Multi-functional micro-magnetic non-destructive testing instruments

Suitable for detecting ferromagnetic parts and components
Rapidly evaluate the homogeneity of microstructure
Quantitative testing of mechanical property and residual stress

NCS Testing Technology CO., Ltd.

NCS Testing Technology CO., Ltd.

Instrument Principle

Micro magnetic non-destructive testing technology utilizes the multidimensional magnetic properties of ferromagnetic materials and the inherent correlation between micro-structure, residual stress, and macroscopic mechanical properties, to achieve the evaluation of micro-structure uniformity and quantitative non-destructive testing of mechanical properties and residual stress.

Micro magnetic non-destructive testing technology has broken through the limitations of traditional "sampling failure" testing methods, and can directly conduct quantitative testing on various performance indicators such as surface hardness, hardening layer depth, yield/tensile strength, plastic deformation, residual stress, impact energy, etc. for steel plates, steel pipes, gears, bearings, crankshafts, vehicle body structural components, etc.

Figure1   figure 1 Principles of Micromagnetic Detection

Micro-magnetic detection technology

Under the action of an alternating magnetic field, the internal magnetic domains of ferromagnetic materials undergo complex dynamic behavior. The motion of magnetic domains (walls) is discontinuous due to the pinning effect of micro defects such as dislocations, inclusions, and grain boundaries in materials, which perturbs the local magnetic field to form a magnetic pulse sequence and forms micro-scale pulse eddy currents around the micro defects in the material. The micro-scale magnetic pulse sequence is received by a magnetic sensitive element placed on the material surface and outputted in the form of voltage, known as magnetic Barkhausen noise; Micro scale pulse eddy currents can be detected through incremental eddy current technology, known as incremental magnetic permeability.
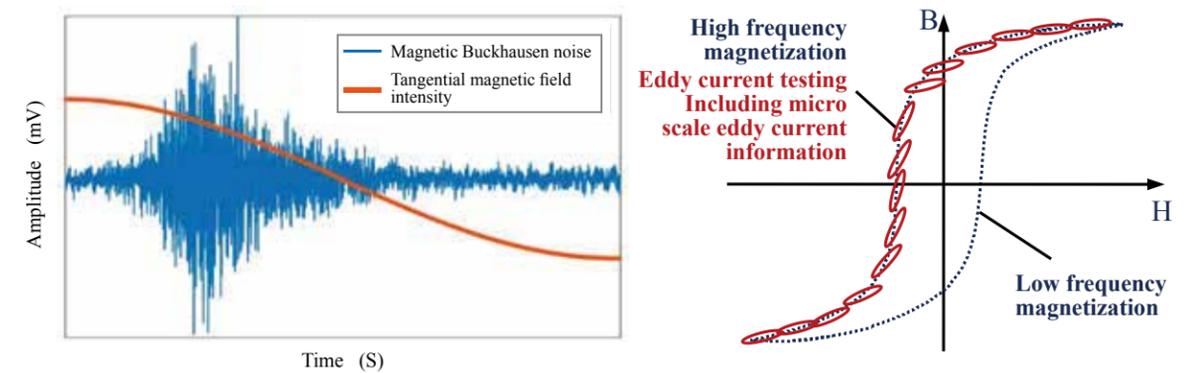

