Full Automatic Transformation Measuring Apparatus
With
Low (Subzero) Temperature Range Cooling Mechanism

formastor - FII

(Model: FTF-340)

Specifications

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approval	check		editor	

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CONTENTS

1. INTRODUCTION

Formastor-FII is a full automatic transformation temperature measuring apparatus detecting various kinds of transformation temperatures of metallic material structure, specifically of iron and steel structure through curves of 「Time-Temperature・Dilation」. Highly precise reproducibility of temperature history and dilation measurement are possible in wide range of temperature from 1400℃ down to –150℃ by introduction both of high frequency induction heating system and gas spray cooling system. Particularly in the low (subzero) temperature range from 1200℃ down to –150℃, the low temperature gas generation mechanism by medium of liquidified gas – low temperature gas spray cooling system – allows to do optional temperature program setting for heating and cooling. This makes it possible to reproduce temperature history and to measure transformation temperature occurring in accordance with changes of structure during the process.

1.1 Main measurement items:

(1) Measurement of Ac_1, Ac_3 transformation temperature.
(2) Measurement of continuous cooling transformation and 「CCT diagram」 making.
(3) Measurement of Time Temperature Transformation and 「TTT diagram」 making.
(4) Measurement of martensite transformation (Mf).

1.2 Features

(1) This apparatus is incorporated with a high frequency induction heating and a gas spray cooling systems, which simultaneously control adjustment both of heating power and cooling gas volume. Hence, wide range of temperature (general temperature range test in RT ～1400℃ and low (subzero) temperature range test in RT～1200℃～ -150℃) can be controlled at optional rates for rapid heating/cooling and also gradual heating/cooling to enable reproduction of heating history corresponding to various heating treatments.

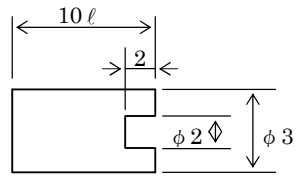
(2) Computer system enables to do integrated treatments starting with pattern making to pattern generation = test =data collection, operational monitoring and test = data processing of measurement results (automatic detection of transformation temperature, CCT・TTT diagram making, etc.). This system consists of relating hardware and software as a total system and is very easy to operate.

(3) Detection mechanism for dilation changes occurring from transformation is composed of low dilation material like quartz, super invar material, and so on to avoid, to the utmost, affects from surrounding temperatures. This makes more precise measurement

(4) In order to prevent materials from oxidation, de-carbonization and so on, It is possible to automatically make test atmosphere condition of vacuum or inert gas atmosphere

2. MAIN PERFORMANCES

2.1 Dimension of Specimen



2.2 Heating System

Heating system　　High Frequency Induction Heating System

2.3 Cooling System

(1) General temperature range test (test over room temperature)
Gas spray system through double coiled nozzles (automatic flow control by Gas flow control valve)

(2) Low temperature range test (sub-zero treatment)
Low temperature gas spray system through exclusive nozzle.

2.4 General Temperature Range Test Performance

1) Temperature detection　　: R thermocouple
2) Temperature range　　: RT～1400℃
3) Heating rate　　: No controlled heating
: Max 140℃/sec (RT～1400℃averaged rate)
: Controlled heating
: Max 100℃/sec (RT～1400℃linear control)
4) Temperature control　　: ± 1 ℃ (RT～1400℃　stationary state)
5) Cooling medium gas　　: N_2, Ar, and He
6) Max. cooling rate and accuracy
: No controlled cooling　　: Max. 300℃/sec
(He gas, Averaged rate in 1350～300℃)
:Controlled cooling　　: Max. 50℃/sec
(He gas, Linear control in 900～300℃,
excluding latent heat transformation affect)

