Georgia Tech Mechanical Properties Characterization Facility
Institute for Materials

MECHANICAL PROPERTIES CHARACTERIZATION FACILITY (MPCF)
STATUS AND SUMMARY OF ACCOMPLISHMENTS

http://mpcf.gatech.edu/

Fiscal Year 2019 Report
July 2018 – June 2019

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Institute for Materials
Georgia Institute of Technology

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Overview of the Mechanical Properties Characterization Facility

The Mechanical Properties Characterization Facility (MPCF) is an Institute for Materials facility that supports education and research programs related to processing-structure-properties relationships in structural materials. Its principal activities are directed towards the measurement and modeling of the mechanical properties of engineering materials, primarily related to deformation and reliability of materials. Other activities include component and non-standard mechanical testing, thermomechanical processing, and the aging and long-term reliability of materials.

The MPCF and its faculty users have an international reputation for excellence in several areas:

- Fatigue and fracture studies of structural materials, structures, and joints/attachments, particularly in extreme environments including high temperature applications.
- Development of constitutive equations for deformation and damage, incorporating these advances into life prediction methodologies.
- Multiscale modeling and simulation of materials and microstructure-sensitive fatigue and fracture approaches, making contact with experiments to discern mechanisms and validate models and methodologies, both deterministic and probabilistic (e.g., supporting the Center for Computational Materials Design, Integrated Computational Materials Engineering (ICME), and Materials Genome Initiative (MGI)).
- Characterization and quantitative analysis of microstructure and damage in engineering materials such as structural alloys, composites, metal foams, thin films, biomaterials and nanostructured materials and alloys.
- Durability and degradation of aging materials and structures.

We see the use of the MPCF growing with the push of the Materials Genome Initiative (MGI) and the growth of structural materials fabricated by additive manufacturing as well as the continued push for advanced materials with better performance. This facility gives GT a competitive edge.

The mission, vision, and research thrusts are fully described on our website, mpcf.gatech.edu. The MPCF has a direct impact on instructional and research programs across the Institute. Research projects that require the need for the MPCF involve over $4.6M expended in externally sponsored research each year, based on a survey a faculty who have used the facility in FY19.

MPCF currently has capabilities that are known internationally and are among the top three universities in the USA. The MPCF is central to our competitiveness for industry funding in major auto, aerospace, and energy sectors. Georgia Tech is a Pratt & Whitney Center of Excellence in materials and is one of two institutions in the USA that have been named a Siemens Center for Knowledge Interchange (CKI). The presence of the MPCF was a key element in bringing these Centers to Georgia Tech. Advanced materials manufactured in our new Advanced Manufacturing Pilot Facility (AMPF), with Boeing and Delta being anchor sponsors, are regularly evaluated in the MPCF. MPCF will play an important role in a proposed NSF IUCRC on adhesive bonded joints

called Digital Composite Joining and Repair (D-CJAR) led by Chuck Zhang. It is also notable that we are receiving more requests to team on proposals with other universities who do not have this sort of facility available to them.

The MPCF occupies a total of 4250 sq ft across three buildings [2500 sq ft in Bunger-Henry (rooms 153, 158, and 173), 1250 sq ft in Callaway (MaRC) Hibay lab, and 500 sq ft in MRDC 2340]. A listing of MPCF equipment can be found at mpcf.gatech.edu/facilities. Major equipment and tools include:

- Servohydraulic test systems (14 with capacities ranging from 5 to 100 kips (22 kN to 440 kN), which gives us the flexibility to match the user with the appropriately sized test system
- Electromechanical test systems (7 with capacities from 500 lb to 20 kip (2.2 kN to 100 kN))
- Fretting and reciprocating sliding tester
- Drop weight impact tester
- Charpy impact tester
- Thermal aging and creep facilities

Major accessories and expertise include:

- Gripping / adapters for tension, compression, bending, fracture, etc.
- Various extensometers for axial, diametral, axial-torsion, high temperature, crack opening, etc.
- Digital image correction (DIC) accessories for full field, non-contact strain measurements
- Environmental chambers, ovens, and furnaces
- Induction heaters
- Temperature measuring devices (thermocouples, pyrometers)
- Long-focal length optical microscopes for in-situ observations
- Specimen preparation, microstructure characterization prep, and image analysis
- Portable hardness tester

In addition, MPCF supports a wet lab with specific expertise on metallography and failure analysis to prepare samples for either mechanical property testing or for further analysis using tools in the Materials Characterization Facility (MCF) also administered through the Institute for Materials (IMat).