Figure2   Magnetic Barkhausen noise signal waveform (left); Schematic diagram of incremental permeability detection principle (right)
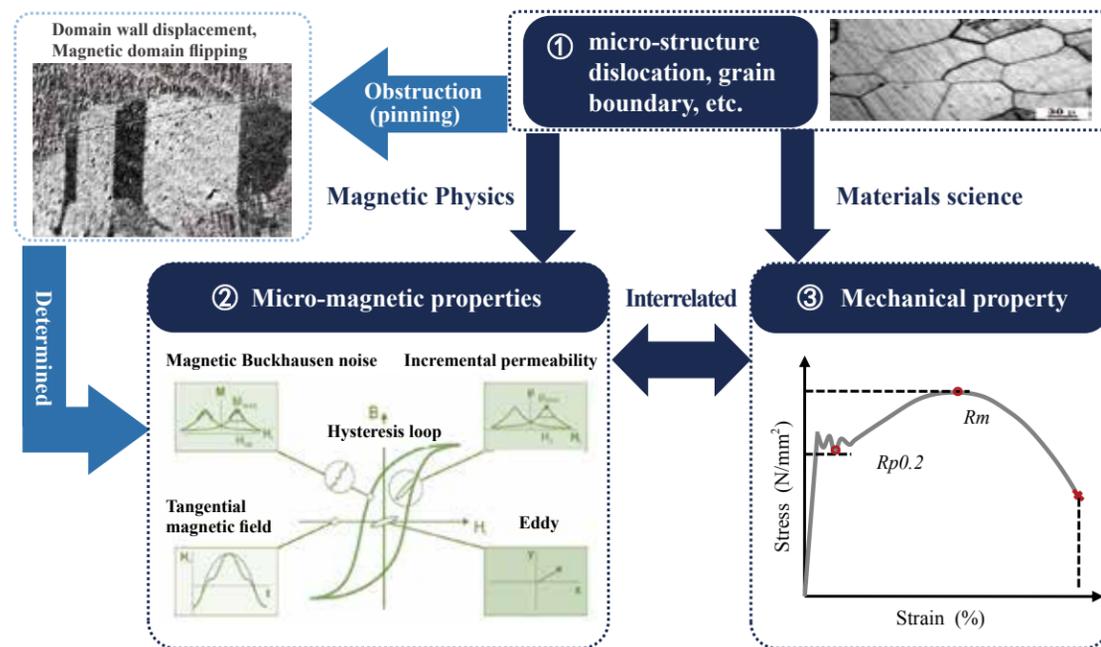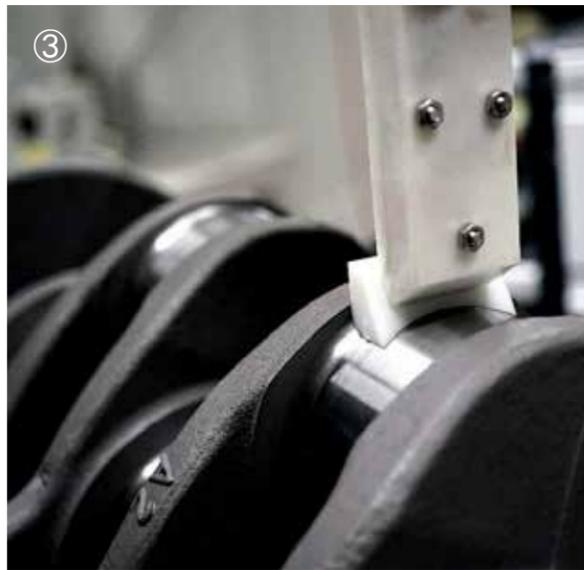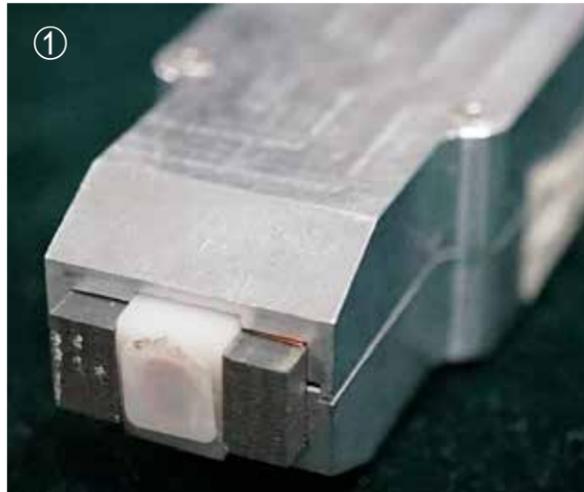
Micro magnetic detection technology refers to the experimental testing technique for magnetic Barkhausen noise and incremental magnetic permeability, which uses a single sensor to synchronously obtain multiple magnetic signals in the same testing area, including at least magnetic Barkhausen noise or incremental magnetic permeability, and is called multifunctional micro magnetic detection.

Multi functional micro magnetic sensor structure

① Magnetic Buckhausen noise
② Multi frequency eddy current impedance
③ Tangential magnetic field strength
④ Incremental permeability
⑤ Hysteresis loop
⑥ Local hysteresis loop cluster