2.5 Low Temperature Range Testing Performance

1) Temperature detection	: K thermocouple
2) Temperature range	: －150℃～1200℃ (continuously)
3) Heating rate (Controlled heating)	: Max.50℃/sec (RT～1200℃)
4) Cooling rate	: ① 100℃/sec (1200～50℃)
	: ② 15℃/sec (50～－50℃)
	: ③ 1.5℃/sec (－50～－100℃)
	: ④ 0.8℃/sec (－100～－150℃)
5) Control accuracy	: ①±1℃ (RT～1200℃ stationary state)
	: ②±3℃ (RT～－150℃ stationary state)
6) Atmosphere	: ① Vacuum, Inert gas (RT～1200℃)
	: ② He Gas (Low temperature range RT～ －150℃)

2.6 Dilation Measurement

1) Detection system	: Differential transformation system
2) Measuring range	: 4 ranges of; 0.5, 0.2, 0.1, 0.05mm /±5V
3) Accuracy	: ±1.0% / F.S.
4) Output voltage	: ±5V / F.S.
5) Stability	: room temperature 1μ/4hours sub-zero temperature 5μ/20minutes (RT change within 5%)

2.7 Vacuum/Exhaust System

1) Rotary pump	: 162 (50Hz) / 197 (60 Hz) ℓ /min.
2) Diffusion pump	: 360 L /sec (Dia. 3 inches)
3) Vacuuming rate	: Max. 1.3 x 10^{-2} Pa / 15 min.
4) Attainable vacuum	: Order of 10^{-3} Pa
5) Valve drive	: Air drive system

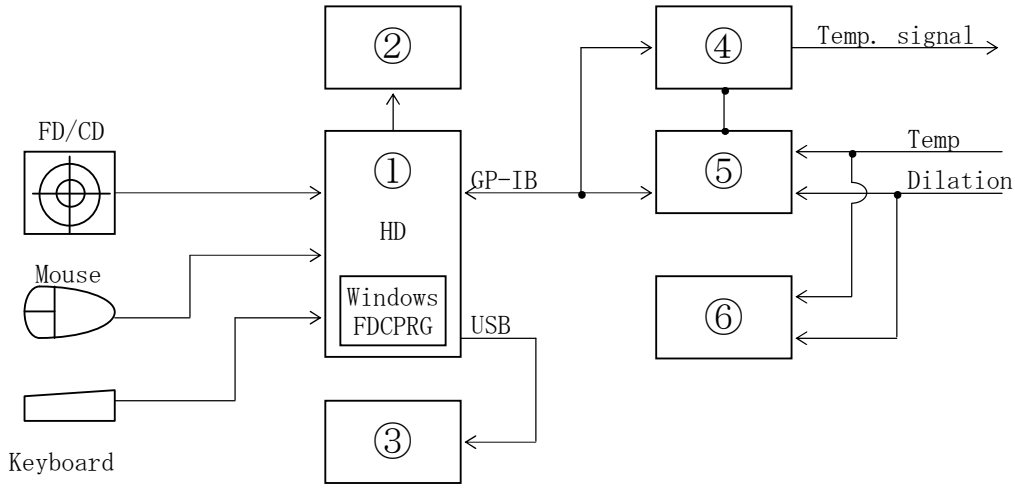
3. COMPUTER SYSTEM

This system carries out the following;

- Program pattern generation and data logging/cooling/other commands.
- Test program making and control of behavior in testing process according to the test program.
- Data accumulation obtained in the testing process and data processing of operation/analysis/diagram making/etc. based on the test results.

This system consists of the following hardware and also software described hereunder.

3.1 Hardware



1	Computer O.S.	Windows O.S.
2	Display	17 inch. color
3	Printer	A4 size, color laser jet
4	Pattern generator	Model PSG-104, 1CH, 16 bit
5	Data logger	Model NR-500, 2CH, 14 bit
6	Pen recorder	Model 3712-21(YEW), 2 pens

Fig. 1 Computer system - Hardware constitution

3.2 「FDCPRG」 Software

「FDCPRG」software is operated under 「Windows」O.S. and uses “C language”.

