1. Introduction

The HFT series high-frequency fatigue testing machine operates based on the principle of mechanical resonance. Initially, a servo motor applies a static load to the specimen until the required preload is achieved. An electromagnetic excitation system, composed of an electromagnet and an armature, then generates an oscillating force corresponding to the specified dynamic load. Through frequency sweeping, the excitation frequency is matched with the natural frequency of the host system, resulting in resonance. Under this resonant condition, a constant-amplitude sinusoidal inertial force—i.e., the dynamic load—is produced. The controlled static and dynamic loads act repeatedly on the specimen until the preset test conditions are met, thereby completing the fatigue test.

In the axial loading system, which includes the specimen, fixtures, force transducer, and dynamic exciter, the mass between the force transducer and the specimen generates an inertial force due to acceleration during motion. To accurately measure the actual force applied to the specimen, this inertial force must be compensated. The inertial force Fi=m/g×a, *Fi* is the inertial force, *m* is the mass between the force transducer and the specimen, and *g* is the gravitational acceleration.

2. Functions

It is primarily used to test various technical parameters related to the fatigue fracture resistance of

metallic materials, composites, and other materials. When equipped with corresponding fixtures and accessories, the system can perform tests such as S-N curve analysis, KIc, JIC, and CTOD measurements. It is particularly suitable for evaluating the fatigue characteristics and fatigue life of various components (e.g., plates, gears, crankshafts, threads, bolts, screws, studs, chains, connecting rods, compact tension specimens, valves, etc.) and structural parts (e.g., operating joints, connectors, helical kinematic pairs, etc.) under alternating loads. The machine also supports pre-cracking, crack propagation tests, and can conduct a wide range of fatigue tests including:

- Symmetric and asymmetric fatigue tests
- Tension-tension or compression-compression fatigue tests
- Programmed (block spectrum) fatigue tests
- Waveform-composite (modulated) fatigue tests
- Three-point, four-point, and eight-point bending fatigue tests
- Torsional fatigue tests
- Quasi-static fracture toughness and plane strain fracture toughness tests

Furthermore, it enables fracture mechanics studies on CT and SEB specimens. When configured with specific environmental chambers, it can also perform fatigue tests under complex conditions such as high/low temperatures, corrosive environments, and high/low pressure.

This system is widely applied in quality control (QC), quality assurance (QA), and research & development (R&D) fields.