In its role as an interdisciplinary umbrella organization for experimental research in mechanical properties of materials, the MPCF coordinates equipment usage, and provides training, test planning support, and maintenance. The centralized facility provides a significant space and cost savings to academic units and faculty compared to the conventional university strategy of distinctly-controlled, single investigator equipment. The MPCF provides space savings by locating the test systems in a specially designed consolidated space with shared hydraulic power supplies and accessories. The space required for an isolated mechanical test system which includes the

load frame, hydraulic power supply, control system, and accessories is roughly 750 sq ft because of space needed for heat dissipation and noise abatement. Systems in the MPCF occupy space more efficiently because the hydraulic power supplies are consolidated in dedicated external rooms (usually the building utility room) which creates an efficient and low noise environment for the operators and experiments in the laboratory. Moreover, these systems have high power and thermal loads that are incompatible with typical laboratories on campus. The MPCF is the most efficient utilization of space and resources for this type of equipment and accessories.

The MPCF provides cost savings by supporting new and established faculty. The MPCF allows new faculty who need to characterize mechanical properties to efficiently utilize their startup funds. The MPCF provides guidance to faculty when they develop new facilities, and counsels them so that systems are not unnecessarily duplicated. It is quite common for new faculty to request a mechanical test system in their startup package. We work with new faculty to identify special equipment or accessories to enhance the capabilities of MPCF while utilizing the existing equipment to greatly reduce the startup package cost. The cost savings to a new faculty startup is extreme; a new servohydraulic test system with the necessary accessories costs approximately $300K. Finally, the MPCF staff helps new faculty to establish successful research groups by removing some of the burden of acquiring equipment training for their graduate students to use the equipment safely and effectively.

The staff supported by the MPCF, which includes Research Engineer, Dr. James Collins, assisted by part-time graduate students, provide training on the use of a variety of mechanical test systems, including servohydraulic systems that can cause serious injury if used incorrectly. MPCF staff support both instructional and sponsored research projects in setting up test programs, designing accessories and adapters, developing new protocols, integrating new sensors and transducers, developing control algorithms, etc. MPCF staff also perform routine maintenance and repairs to keep systems in a state of readiness. Using staff to perform routine maintenance in a user facility is the most effective, responsible way to utilize state and federal funds. If each test system was "owned" by a faculty member, they would either spend about $25K per year on a service contract per system to perform such maintenance, or the equipment would be underutilized or in some cases not utilized for long periods of time taking up precious space. This cost savings is only possible when dedicated, trained staff are available, that is able to perform this routine maintenance.

MPCF staff also ensure all users comply with EH&S requirements. We have implemented a test proposal submission and lab management system to facilitate a quick response to users and to make sure everyone (advisor, student, research engineer) is on the same page so that experimental programs conducted in MPCF are successful. The lab management system helps us maintain compliance with EH&S requirements by documenting all required Institute safety and equipment training for each user of the lab.

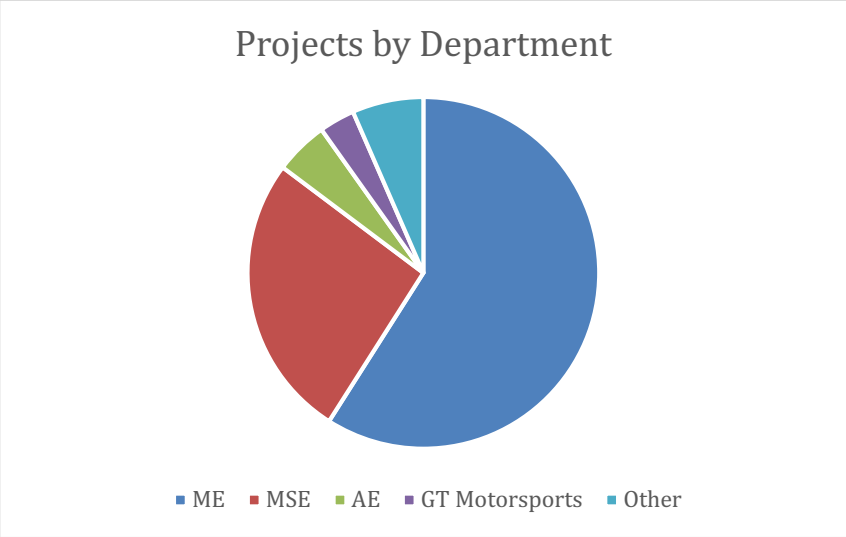
Support for the operation and maintenance of the facility comes from the Institute for Materials and revenue received from our recharge center using the Shared User Management System (SUMS).