「FDCPRG」 consists of the following files;

「FDCPRG」 System for formastor-FII		
Program		Description
Main menu		Program selection
Pattern generation/making		Program generation pattern making and filing
Operation/Data logging		Pattern generation/data logging (accumulation) and filing
Data analysis menu		Selection of the following data analysis program.
	TDDP	「Temperature-Dilation」 diagram →CCT transformation temperature detection
		「Temperature-Dilation curves：overwriting up to 24 curves
		「Time-Temperature/Dilation」diagram*1 →TTT transformation temperature detection
		「Coefficient of dilation」 operation
		Data filing to CCT/TTT*2
	CCT	CCT diagram drawing (up to 24 curves)
		CCT diagram filing
	TTT	TTT diagram drawing (up to 12 curves)
		TTT diagram filing
	TIMEDP	Data analysis for equally divided time
Data check		For logging data check
PRESENT		Sheet making for analysis data presentation
Disk utility		Path setting of pattern data
		Path setting of accumulated data
		Read-out of disk manager soft

*1 Time axis is in logarithm graduation.

*2 It is possible to select either “binary” or “ASKII” filing.

3.3 Data Processing

3.3.1 TDDP

1) Operation/ Display/Drawing

① This reads out the accumulated actual data and then by moving averaging these data , 「Time -Temperature・Dilation」or 「Temperature – Dilation」is operated and displayed.

② Above curve is displayed and also output to plotter.

Note: Both of temperature scale and dilation range can be freely changed.

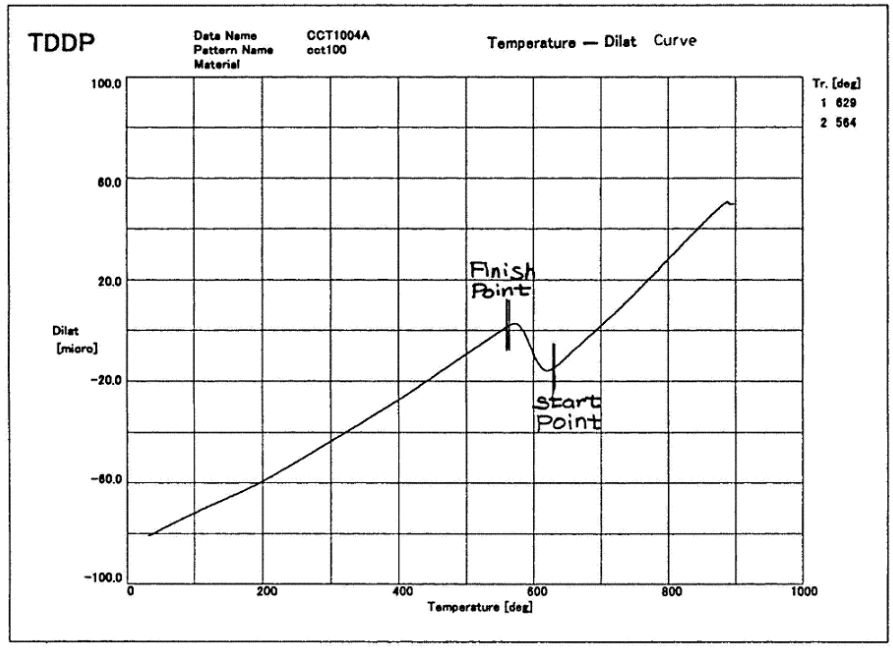


Fig 2. 「Temperature – Dilation」(CCT) curve and Transformation temperature detection on CCT curve

2) Transformation Temperature Detection

Transformation temperature is detected on the curve drawn on the item (Operation/Display/Drawing)-1)

＜ Detection on 「Temperature - Dilation」(CCT) curve ＞… Fig.2

① When "Automatic Detection" is selected, cursor is indicated. It comes down on the curve from higher temperature side, operating gradient and so on.

② When the transformation temperature is detected, the point is acknowledged as the starting point of transformation. Cursor stops at the point, which is the 「transformation temperature」.