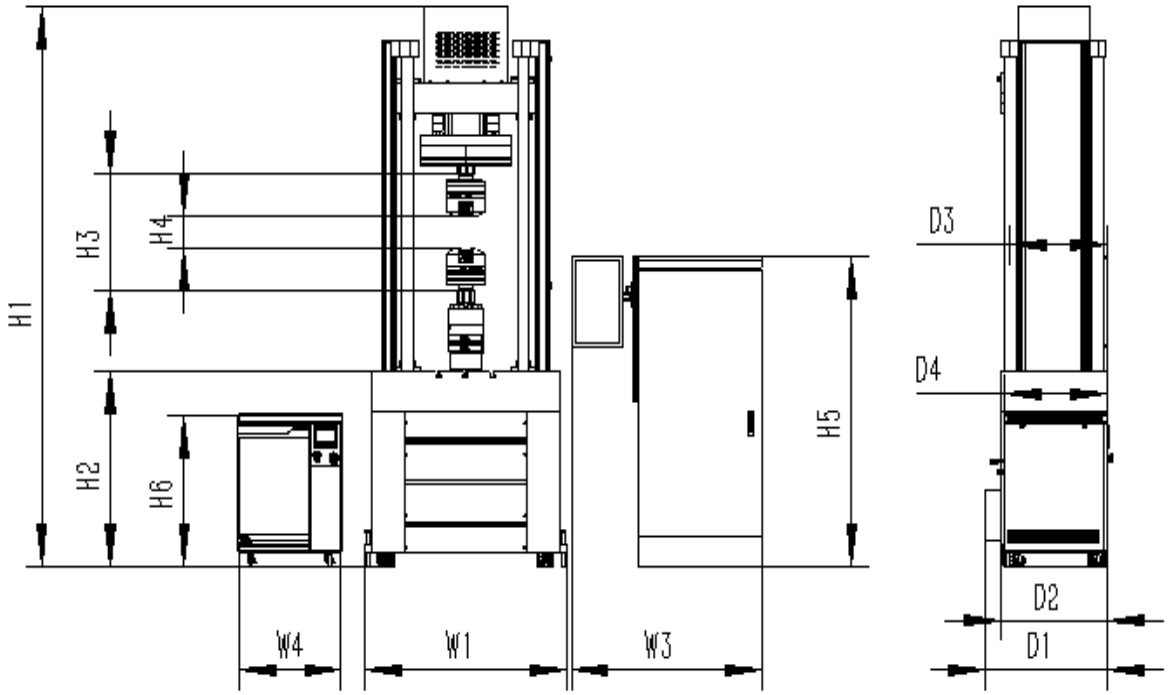
3. Complied standards

- GB/T 2611, GB/T 25917.1, GB/T 16825.1, GB/T 25917.1, GB/T 16825.1
- JB T 5488, JJG 556
- ASTM E647, ASTM E467, ASTM E1012
- ISO 4965, ISO 204
- GB/T 3075, GB/T 26076, GB/T 21143, GB/T 4161, GB/T 6398, GB/T 1499.2
- GB/T 5224, GB/T 13682, GB/T 20736, GB/T 3098
- GB/T 14212, *GB/T 1243*, GB/T 21839, GB/T 28900
- ISO 6934-4, ISO 606, ISO 10190, ISO 15654, ISO 15630-3, ISO 15630-1
- ASTM E399

4. Technical data

Model	HFT504	HFT105	HFT255	HFT505	HFT106
Maximum force, kN	50	100	250	500	1000
Mean load max., kN	±50	±100	±250	±500	±1000
Force amplitude max., kN	±25	±50	±125	±250	±500
Displacement max., mm	4 (±2)			2 (±1)	2 (±1)
Test frequency range, Hz	50~320		50~285	50~285	50~285
No. of frequency steps via attach/detach dead weights	6	8	8	8	8
No. of guide columns	4	4	4	4	4
No. of lead-screw drives	2	2	4	4	4
Drive voltage adjustment	Automatic				
Sampling and control frequency, kHz	10				
PC communication	LAN cable				

Specimen clamping	Hydraulic grip, manual thread type				
Frame stiffness at 1000mm crosshead separation, kN/mm	180	400	380	980	980
Drive stations	1	3	3	4	6
Full loading at full frequency	Yes				
Coaxiality	≥5%				
Zero drift	±1%				
Relative resolution	0.5%				
Static tests and for mean force control	AC servo motor				
Zero point relative error of force measurement System	±0.5%				
Static force reading accuracy	±0.5%				
Static force relative repeatability	1%				
Static force relative reversibility error	±1.0%				
Cyclic force reading accuracy	±2.0%				
Cyclic force reading repeatability	±2.0%				
Peak cyclic force reading accuracy	±2.0%				
Peak cyclic force reading repeatability	±2.0%				
Cyclic force reading fluctuation in 10 min	±2.0%				
Peak cyclic force reading fluctuation in 10 min	±2.0%				
Timer range	≥$9x10^9$				
Loading speed (mm/min)	0~550	0~450	0~550	0~250	0~250
Maximum crosshead speed (mm/min)	800	600	880	700	700
Position repeatability (μm)	±8				
Static force control range (MPa/s)	0~30				
Motor with brake function	Yes				
Static force loading by	Servo motor				
Dynamic force loading by	Electromagnetic				
Noise (dB)	≤90	≤100	≤110	≤115	≤115
Weight (kg), without grip	1800	4200	4500	13000	20000
Frame dimension (mm), (LxWxH)	660x 915x 2500	685x 1130x 2820	820x 1150x 3130	1500x 1350x 3600	1550x 1700x 4600
Control cabinet dimension (mm) , (LxWxH)	450x 800x 1200	550x 1080x 1500	550x 1080x 1500	550x 1080x 1500	550x 1080x 1500



Model	HFT504	HFT105	HFT255	HFT505	HFT106
Machine, W1xD1xH1, mm	915x660x2500	1130x685x2820	1155x120x3600	1350x1500x3600	1700x1550x4600
Bench height, H2, mm	948	948	988	1100	1200
Distance between hydraulic grips, H4, mm	725	250	325	500	600
Distance between adapters, H3, mm	800	660	820	1000	1200
Control cabinet, W3xD3xH5, mm	800x450x1200	1080x550x1500	1080x550x1500	1080x550x1500	1080x550x1500
Hydraulic power unit for grip, W4xD4xH6, mm	670x650x750	670x650x750	670x650x750	670x650x750	670x650x750