A graduate multidisciplinary certificate in the Mechanical Properties of Materials is also offered and administered by the Director of the MPCF.

Summary of Activities in FY19

As an interdisciplinary and multi-user facility, the MPCF serves researchers at Georgia Tech and external industry and university partnerships. Internal projects included sponsored and non-sponsored research, senior capstone projects, extracurricular clubs and organizations (e.g., GT Motorsports), and undergraduate class support. External projects included short-term and long-term consulting and research with industry partners. The following is a summary of the various projects MPCF supported during fiscal year 2019:

- 61 sponsored, non-sponsored, class, and capstone design research projects
- Projects from the Mechanical Engineering, Materials Science and Engineering, Aerospace Engineering, Civil Engineering, Environmental Engineering, Emory, and GTRI



- Class support for training TA's, guidance for design of experiments, and testing support for undergraduate classes for MSE 3021 and MSE 4022

MPCF accomplishments from July 1, 2018 to June 30, 2019 are summarized in the Table below, with 18 of 31 current or past faculty users responding, 16 of whom stated that they had some level of sponsored funded research activity that benefitted from the MPCF during the past year.

# Faculty Reporting Funded Activity	# Funded Projects	Journal Articles	Conference Proceedings & Seminars	Students Graduated		Honors and Awards
				Ph.D.	M.S.	
16	31	59	69	5	5	8

Approximately $4.6M amount in externally sponsored research during the past year, as reported by faculty who used the facility, was enabled by the tools available in the MPCF. The distribution of per capita funding of the 16 faculty respondents this past year who were actively involved in sponsored MPCF research was as follows: at or above $300K (4), between $200-299K (3), $100-199K (3), less than $100K (6).

It is estimated that over 24 graduate students were involved during the past year in MPCF-related research. In addition, it is estimated that over 19 undergraduate students used the lab during the past year for either undergraduate research or a capstone design project. This is in addition to the instructional use of MPCF for both undergraduate and graduate courses in both ME and MSE. MPCF staff provide support for these instructional services covered through either direct salary support from the School or through the recharge center.

Highlights

Administrative highlights of 2018-2019 included the following:

- Worked with Facilities Design and Construction (FDC) and an external engineering and architectural firm on designing the new spaces for MPCF in Bunger-Henry. The engineering and architectural study occurred during this year with final report containing detailed cost summary expected at beginning of FY20. See paragraph below providing additional details on the status of the relocation.
- Continued to work with the Executive Director of the Institute for Materials (IMat), Dave McDowell, to make MPCF a strategic user facility in IMat and participated in both large center proposals and cooperative partnerships with industry where MPCF will have a significant role. Some specific major activities focused on new large program developments where MPCF will play a major role:
    - Organized two workshops, one in Houston on December 14, 2018 and the other at GT on March 28-29, 2019, sponsored by a NSF Engineering Research Center (ERC) planning grant on the topic of Advanced Materials Manufacturing and Discovery for Extreme Environments (CAM^2DE^2) in collaboration with Texas A&M University and Duke University.
    - Organized workshop with Oak Ridge National Lab held at the GT Global Learning Center on April 15, 2019 on the topic of Manufacturing and Materials for Harsh Environments.

