Resonance Fatigue Testing Machine RF

~Enables Quick Fatigue Testing for Paper-Thin Plates with Thicknesses of 0.05 to 0.8 mm~

Paper-thin plates are indispensable materials for precision components used in springs, belts, valves, diaphragms, connectors, and switches. In recent years, thin metal plates have also been incorporated into precision components within battery stacks and electronic devices, with demand expected to increase in the future. The fatigue life of these paper-thin plate materials is a critical property that affects the reliability of products. However, as the thickness of the samples decreases, the difficulty of fatigue testing increases, leaving many aspects of the fatigue strength characteristics of paper-thin plate materials unexplored.
Kobe Material Testing Laboratory Co., Ltd. (KMTL) has launched a commissioned testing service using a resonance-based bending fatigue testing method that rationally addresses the unique challenges of paper-thin plates.

Principle and Features of Resonance Fatigue Testing

Resonance fatigue testing utilizes the resonance frequency, one of the natural frequencies of a sample, to conduct fatigue life testing. When the sample reaches a resonant state, repeated stress can be applied to the sample with minimal energy. Unlike conventional mechanical fatigue tests, this method allows stress to be applied while fixing only one side of the sample, enabling high-precision and rapid stress application to extremely-thin plate materials. The dynamic stress under resonance conditions needs to be calculated using FEM analysis, as described later.
The name "RF" for this device is derived from the initials of resonance and fatigue.

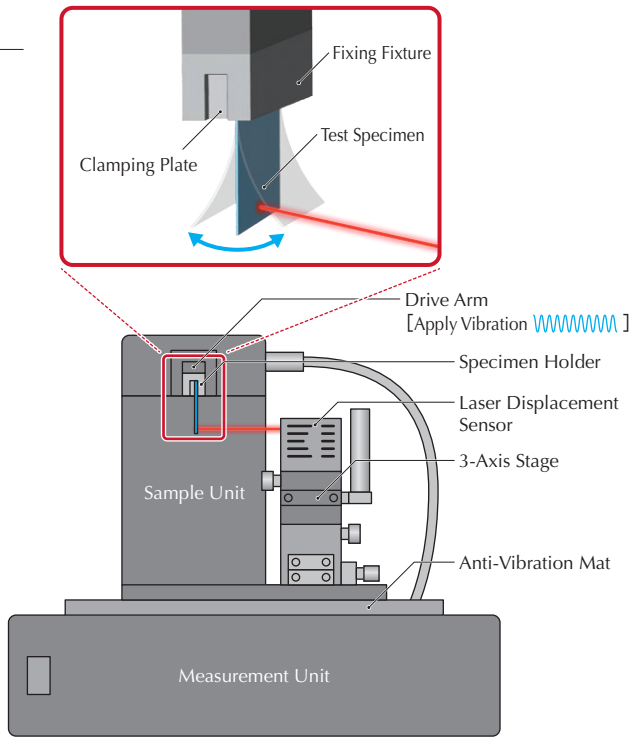
Specifications of RF Device

Output: S-N Curve

(Relationship Between Stress Amplitude and Number of Cycles to Failure/Nonfailure)

Test Sample	Metallic and Ceramic Materials
Displacement Amplitude Measurement	Laser Displacement Sensor
Amplitude Range	±5mm
Test Temperature	Room Temperature to 200°C
Thickness of Test Specimen Thickness	0.05 ~ 0.8 mm
Width of Test Specimen	3 ~ 5 mm
Length of Test Specimen	15 ~ 35 mm
Vibration Frequency Range	100 ~ 1000 Hz
Fracture Detection	Reduction in Resonance Frequency*

* When fatigue cracks initiate and propagate in the sample, the sample's stiffness decreases, resulting in a reduction in the resonance frequency.



Core Competence

We organized a new department specializing in resonance testing, Resonance Method Department, and developed this highly-reliable RF testing equipment.

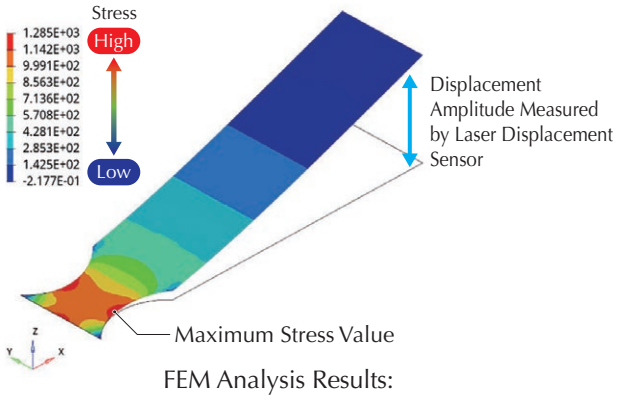
This machine is a highly specialized fatigue testing machine designed for paper-thin plate materials, offering a unique capability in the field.
It operates at a higher frequency than conventional fatigue testing machines, enabling rapid data acquisition.