(1) Instrument core technology

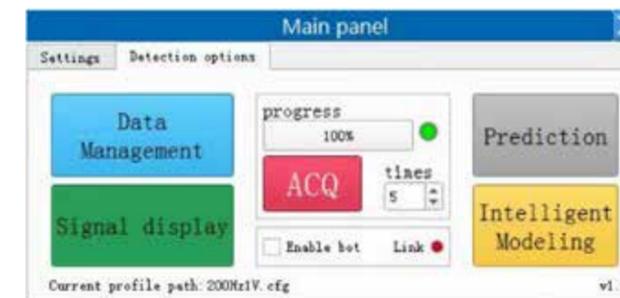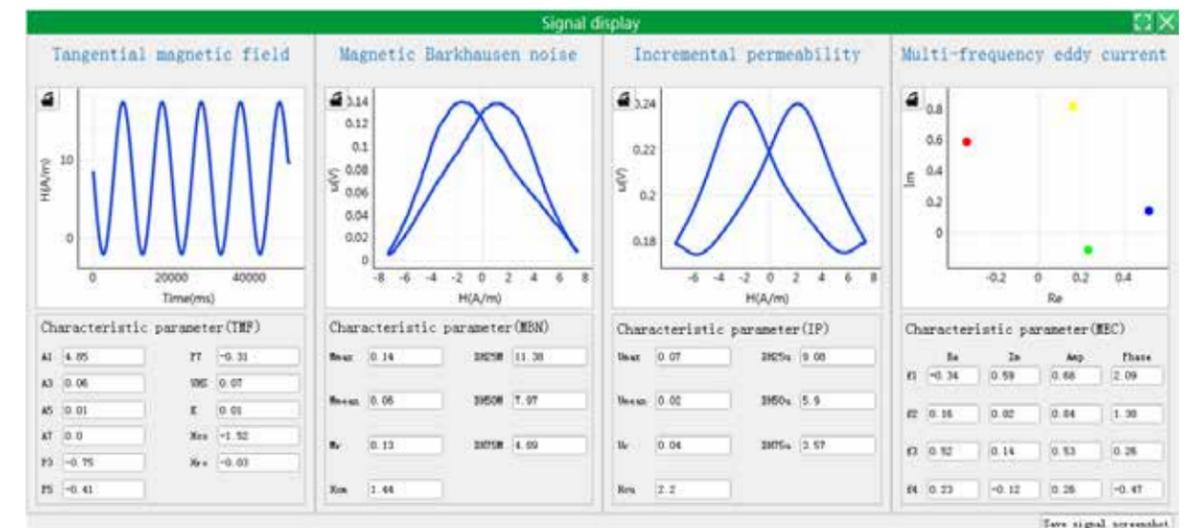| ① Impact specimen detection sensor	② Vehicle body structural component detection sensor
③ Crankshaft detection sensor	⑤ Gear detection sensor
④ Blade detection sensor	

(2) Multi class micro magnetic signal detection circuit across amplitude and frequency bands

The new method of "high/low frequency intermittent superposition magnetization" based on originality is designed using a combination strategy of "physical channel+same direction following separation", "multiplexing gating conditioning+hardware demodulation", etc. It can excite and receive multiple types of magnetic signals, achieve synchronous sensing and ultra fast detection of multi-dimensional magnetic parameters.

(3) Instrument control software and feature parameter extraction algorithm based on Python

✓ Modular interface design for easy operation

✓ Support hardware encryption dog driver control

✓ Customized hardware configuration files for customers

✓ Open robot joint control interface

Instrument core technology

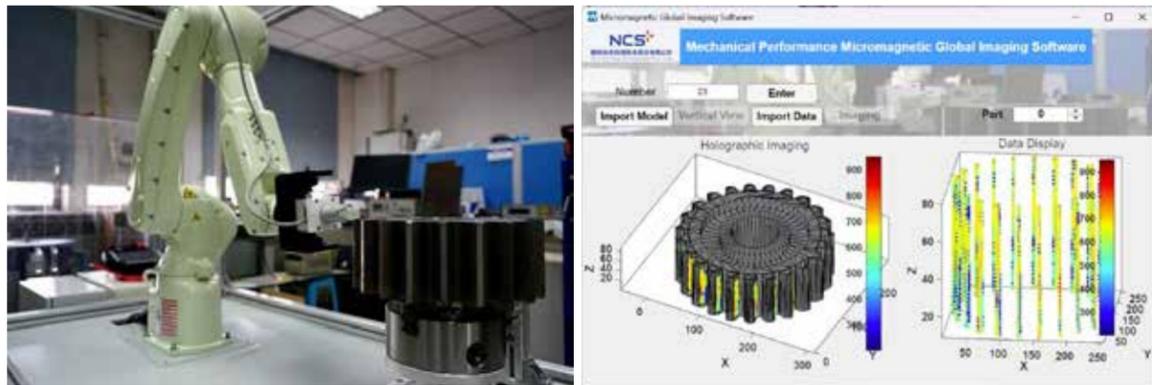## (4) Robot-based Micro-magnetic Scanning Imaging of Parts

Figure 4   Micro magnetic scanning imaging system for components (left) and visualization software (right)