③ "Automatic Detection" starts again, cursor simultaneously moves and stops at the different point on the curve, which is the second transformation point and finishing point.

④ Simultaneously, detection and registration of transformation temperature shall be repeatedly done.

< Detection on 「Time – Temperature・Dilation」 Curve >… Fig. 3

Transformation temperature is detected on dilation curve and starting/finishing time is detected on temperature curve.

① Automatic detection of transformation temperature starts with data starting point on time axis. Same operation as stated in the above shall be done for detection of transformation and registration.

② The point when the temperature falls to constant temperature shall be the starting point (" 0 " second) for the time determination. It is the time standard.

Note 1: When "automatic detection" is impossible, when manual detection is desired or when detection point is desired to be corrected/added, cursor manually.

Note 2: It is possible to detect transformation temperature by enlarging a specific part of the curve.

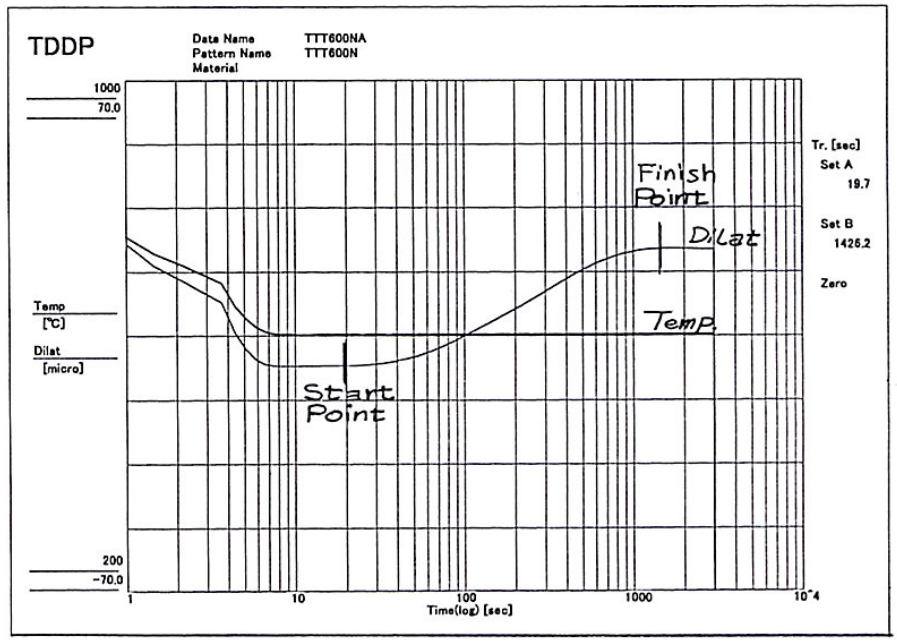


Fig. 3「Time –Temperature・Dilation」(TTT) curve and transformation temperature detection on TTT curve

3) 「CCT」 and 「TTT」 file making

① Data that the transformation temperature is detected and registered on「Temperature – Dilation」curve shall be saved in 「CCT」 file for making 「CCT diagram」.

② Data that the transformation point is detected and registered on 「Time – Temperature・Dilation」curve shall be saved in 「TTT」file for making 「TTT diagram」.

4) Operation of coefficient of linear thermal expansion Dilation coefficient can be operated from 「Temperature – Dilation」(CCT) curve.
For this, data during heat rise process is necessary.
By inputting temperature range and step temperature, dilation coefficient is output accordingly.

3.3.2 「CCT」and 「TTT」

1) 「CCT」diagram … Fig. 4

① Read out maximum 24 curves of CCT data from 「CCT」file made under the item 3) in 3.3.1 and output 「Time – Temperature」curve on display screen.

② Make CCT diagram on display by inputting necessary comments and boundary line by using mouse and key.

③ After outputting to printer, save whole CCT drawing in 「CCT」file.

