Research on improvement and evaluation of reliability, static and fatigue strengths of metals, ceramics and micro-materials

Takashi MATSUMURA Laboratory

Takashi MATSUMURA

Summary of Research

Improving and Evaluating the Strength and Reliability of Metal and Ceramics

In our laboratory, we carry out researches of static and fatigue strengths of metal materials, ceramics and advanced composite materials using in the railway, automotive, nuclear power industries, biomaterials, aircraft and aerospace vehicles. We also develop reliability estimation methods of strength and fatigue for these materials. In recent years, we have engaged in commissioned projects on standardizing the static and fatigue strengths of various fine ceramics. We are currently involved in research associated with the Japan Industrial Standards and International Organization for Standardizations to develop methods to evaluate sphere indentation strength for porous ceramics used as exhaust gas filters in diesel engines, compressive strength and sphere indentation strength of biomedical ceramics, and thermal fatigue damage to ceramic substrates.

Very High Cycle Fatigue (Giga Cycle Fatigue)

The crack origin of the fatigue fracture of conventional steel material was on a material surface. But, in recent years, it was found that the crack origin of the fatigue fracture of high-strength steel and surface hardening materials was inside the material. Especially, in the giga cycle fatigue area, it is large problem that the latter fatigue life shortens further than the former. The high-strength steels are used as a material of nuclear power and thermal power generation plants for which the safety is required. The fatigue fractures in the giga cycle fatigue area of high-strength steels are very dangerous. Our laboratory carries out the joint research with multiple universities and enterprises for the elucidation and reliability estimation of the fatigue properties of giga cycle fatigue.

Test Methods for Micro-material Strength

We are also developing a standard test method for static and fatigue strengths of micro-materials such as ultra-thin sheets and ultra-fine wires and accumulating these data. For example, the materials used in the micro-machine are very small. Therefore, the research of our micro-material uses metal plates of thicknesses on the order of several tens of micrometers (ultra-thin plates) or metal wires finer than a strand of hair (ultra-fine wires). These micro-materials are extremely delicate and difficult to handle, and the load imposed on them in tests are extremely small. Therefore, the strength and fatigue tests of ultra-thin plates and ultra-fine wires are very difficult. We carry out the strength and fatigue tests for ultra-thin plates and ultra-fine wires using microforce testing machine and reliability estimations of these.

Advantages

Confidence in Our Expertise in Experimental Methods Accumulated Over the Years

Dedicated to achieving an ever deeper understanding of the strength of materials, our laboratory takes pride in its expertise in experimental methods gathered through these efforts. We offer a special expertise in experiments associated with fatigue, which we make available upon request to commercial enterprises. The results of our study on ceramics have found applications in the standardization of test methods for material strength characteristics, demonstrating the superior strength characteristics of Japanese ceramics and associated products and contributing significantly to securing the global competitiveness of these domestic industries.

Pride in Our Powerful Lineup of Material Test Machines

Material strength tests require high-performance material testing machines. We up-

Keywords

Material strength, fatigue strength, static strength, impact strength, very high-cycle fatigue (giga cycle fatigue), reliability evaluation, micro-material, ceramics, fine ceramics, stainless steel, aluminum alloy, copper

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date our lineup of instruments to ensure our laboratory offers a powerful high-precision testing environment. Just over the past few years, we have replaced our servohydraulic fatigue testing machine, a universal testing machine, and a nanoindenter. Few laboratories specialize in the area of micro-material reliability estimations, a domain unique to our laboratory in many key ways. As for the aforementioned dedicated material testing machines for ultra-small loads, fewer than 10 academic and corporate research laboratories own and operate such equipment in Japan. In the field of material strength research, our access to these rare, high-performance, state-of-the-art material testing machines and evaluation machines constitutes one of our greatest advantages. Our laboratory also operates a micro-area X-ray residual stress measurement system, another world-class instrument that gives us the capacity to perform high-precision measurements.

