TAO
Technical Applications Office
HIGHLIGHTS
Los Alamos NATIONAL LABORATORY

Future Advanced Machining Platform Testbed

Los Alamos National Laboratory (LANL) and the Associate Laboratory Directorate for Weapons Production's (ALDWP) Technical Applications Office (TAO) have partnered with Montana State University (MSU) and TechSource, Inc. in the Weapons Production Technology and Nuclear Training program (WP-TNT) to look at future advanced machining platform testbeds (FAMPT). The goal of FAMPT is to apply future advanced machine tool technologies to the pit production needs of LANL or the Savannah River Plutonium Production Facility (SRPPF). The project seeks to provide technology refresh options for pit manufacturing as current installed (LANL) and planned (SRPPF) platforms age out during equipment production life cycles.

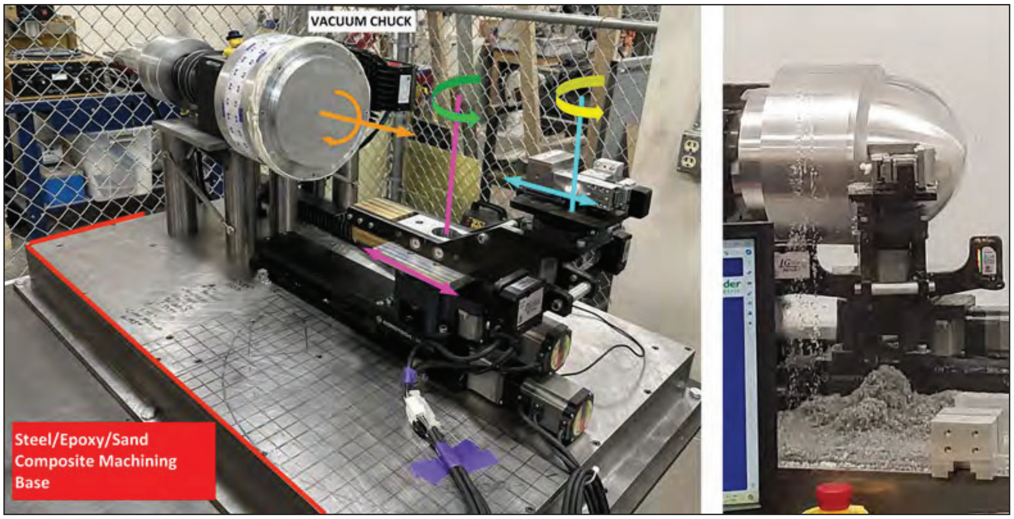

Figure 1. The testbed consists of a vacuum chuck capable of holding a hemisphere for internal or external machining (external machining shown on the right) and offers five degrees of motion.

MSU undergraduate Capstone students designed, built, and preliminarily tested a testbed on which elements of the advanced manufacturing platform can be incorporated and evaluated Figure 1).

The testbed consists of a vacuum chuck capable of holding a hemisphere for internal or external machining (external machining shown on the right) and offers five degrees of motion: 1) rotation of the chuck with variable speeds, 2) translation of the main frame (pink double headed arrow), 3) rotation of the main frame (green round arrow), 4) translation of the cutting tool (blue double headed arrow), and 5) rotation of the cutting tool. The system is mounted on a Steel/Epoxy/Sand composite base to isolate and damp the machining process from room vibrations.

As a testbed, the system is specifically designed with a modular architecture using commercial off-the-shelf tools, standard sized actuators (NEMA 23 and 34 motors, for instance), and controls. This facilitates straightforward "swaps" of advanced emerging technologies for evaluation. As an example, MSU is also developing a hybrid brushless DC motor controller to drive conventional stepper motors. This approach allows the current to the "stepper" motor to be measured; variations in motor current required by the machine may indicate an anomaly associated with the machining process, whereas expected currents may indicate a trouble-free process. Other monitoring/control applications include accelerometers to indicate abnormal vibrations, tool/toolholder force/strain measurements to indicate "out of bounds" cutting tool forces, and geometric measurements using non-contact coordinate measuring machine (CMM) technology.