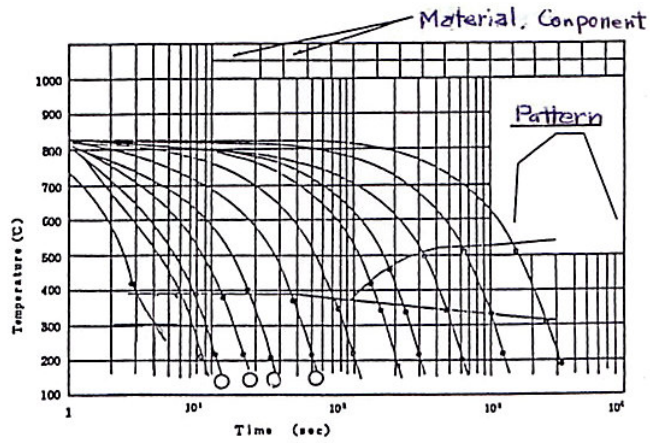


Fig. 4 CCT diagram

2) 「TTT」diagram … Fig. 5

① Read out maximum 12 curves of TTT data from 「TTT」file made under the item 3) in 3.3.1 and output, on display screen, transformation temperature on「Time – Temperature」co-ordinate.

② Make TTT diagram by similar operation to the item 1). After outputting to printer, save whole TTT diagram in 「TTT」file.

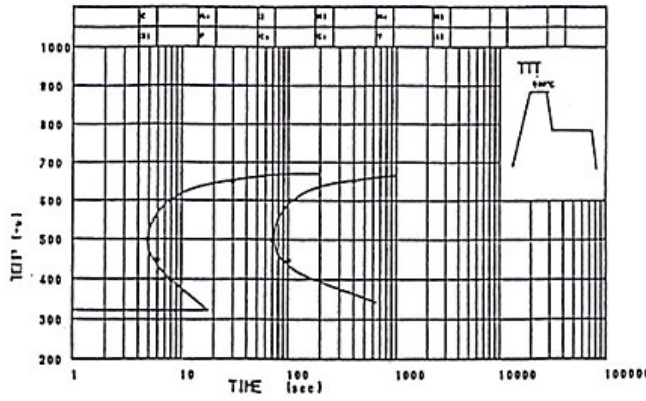


Fig. 5 TTT diagram

3.3.3 「PRESENT」

This is to make sheets for presentation. This can output the following diagram analyzed;

① Actual data	: Diagram processed by 「TIMEDP」
②「Temperature – Dilation」data	: Diagram processed by 「TDDP」
③「Time – Temperature・Dilation」data	: Diagram processed by 「TDDP」
④ CCT diagram	: Diagram processed and made by 「CCT」
⑤ TTT diagram	: Diagram processed and made by 「TTT」