(5) Intelligent modeling of the mapping relationship between mechanical properties and micro magnetic parameters
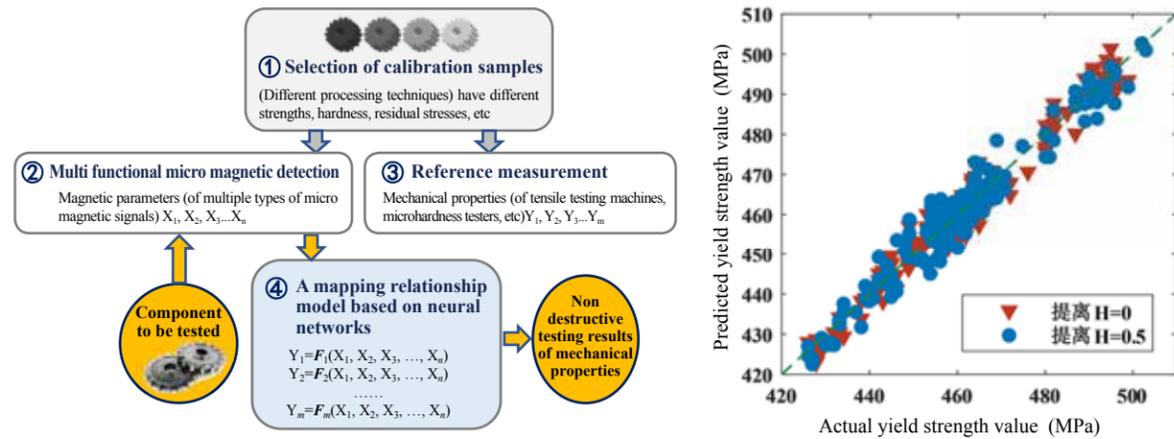

Figure 5   Calibration experimental process of micro magnetic non-destructive testing technology for mechanical properties (left) and typical modeling results (right)

Table 1   Detection accuracy of the model for typical mechanical performance indicators (*)

Number	leading indicator	Current Index Values Reached
7	Relative error of yield strength	±10%
8	Residual stress error	±10MPa
9	Relative error in hardness and hardened layer depth	±5%
10	Plastic deformation	±20%
* Remark	The accuracy of the model is related to the quality of calibration experimental data	

Micro magnetic testing instrument (standalone version)

Table 1   Detection accuracy of the model for typical mechanical performance indicators (*)

Number	leading indicator	Current Index Values Reached	
1	Detection object	Ferromagnetic materials and structural components(such as steel plates, gears, bearings, etc.)	
2	Detectable performance indicators	Surface hardness, depth of hardened layer, residual stress, yield tensile strength, plastic deformation, residual Austenite, impact energy, etc	Precalibration required
3	Detectable types of micro magnetic signals	Tangential magnetic field strength (11 magnetic parameters); Magnetic Buckhausen noise (7 magnetic parameters); Incremental magnetic permeability (7 magnetic parameters); Multi frequency eddy current (16 magnetic parameters)	The default 4 functions are standard and can be selected independently during use
4	Testing accuracy of mechanical performance indicators	Surface hardness ± 5%; Residual stress ± 10Mpa, depth of hardened layer ± 5%; Yield/tensile strength ± 10% plastic deformation (residual elongation) ± 20%	Actual accuracy is related to calibration experiments
5	The main parameters of the detection circuit	Tangential magnetic field: frequency 50Hz~500Hz, maximum power 50W; Eddy current testing frequency: 10kHz~500kHz; Signal sampling rate: 1MS/s	Customizable according to specific needs
6	Battery specifications	Capacity 24V-2800mAh, continuous working time>4 hours	Customizable according to specific needs
7	work environment	Temperature -5~45 ℃; Relative humidity<90%	
8	protection grade	Sensor: IP30; Instrument host: IP40	
9	Sensor: IP30; Instrument host: IP40 instrument appearance and size	Customized according to needs	
10	Overall weight	Can be less than 5kg	