- For example, with a resonance frequency of 500 Hz, a fatigue test of 10 million cycles can be completed in just 5.5 hours.
- Ultra-high-cycle fatigue testing of $N \geq 10^7$ is achievable.

Paper-thin plates, known for their excellent heat dissipation, present a low risk of overheating during high-speed cyclic deformation.

Calculation of Stress Values Using FEM (Finite Element Method) Analysis

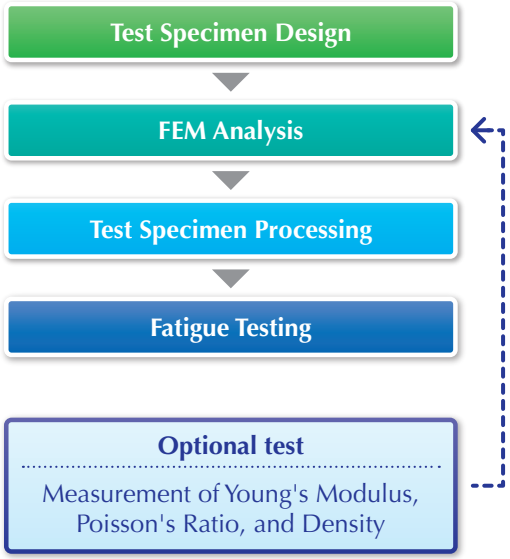
In FEM analysis, the target object or structure is divided into small elements, and the behavior of each element is mathematically modeled. Each element has a geometric shape, such as a triangle and/or quadrilateral, and its internal behavior is expressed through mathematical equations or relationships.
In RF testing, the resonance frequency and the relationship between stress and displacement are determined through eigenvalue analysis using FEM. The stress amplitude in RF testing is defined based on FEM analysis.
To perform FEM analysis, material property values such as **Young's modulus, Poisson's ratio, and density are required.**
At our company, we utilize ABAQUS as the solver for FEM analysis.



FEM Analysis Results:
Dynamic Bending Stress Distribution Diagram

Model Case of Fatigue Testing Flow

- The shape and dimensions of the fatigue test specimens used in RF testing are defined by our company. In principle, there are no specific standard specimen shapes and dimensions.
- Even if material property values required for FEM analysis, such as Young's modulus, Poisson's ratio, and density, are unavailable, we can conduct various tests in-house to obtain the necessary data and incorporate it into the FEM analysis.
- Specimen processing involves techniques such as wire cutting and punching (commonly known as stamping). After processing, precise dimensional and weight measurements are performed.
- As standard deliverables, **we provide fatigue test data, FEM analysis results, and test specimen dimensional inspection reports.**
- To estimate the target stress levels, we may request information on static properties such as strength and hardness.
- Fractographic analysis of the fractured specimens can also be performed upon request.



Pioneering the Evaluation of Fatigue Strength Characteristics in Paper-Thin Plates

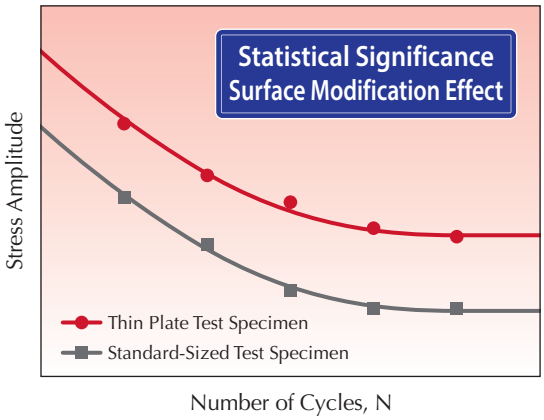
Statistical Significance

Fatigue strength is often determined by the analogy of weakest link of the material.
For example, in high-strength steels, material defects such as inclusions often serve as initiation sites for fatigue failure. The statistical distribution of inclusion sizes has a significant impact on their fatigue strength characteristics. When the thickness of a plate is reduced, the probability of encountering large defects decreases dramatically. Consequently, fatigue strength values obtained through RF testing may tend to be higher than those derived from conventional fatigue testing methods.

Surface Modification Effect

The fatigue strength of paper-thin plates is highly influenced by the properties near the surface. As a result, surface modification techniques affecting only tens of microns from the surface may significantly contribute to improving fatigue strength.

Future Prospects for
Thin Plate Fatigue Characteristic Evaluation



RF testing offers the potential to reveal the hidden fatigue strength characteristics of paper-thin plates. Although this is a specialized testing technique that has yet to gain widespread adoption, we are fully committed to leveraging our comprehensive expertise to meet your needs.

We proudly recommend the purchase of this reliable equipment. Please feel free to contact us.

KMT Kobe Material Testing Laboratory Co., Ltd.

HP https://en.kmtl.co.jp/
TEL +81-79-435-5010

Contact