5. Site preparation

Capacity	50kN/100kN	250kN	500kN	1000kN
Power supply	3-phase 380VAC, 50Hz/60Hz, 1-phase 220VAC，50Hz/60Hz			
Power consumption	2kW	5kW	8kW	15kW
#46 hydraulic oil	25 liters	25 liters	25 liters	25 liters

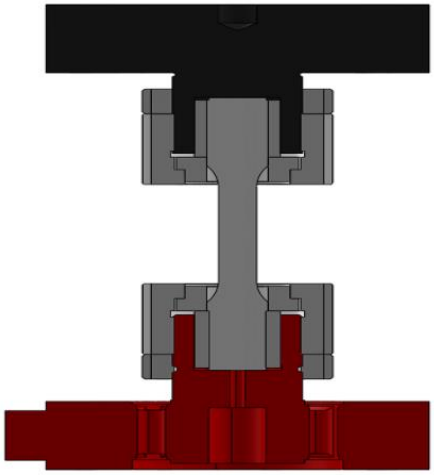
6. Standard accessories

No.	Name	Description	QTY	Unit
1	Machine		1	Set
1.1	Hydraulic wedge tensile grip		1	Pair
1.2	Hydraulic power unit		1	Set
1.3	Alignment fixture		1	Set
1.4	T-slot table		1	set
2	Electric control system		1	Set
2.1	Control cabinet with controller		1	Set
3	Test software		1	Set
4	Computer		1	Set
5	Documents		1	Set

7. Optional accessories

7.1 Hydraulic grip

Capacity	Vee jaws	Flat jaws	Outside diameter	Height (one grip)	Weight (One grip)
50kN 100kN	Φ5~Φ10mm Φ10~Φ15mm Φ15~Φ20mm	0~8mm 8~15mm Jaw size:50×65mm (width x height)	Φ210mm	175mm	39kg
250kN	Φ10~Φ20mm Φ20~Φ30mm	0~10mm Jaw size:50×90mm (width x height)	Φ270mm	232mm	85kg
500KN	Φ10~Φ20mm Φ20~Φ30mm Φ30~Φ40mm	0~12mm 12~24mm Jaw size:80×90mm (width x height)	Φ340mm	290mm	160kg
1000kN	Φ20~Φ30mm Φ30~Φ40mm Φ40~Φ50mm	0~15mm 15~30mm Jaw size:180×160mm (width x height)	Φ444mm	434mm	474kg



7.2 Manual grip

Grip capacity	Thread	Remark
50kN,100kN	M32x1.5	For other thread, please provide dimensions
250kN	M42x2	
500KN	M72x2	
1000kN	M80x2	

7.3 SEB bending fixture

Grip capacity	Span	Remark
50kN,100kN	Span: 40~300mm Roller length:46mm Roller diameter: D=10, 15 or 20	• Roller diameter can be customized • COD gauge is not included
250KN	Span: 80~600mm Roller length: 75mm Roller diameter: D=20, 30 or 40	
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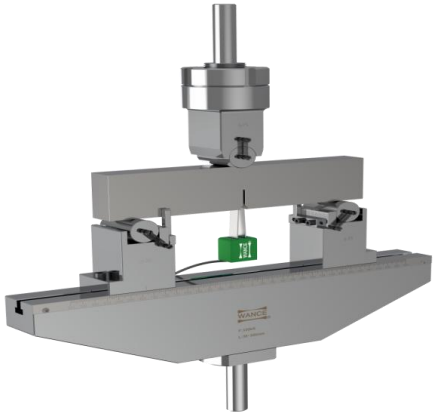
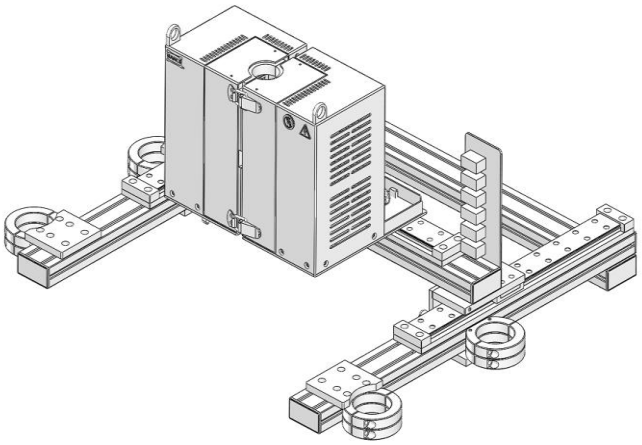