4. OPERATION FLOW CHART

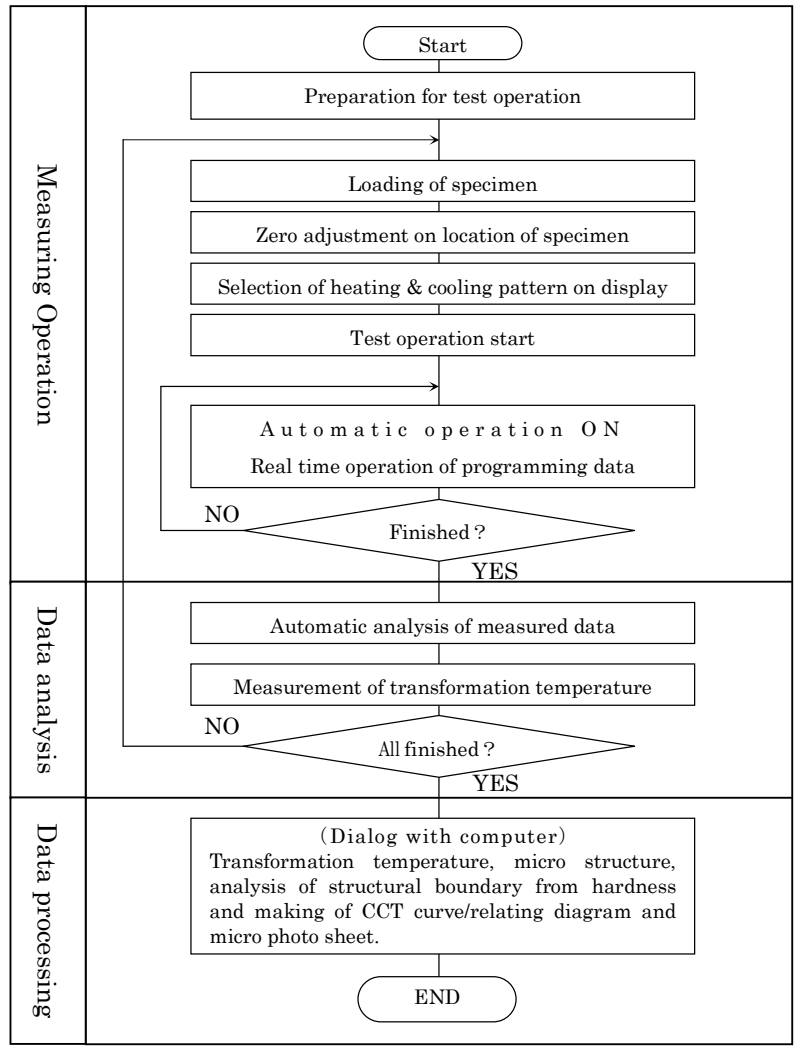
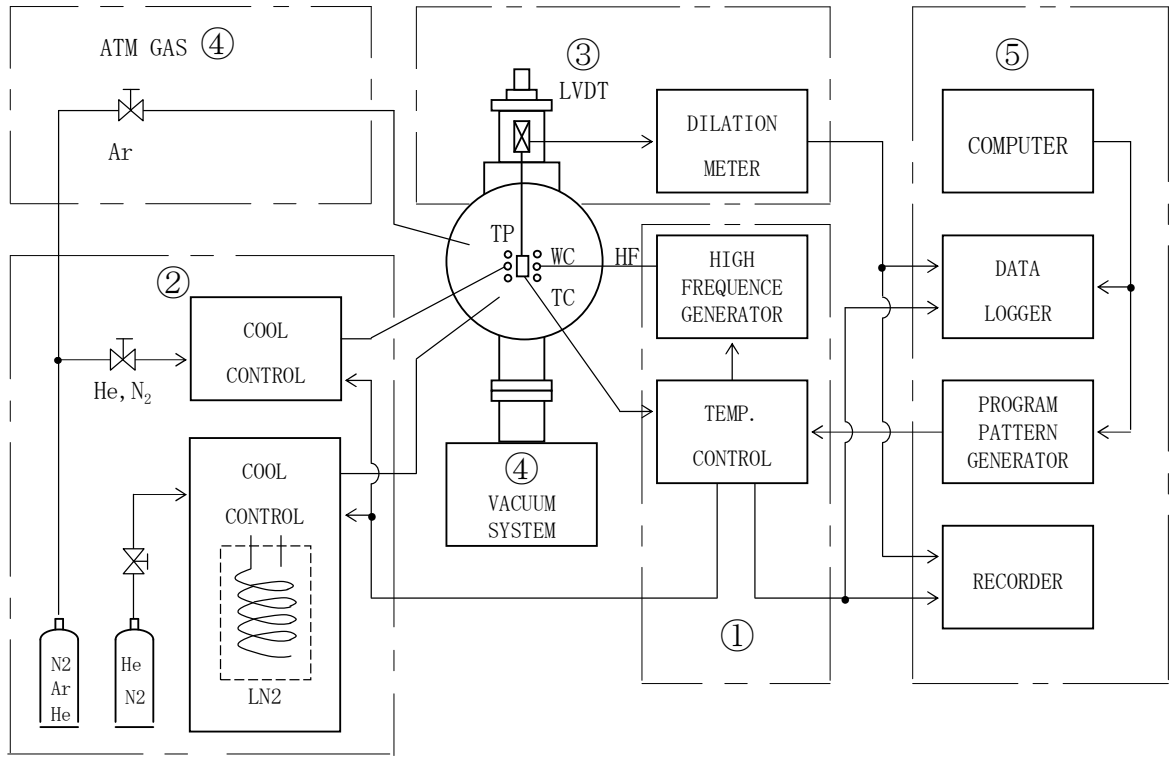