One effort underway is the development of a new means to measure tool forces in situ. A common approach to measuring tool forces during cutting is to add a measurement fixture between the workpiece fixture and workpiece. This changes geometry due to offsets introduced by the measurement fixture and reduces the effective stiffness of the system. The method being developed at MSU relies upon directly measuring the forces acting on the workpiece via back-drivable ball screws driving the tool. The force transmitted from the cutting tool to the load will be transmitted directly to the axial load on the positioning screw. The force applied by the tool is proportional to the torque applied by the actuating motor, alleviating the need for a sensor between the cutting tool and fixture.

MSU is developing a synchronous motor driver to operate as a hybrid brushless DC motor (torque proportional to current) to drive a conventional stepper motor. A single axis test fixture has been constructed to use in the calibration of screw axial force with motor torque/current. The prototype system is pictured in Figure 2.

Conventional, high-volume components are made on a mill or lathe and then inspected on different machines sometimes located in other rooms or even facilities. Traditionally, as part tolerance requirements become more stringent, bigger/stiffer/costlier machining centers are needed. The hybrid composite based of the FAMPT uses the internal damping properties and steel “X” geometry to improve stiffness and vibration control as an alternative to simply larger/stiffer/costlier machining centers.

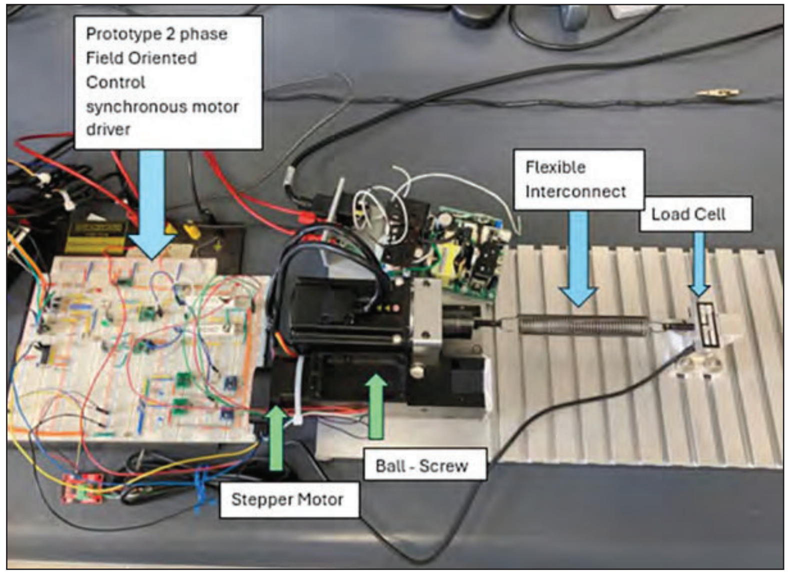

Figure 2. MSU is developing a synchronous motor driver to operate as a hybrid brushless DC motor (torque proportional to current) to drive a conventional stepper motor.

Figure 3. The process of continuously measuring outcomes of a machining operation with non-contact CMM technology to continuously adjust for the difference between the actual and desired geometric machining results.

By continuously measuring the outcomes of the machining operations with the non-contact CMM technology, MSU can continuously adjust for the difference between the actual and desired geometric machining results (Figure 3). This allows an increase in the tolerance capabilities of a less stiff machine beyond its baseline. A smaller machining center would result in smaller footprint needs and smaller/cheaper glove box enclosures. Also, having been inspected in situ, there is a significant potential for reducing rework. If a piece can be determined to be terminally out of specification, the machining process can be terminated, reducing production time and cost.

With the completion of the Capstone testbed project (Figure 4), the improvement of the machining processes and integration of inspection and monitoring systems (non-contact CMM, motor torque monitoring) will begin in the fall 2024 semester with a new graduate student.

Figure 4. MSU Capstone students responsible for the design and build of the Future Advanced Machining Platform Testbed (FAMPT).

MSU has classified research capabilities, cleared professional staff, and a strong engineering student population. In addition to work product, MSU continues to provide LANL with the opportunity to hire four cleared graduates with relevant work experience from our student research teams.

Funding for this project has been provided from NA-191 through a contract from LANL and the ALDWP TAO office.

ALDWP Management Lead
Dr. Robert Putnam, Program Director
505-665-8494 • rputnam@lanl.gov

TAO contact:
Dara McKinney, PM
505-665-3361 • dmckinney@lanl.gov

MSU contact:
Dr. David Miller, Professor
406-994-6285 • davidmiller@montana.edu

October 2024
LA-UR-24-31409