7.4 CT tensile fixture

Type	Span	Remark
Type 1	B=6.35；W=25；d=6	COD gauge is not included
Type 2	B=12.7；W=50.8；d=12.2	COD gauge is not included
Type 3	B=25.4；W=50.8；d=12.2	COD gauge is not included

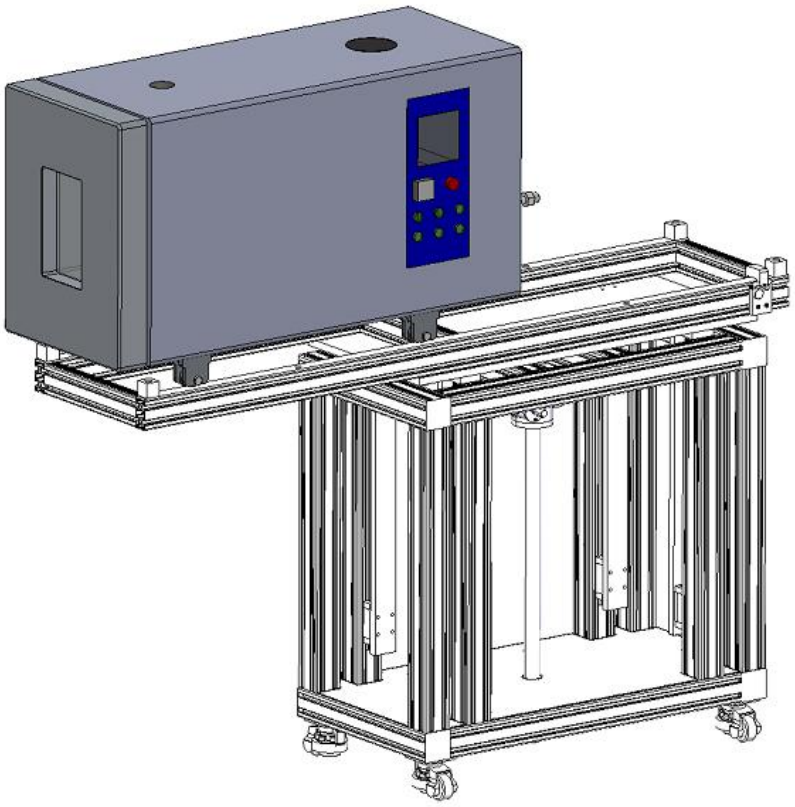
7.5 Furnace

Name	Description
Working temperature	200℃~1000℃
Inside dimension (LxWxH)	62.5x62.5x185mm
Outside dimension (LxWxH)	300x145x223mm
Front open	25x8mm
Furnace structure	Three sections of silicon carbide heating elements.
Heating power	1-phase, 220V, 2.4kW
Uniform zone	60mm



7.6 Environmental chamber

Name	Description
Working temperature	-180℃~350℃
Temperature fluctuation	≤±0.5℃
Inside dimension (LxWxH)	230x230x340mm
Outside dimension (LxWxH)	900x380x500mm
Inside material	304 stainless steel
Observation window	Electrothermal frost-resistant
Control	Touch screen control
Power	3-phase, 380V, 1.6kW



8. Features

8.1 Frame

- **Static and Dynamic Loading Integration:** Static loads are applied via a servo motor-driven ball screw, while dynamic loads are generated through electromagnetic resonance. This design eliminates mutual interference between static and dynamic forces, enabling dual functionality for both dynamic and static testing.
- **High Test Frequency and Short Duration:** Offers high-frequency testing capabilities, significantly reducing test time.
- **Low Energy Consumption:** Electromagnetic resonance technology consumes minimal energy (approximately 3% of that of electro-hydraulic servo fatigue testing machines).
- **Precise Mean Force Control:** The servo motor ensures rapid and accurate control of the average test force.