Fig. 6　Test operation flow chart

5. SYSTEM CONSTITUTION AND SPECIFICATIONS

Constitution of formastor FII is hereunder described. This system consists of Vacuum・Atmosphere Chamber (Heating・Cooling System) as the main constitution, Atmosphere adjustment system, Dilation measurement system, Heating control system, Cooling control system and Computer system..



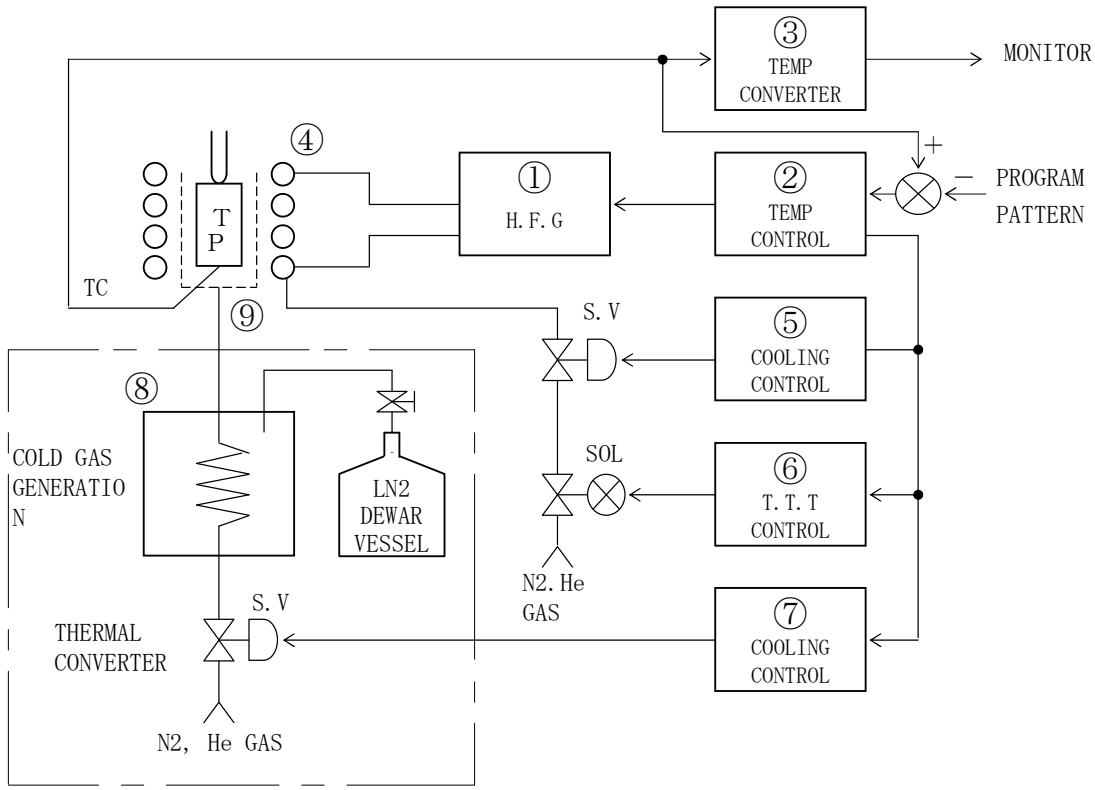
①	Heating control system	Heating control of specimen
②	Cooling control system	Cooling control of specimen
③	Dilation measurement system	Thermal dilation measurement
④	Atmosphere adjustment system	Vacuum or atmospheric gas adjustment
⑤	Computer system	Operation control・measured data treatment

