines — apples-to-apples?

Even in a comparative evaluation where large-tool CNC machines have been ruled out and the focus is on several different microtooling CNC machines, there are number of different chassis construction or fabrication methods to compare.

Welded Steel Plates: The least costly process is, in fact, the least desirable. Steel plates that are joined together by welding are susceptible to the effects of vibration. The welding process requires superheating of both solder and sheet metal in order to join plates together to form the chassis of the CNC machine. Within each cooled and hardened welded joint there exists significant tension that naturally is looking to escape. Vibration produced by the machine's motor provides a means for that escape. When the tension is released due to this vibration, the chassis becomes deformed — perhaps not enough to be noticed by the human eye, but enough to sacrifice accuracy and repeatability.

888.262.2833
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DATRON Dynamics, Inc.
115 Emerson Road
Milford, NH 03055

DATRON Dynamics West
6255 Southfront Road
Livermore, CA 94551

Phone: 888.262.2833
www.datron.com

Cast Steel: A more expensive process, aged casts exhibit excellent long-term stability. Through the reduction or even elimination of joints in the chassis of a CNC machine, it is inherently less likely to have its structural integrity compromised by vibration. However, casting is difficult to do on a large scale and this forces CNC makers to consider two options. Either reduce the size of the chassis (including bed size and work envelope) or join two or more casts together. Smaller bed sizes are logical for machines designed for one-up production or small batches, but not for true batch-machining. Joined casts, like welded steel plate construction, once again, provides a window of opportunity for vibration and deformation.

Polymer Concrete: Everyone knows that if you flick your finger against steel you can hear a reverberation, but if you try the same thing with concrete what you hear is a muffled thud and perhaps your own screams of pain. That's because concrete absorbs vibration. So, by virtue of superior vibration dampening qualities, aged polymer concrete reigns supreme in the design and construction of a CNC machine chassis. Plus, this process can be used in concert with the other fabrication methods to yield vibration dampening and stability that they would not have on their own.

Wrapping it up

For manufacturers specializing in the production of small parts, a microtooling CNC machine featuring a concrete-polymer chassis, or one that combines concrete polymer with steel, provides both the vibration dampening qualities and long-term durability required to support continuous production and accuracy. At the same time, the CNC manufacturer can leverage the fact that the low-force, produced by high-speed spindles, allows for a lighter chassis construction. The resulting light-weight, concrete-polymer design provides the manufacturer with the flexibility to quickly adapt to changing needs by moving the machine to fit into various manufacturing cells. So, the manufacturer thereby exhibits an agility that gives them the competitive edge, improves time-to-market and significantly impacts their bottom line.

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