- **Pulse Width Modulation (PWM):** Enhances control stability through advanced modulation techniques.
- **Versatile Compatibility:** Supports a wide range of specimens and tests with interchangeable accessories.
- **Comprehensive Safety Protections:** Includes overload protection, mechanical limit protection, exciter overcurrent protection, fracture protection, frequency variation protection, and crossbeam travel limit protection.
- **High-Rigidity Frame:** Constructed with a four-column and four-ball-screw structure for exceptional stiffness.
- **High Coaxiality Alignment:** Equipped with a coaxiality adjustment device to ensure superior alignment accuracy.
- **Adjustable Magnetic Gap:** Features a widely adjustable magnetic gap to accommodate diverse specimen sizes.
- **Flexible Coil Configuration:** Coils can be reconfigured via a switch for different operational modes.
- **Dual Clamping Modes:** Combines hydraulic clamping and manual threaded clamping for rapid, reliable, and durable specimen fixation.
- **Frequency Adjustment:** Test frequency can be modified through multi-level adjustments of counterweight mass.
- **Expandable Worktable:** A T-slotted (T-type) workbench facilitates easy attachment of additional accessories and fixtures.

8.2 Controller

- **Fully Digital Closed-Loop Control:** Utilizes a DSP-based digital control system with multi-channel data acquisition and high-speed data transmission capabilities.
- **Resonant Frequency Analysis:** Accurately identifies and tracks system resonance via FFT analysis, ensuring smooth and reliable startup of the testing machine.
- **High-Frequency Sampling & Control:** Operates at a 10 kHz sampling and control frequency for precise peak-valley data accuracy and reliability.
- **Digital PID Control:** Employs advanced digital PID algorithms and hardware-based PWM modulation to precisely regulate excitation power output, maintaining dynamic load stability.
- **Phase Detection & Frequency Locking:** Leverages DSP's high-speed capture functionality to lock the phase of feedback signals, ensuring synchronous resonance phase alignment.
- **Comprehensive Data Acquisition:** Collects multiple test parameters in real-time, including frequency, mean values, cyclic data, power supply voltage, operating current, and working voltage.
- **Adaptive Pulse Width Modulation:** Automatically adjusts voltage output based on pulse width to maintain precision control within optimal ranges.
- **Fine-Tunable Control Parameters:** Allows detailed adjustment of proportional, integral, and derivative (PID) gains; flexible configuration of startup frequency, pulse width, and timing; and precise limits for operating voltage and current.
- **Dual-Level Control Architecture:** Implements a master-slave framework where the DSP-based lower-level controller handles real-time phase locking and PWM output during resonance, while the PC performs monitoring and supervision.

- **Autonomous Operation:** The DSP controller operates independently even if the PC fails, ensuring 试验 continuity and data integrity without loss.
- **Secure Connectivity:** Features lockable connectors for robust, durable, and reliable interfacing; all ports are logically arranged for easy access and operation.
- **Dual Emergency Stop Buttons:** Provides redundant safety mechanisms to protect both operators and equipment.

8.3 Software

- **C# Programming:** Developed using the C# language for efficient and rapid operation.
- **Flexible Load Configuration:** Static and dynamic loads can be set independently or simultaneously during tests.
- **Real-Time Data Display:** Dynamically shows static force, cyclic force, displacement, voltage, frequency, cycle count, pulse width, strain, and other critical parameters.
- **Fault Code Monitoring:** Detects and displays error codes for immediate troubleshooting and process control.
- **Comprehensive Data Management:** Supports real-time monitoring, live waveform display, data graphing, saving, and export, as well as test report storage and printing.
- **Intelligent Online Diagnostics:** Continuously monitors the test process with instant alerts to ensure safe and accurate operation.
- **Test Protocol Editing:** Allows users to create and modify test procedures for adapting to new requirements.
- **Standard Test Library:** Includes pre-configured test methods based on industry standards for faster and simpler setup.
- **Online Status Monitoring:** Tracks frequency, force, limits, displacement, and other parameters; triggers emergency shutdown in abnormal conditions to protect equipment.
- **Multi-Type Curve Support:** Enables seamless switching between different graph types during tests.
- **Interactive Curve Operations:** Supports zooming, panning, and traversing of test curves; automatically adjusts coordinate systems to keep data optimally displayed.
- **Data Export Options:** Allows saving and printing of curves for analysis and reporting.