Specification and model	Functions and application scenarios	Main technical parameters	Notes
NCS-MBN200 Magnetic Buckhausen noise detector	(1) Number of channels：1 (2) Functions：Scanning for grinding burn of gear and bearing；Quantitative detection of surface hardness and hardening layer depth； (3) Configurations：Host (including software), sensors	Magnetization voltage range：1V~20V Magnetization frequency range：10Hz~1kHz Signal gain range：0~50dB Hardware bandpass filter：10kHz~450kHz Signal sampling rate：2MS/s Detect repetition frequency：10Hz~1kHz	Customized sensor technology size parameters as needed
NCS-RSTI500 Incremental eddy current residual stress detector	(1) Number of channels：1 (2) Functions：Welding residual stress、Rapid scanning for uniformity of steel plate structure；Quantitative detection of residual stress； (3) Configurations：Host (including software), sensors	Magnetization voltage range：1V~20V Magnetization frequency range：10Hz~1kHz Incremental eddy current excitation frequency：250Hz~25kHz Incremental eddy current excitation voltage：≤12V Signal gain range：0~30dB Signal sampling rate：2MS/s Detect repetition frequency：10Hz~1kHz	Customized sensor technology size parameters as needed
NCS-MMTI100 Multi-function micro-magnetic non-destructive detector	(1) Number of channels：8（customizable) (2) Functions：Steel plate hard spot detection； (3) Configurations：Host (including software)、sensors、Detection car	Instrument parameters：The same as NCS-MBN200 or NCS-RSTI500 spatial resolution：≥10mm Scanning speed：≤1m/s Battery life：≤6h（Customizable)	Customized instruments, sensors, and small cars as needed

Specification and model	Functions and application scenarios	Main technical parameters	Notes
NCS-MMTI600 Multi-function micro-magnetic non-destructive detector	(1) Number of channels：1 (2) Functions：Detection of multiple magnetic properties of ferromagnetic materials (magnetic Buckhausen noise, tangential magnetic field, incremental permeability, multifrequency eddy current, main magnetic flux, etc.)； (3) Scope of application：It is used for scientific research, nondestructive quantitative evaluation of mechanical property indexes (surface hardness, yield strength, elongation, impact energy, etc.) and residual stress of steel plates and steel parts, and applicable to manual inspection； (4) Configurations：Host (including software)、sensors	Magnetization voltage range：1V~20V Magnetization frequency range：50Hz~500Hz Eddy current amplitude：≤4V Eddy current frequency：1kHz~500kHz Magnetic Buckhausen signal gain：-20~60dB Magnetic Buckhausen signal filter：10kHz~450kHz Signal sampling rate：2MS/s Detect repetition frequency：5Hz~50Hz	Customized sensor technology size parameters as needed
NCS-MMS800 Multi-function micro-magnetic non-destructive detector	(1) Number of channels：1 (2) Functions：Scanning and quantitative evaluation of surface mechanical properties and residual stress uniformity of complex parts such as gears, bearing rings, body structural parts, crankshafts and blades； (3) Configurations：Six degree of freedom robot, parts turntable, multi-function micro-magnetic NDT instrument (including software and sensor), etc	Instrument parameters：The same as NCS-MMTI600 Spatial resolution：≤10mm(Customizable) Maximum scanning speed：100mm/s (Customizable) Repeatability：≤0.1mm	Customized sensor technology size parameters as needed
NCS-MMA900 Multi-channel online micro-magnetic detection system	(1) Number of channels：Negotiate according to the technical requirements of the Demander (2) Functions：Scanning for material structure and residual stress uniformity of steel plates and pipes; Quantitative detection and imaging of surface hardness and residual stress (pre-calibrated) (3) Configurations：Determined according to the actual development plan	Customized	Customized

Instrument Principle

The instrument system has undergone on-site testing and demonstration applications in more than 10 units, including SHOUGANG JINGTANG UNITED IRON & STEEL CO.,LTD., TAI YUAN HEAVY INDUSTRY TRANSIT EQUIPMENT CO.,LTD., CITIC HEAVY INDUSTRIES CO.,LTD., BAOSHAN IRON & STEEL CO., LTD, winning widespread recognition and high reputation.

Basic materials

首钢集团 SHOUGANG GROUP

BAOSTEEL 宝山钢铁股份有限公司

Components and parts

中信重工机械股份有限公司 CITIC HEAVY INDUSTRIES CO.,LTD.

TZCO 太重集团 太原重工股份有限公司 TAIYUAN HEAVY INDUSTRY CO.,LTD

Auto Parts

一汽-大众 FAW-VOLKSWAGEN

CHX 天津华翔汽车金属零部件有限公司 天津华翔

Scientific research

CUTC 国合通测

国核电站运行服务技术有限公司 STATE NUCLEAR POWER PLANT SERVICE COMPANY

Contact us

Website:www.ncs-ndtchina.com
Tel.:+86-10-62182492/+86-10-62182833
Mobile:+86-18701560969(Zhao Zitian)
Fax:+86-10-62185240
E-mail:ndt@ncschina.com

WEBSITE