Future Prospects

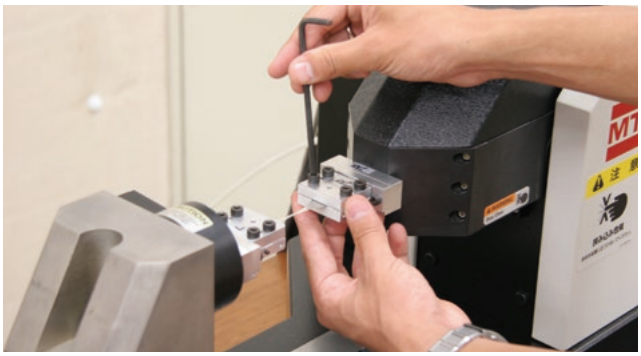
Leveraging Our Know-How to Provide Fatigue Testing Services to Commercial Enterprises

Our purpose is to apply the results of research gathered over the years on fatigue and fracture testing to contribute to industry. Without adequate facilities and experience, obtaining reliable data from fatigue testing can be extremely difficult. We believe enterprises will benefit significantly by commissioning fatigue testing to our laboratory. (Please note that such testing can take up to a year to complete adequately.)

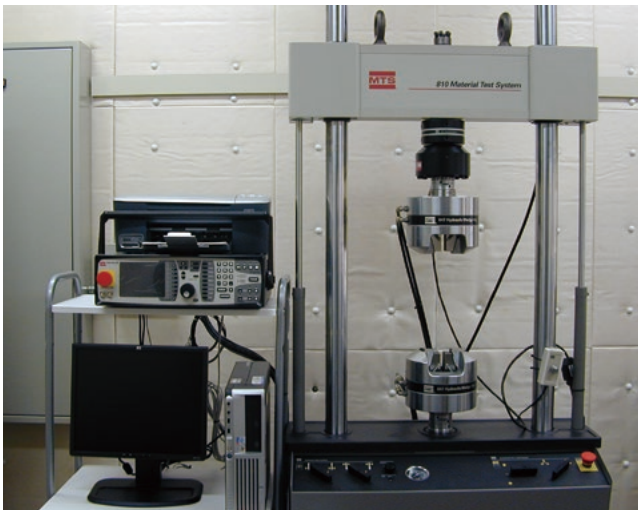
In the near future, strength data (in particular fatigue strength data) will prove a vital component of the basic data required to assess the aging-related deterioration of electronic components and micro-machines. Keeping in mind the key importance of this data for safety management practices, we will continue to gather fatigue strength data on micro-materials.

We also plan to pursue research on the material strength of fine ceramics, a class of materials drawing renewed interest both domestically and internationally for a growing range of applications involving filters, bioceramic bones, and electronic circuit substrates. Our laboratory meets requests for residual stress measurements of ceramics using X-rays. For ceramics, these measurements require several days after the appropriate measurement conditions have been defined. The timeframe is somewhat less for metal materials.

We always welcome the opportunity to pursue long-term joint research efforts on real structural components in partnership with commercial enterprises. Computer simulation studies face limitations in assessing the strength of materials. Testing real materials that can be observed and handled remains of fundamental importance. We believe joint studies undertaken alongside businesses that understand such needs will generate important results for both sides.

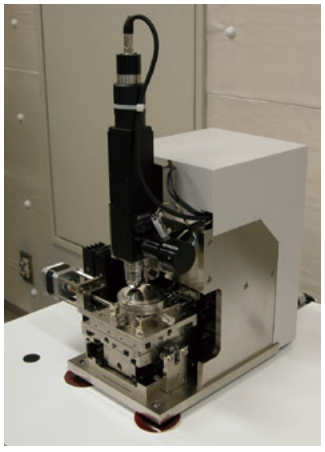


A microforce testing machine

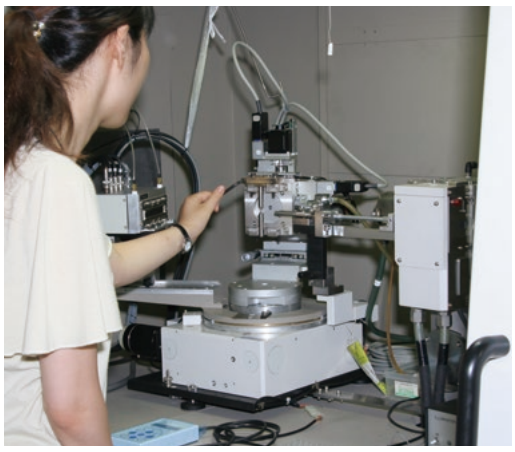


A servohydraulic fatigue testing machine

A universal testing machine



A nanoindenter



A micro-area X-ray residual stress measurement system