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3D Printing Takes a Step Forward

Stepper motors are increasingly rare in additive manufacturing's NextGen designs

When the doors of Detroit's Cobo Hall open this May for the Rapid + TCT trade show, visitors will witness some significant advances in additive manufacturing technology. On the other hand, some of the technology that will be absent from America's premier 3D printing trade show will be equally significant. The absence of open source controller boards, hobby-grade structural components and prosumer machine designs are signs of a larger trend. The industry is rapidly making the transition from its early history of hobbyists, tinkerers and backyard prototypes to a new world of machinery aimed at full scale, everyday industrial production.

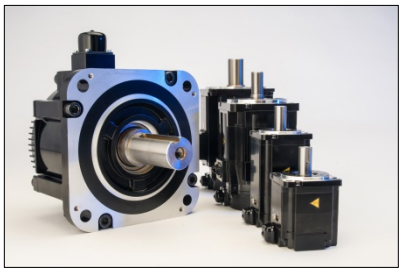
One notably scarce item at Rapid will be the stepper motor, which has been the industry standard for additive manufacturing motion control. Stepper motors are brushless DC electric motors that divide a full rotation of the motor into equal steps. The fact that steppers motors do not utilize any position feedback and have a typical acceleration of 0.25Gs makes them less than optimal for most industrial applications. Despite these drawbacks, they offered the developing 3D printing industry a key advantage: low cost, with acceleration and accuracy that was acceptable to most early users.

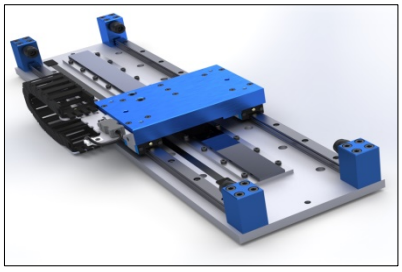
"We can't point to high speed and accuracy as innovations anymore," said Clay Guillory, President of Titan Robotics, an acknowledged industry leader in large format 3D printing. "Super precise, high productivity printers need to become the norm, because end users are putting as much trust in them as they are in the other pieces of industrial equipment on their plant floors." He noted a special need for increased performance in motion control, aimed at reducing overall print time and improving the dimensional precision and superior finish of 3D printed components.

Stepping up to servos

The industry's most advanced printers are now using servo systems for motion control. This offers two significant advantages in the way a print head's motion is managed within a 3D printer.

- **Superior precision** is achieved through a closed-loop feedback system centered around a high-resolution optical encoder, which offers exacting and continuous feedback on the accuracy of motion.
- **Enhanced speed** is gained from the ability of a servo to settle at a particular point much more quickly than a stepper motor can. Servo motors also offer higher rates of acceleration than stepper motors, moving print heads into proper position considerably more rapidly.





"Simply put, when a print head can get to precisely where it needs to be faster than before, the outcome is better productivity," said Matt Hardenbergh, a Regional Motion Engineer for servo system manufacturer Yaskawa America. "You don't need to slow the system down to get the finish quality you're looking for. That means more parts per hour without sacrificing quality," he explained.

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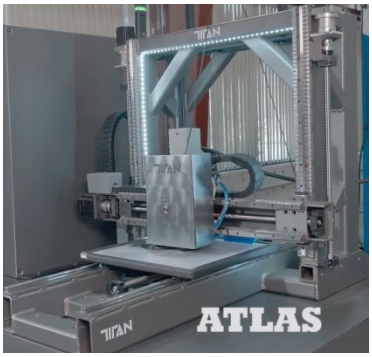
One of the standout exhibits at Rapid+TCT 2019 will be the Atlas 3D Printer from Titan Robotics, a Colorado-based printer manufacturer that has standardized on Yaskawa's latest Sigma-7 servo systems. The result is a printer which reaches print speeds of 350mm/sec, more than double the average of 150mm/s for 3D printers using stepper motors. The Atlas uses acceleration values up to 5Gs to achieve a travel speed of up to 1,500 mm/sec, compared with 450 mm/sec for stepper motor equipped machines. With standard 3D printer sizes of up to 42″ x 42″ x 48″, a single rapid move can be completed 70% faster using Sigma-7 servo motors based on the given speeds and accelerations. A key to a servo system's superior performance is the resolution of the servo encoder. Sigma-7 uses a 24-bit encoder, giving 16,777,216 bits of closed-loop feedback resolution.



News for control freaks

Machine designers in additive manufacturing are also turning to servos for advancements in control technology. The Yaskawa Sigma-7 servo amplifiers that power the Titan Atlas utilize two vibration suppression filters, two anti-resonance filters and up to 5 notch filters to provide extremely smooth motion. This technology yields superior smoothness of motion, eliminating the stepped lines which occur as a result of stepper motor torque ripple. The Sigma-7 servos also automatically perform their own custom tuning, which makes it possible to adapt to changes in the mechanics of a printer or variances in a printing process. Stepper motors do not utilize position feedback, making it impossible to compensate for changes in processes or discrepancies in mechanics.

A lack of encoder feedback means that an additive manufacturing machine using stepper motors must also be homed every time it is powered up. Servo systems with absolute encoder feedback only need to perform a homing routine once, which results in additional savings in printing time.

The extruder of a 3D printer can often be a bottleneck in the printing process. A stepper motor doesn't have the feedback sensing ability to detect an extruder jam, a deficit which can lead to the ruin of an entire print. Servos can detect extruder backups and prevent filament stripping. Absolute encoder feedback also helps a servo system maintain a constant material velocity output from the extruder.

Given the advantages of servo control in additive manufacturing, visitors to Rapid+TCT can expect to see plenty of servo systems at work on the show floor. In addition to the Titan Atlas, printer manufacturer 3D Platform will be exhibiting its multi-gantry additive/subtractive manufacturing system, combining multiple Yaskawa servo systems with a Yaskawa articulated robot to perform robotic machining operations on extra-large finished parts. Servo control is particularly important on the 3DP machine, whose exceptional size requires quick and precise gantry movement across a horizontal axis of 40 feet or more.

Every manufacturer in the additive manufacturing space is facing the need to respond to heightened customer expectations of what 3D printing can do. "We've been hearing for years about the ways 3D will revolutionize manufacturing," said Yaskawa's Hardenbergh. "It's come to the point where the revolution needs to begin, and better motion control technology is bound to be a big part of that formula."

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