    - Siemens Energy Center for Knowledge Interchange meeting on the topic of Materials and Manufacturing Research with several MPCF faculty presenting held on Siemens Energy Campus in Charlotte, April 24, 2019.
- A proposal for a new NSF IUCRC on adhesive bonded joints, for which access to the MPCF will be helpful to the faculty and member companies, has been submitted:
    - Title: Phase I IUCRC Center for Digital Composite Joining and Repair (D-CJAR)
    - Center Director: Chuck Zhang
    - Project Duration: 2/1/2020 – 1/31/2025
    - Funding Requested (from NSF): $750,000 (GT Site only)
    - Industry Funding (expected annual average): $240,000
- Our Research Engineer Dr. James Collins has successfully completed 2.5 years of service to the lab. He is now well entrenched in its operation and can agilely handle requests of faculty, students, post-docs, and external organizations. He is also engaging with potential external industrial sponsors to establish new research projects for MPCF.
- Brian McGlade, Assistant Director of Business Operations for IEN and IMat, was assigned to handle the financial aspects of administrating the center.
- Updated rate study with new rates going into effect at beginning of FY20. Current rates are posted at mpcf.gatech.edu/policies/costs.
- Developed and received approval from G&C to use a standard template for Specialized Services Agreements to facilitate setting up new external projects quickly and easily.
- Increased the readiness of the lab to rapidly handle requests through systematic equipment maintenance, repair, and upgrades. Some of these items included developing and installing a high temperature 4-point bend fixture for advanced ceramics testing, establishing a digital image correlation system that has been used for displacement and full strain map analysis for a variety of material systems and test configurations, and successfully utilized low force load cells for biomedical and small-scale testing to complement the array of high-force and fatigue testing typically conducted.
- Annual force transducer calibrations were performed by outside vendor to maintain compliance required by DOD and other sponsors.

Plans for 2019-2020

- Work with GT FDC on the planning and renovation of the MPCF space. See paragraph below providing additional details.
- Continue to work with the Director of IMat, Dave McDowell, to make MPCF a strategic user facility in IMat and participate in both large center proposals and cooperative partnerships with industry where MPCF will have a significant role.
- Publicize the resources available to the campus community.
- Engage recent new faculty hires in ME, MSE, and AE that may be potential users or interested in adding new capabilities to the facility critical for their research.
- Publicize the Mechanical Properties of Materials Certificate Program.

Status on the Relocation from Callaway (MaRC) Hibay to Bunger-Henry

With the planned conversion of the Callaway (MaRC) Hibay into a robotics showcase, the MPCF has a unique opportunity to consolidate our mechanical test systems in one building to improve the efficiency of the facility's operations. There are currently 10 "tools" in the Callaway Hibay lab facility that are affected. Of those, 8 of them are servohydraulic test systems, two axial-torsion and the remaining six uniaxial, with varying load capacities, ranging from 5 kip to 100 kip. In the last four years, all of these systems except for one have been "rented" for sponsored projects from either days, months, or in a couple of cases, years. One of the axial-torsion systems that has not been used in the past four years is currently being surplused due to both the cost to repair it and limited interest in using it. Of the two remaining tools, one is a unique servohydraulic high temperature fretting and reciprocating sliding machine. That machine is continually being used. The other remaining tool is a drop weight impact tester, which is used by about three projects per year for varying lengths of time. Again, it is a unique tool that is not duplicated elsewhere on campus.

A new space has been identified in Bunger-Henry (B-H), room 176A, which is on same floor as other MPCF equipment and is 740 sq ft in size. This space will be renovated along with our existing space in Bunger-Henry to accommodate a smaller subset of our servohydraulic test systems, high temperature fretting and reciprocating sliding machine, and the drop weight impact tester currently located in Callaway. The renovation will also bring these spaces in B-H used by the MPCF up to modern building codes.

The new consolidated lab footprint is smaller than before, 3740 sq ft, compared to the current combined 4250 sq ft of existing Bunger-Henry labs and the Callaway (GTMI) Hibay location. We can accommodate a smaller space because modern control systems require less space, and we are reducing the number of servohydraulic systems from 14 to 10, made possible because the new control systems will be more reliable resulting in less downtime and a reduced need for redundancy.

In June 2018, GT Facilities Design and Construction (FDC) hired an external architectural and engineering firm to conduct an engineering study to define the project requirements for the move from Hibay to Bunger-Henry. This project will require the installation of 3000 psi hydraulic lines and cooling lines, the new hydraulic power unit, cooling and air lines, and upgrades in the electrical, HVAC, and fire suppression systems. Asbestos abatement is required in two of the rooms. The project will also involve the decommissioning, moving, and recommissioning of the test systems being moved, which involves rigging of heavy equipment. Several test systems will require new control systems since the current control systems are obsolete and require replacements to be recommissioned by the vendor. The engineering study is expected to be completed by July 2019. It is projected that construction will commence in the first quarter of 2020 and the move will occur in Summer 2020, assuming the project gets a green light to move forward in Fall 2019.