Fig. 7 System constitution

5.1 Heating/Cooling Control System

High frequency induction heating system and cooling gas spraying system are incorporated with the machine, enabling highly precise heating and cooling control of wide range of temperature. By using of differential signals from thermocouple welded onto specimen and also from pattern generator, heating and cooling control can be done in two controlling ways; high frequency power output control and cooling gas spraying volume control either independently or in combination thereof.

This wide range of control adjustment mechanism and high speed response enables test of specimen in wide temperature range from low temperature range to melting point temperature range and makes it possible to do long time test for more than one week.



1	High frequency generator	Output 2kW, 450kHz
2	Temperature controller	PID control
3	Temperature converter	For R type thermocouple / K type thermocouple
4	Heating coil	Double coiled with cooling gas pipe with nozzles
5	Cooling gas flow control mechanism	Servo valve controller (cooling controller)
6	Cooling gas automatic stop・automatic reset mechanism	Solenoid valve, integral time adjustment mechanism
7	Cooling gas flow Control mechanism	Servo valve controller (cooling controller)
8	Cooling gas thermal convert mechanism	LN_2 – He gas thermal convert
9	Nozzle	For exclusive use for He gas spray

Fig. 8 Heating/Cooling control system

5.1.1.1 High Frequency Generator

1) Oscillation method : Colpitts method
2) Output : 2 kW
3) Frequency : 450kHz ± 10%
4) Output control : Duty control (PWM)
5) Output range : 0～100% / 0～5V
6) Oscillation bulb : 6T58RA
7) Power supply : 3φ 200V 3.5kVA
8) Cooling water : 8 ℓ/min. 0.25～0.35Moa (2.5～3.5kgf/cm^2)
Back pressure 0.05Mpa (0.5kgf / cm^2)
9) Protection circuit : ① Over current relay
: ② Water shut-off relay

5.1.2 Temperature Controller

1) Control method : PID operation method
2) Setting input : ① 0～4V / 0～1600℃ (R thermocouple)
: ② -0.375～3V / -150～1200℃ (K thermocouple)
3) Thermocouple input : ① 0～16mV / 0～1600℃ (R thermocouple)
: ② -1.5～12mV / -150～1200℃ (K thermocouple)
4) Output signal : ① 0～5V / 0～100% (heating signal)
: ② ±10V / ±100% (cooling signal)
5) Control accuracy : ① General temperature range test: ±1℃
: ② Low temperature range test :
in general temperature range ±1℃
in low temperature range ±5℃
6) Temperature indication : 3-1/2 figures Digital indication
(actual/differential measurement)
7) Protection circuit : Temperature differential limit (±100℃)

5.1.3 Temperature Converter

2 different kinds of converter are prepared for general temperature range test and for low temperature range test separately. These are used for input of signal to temperature monitor and also data logger.

< For General Temperature Range Test = Using「R」Thermocouple >

1) Model	: MS-3701-R
2) Input signal	: 0～18.74mV / 0～1600℃
3) Output signal	: 0～16mV / 0～1600℃ (linear)
4) Accuracy	: ± (0.1%FS + 0.3℃ linearize accuracy)
5) Response Speed	: 100Hz
6) Protection Circuit	: UP Burnout

< Low Temperature Range Test = Using「K」Thermocouple >

7) Model	: MS-3701-K
8) Input signal	: －3.64～48.94mV / －150～1200℃
9) Output signal	: －1.5～12mV / －150～1200℃ (linear)
10) Accuracy	: ± (0.1%FS +0.3℃ linerize accuracy)
11) Response Speed	: 100Hz
12) Protection Circuit	: UP Burnout

5.1.4 Cooling Controller

2 different kinds of cooling control circuits are prepared in 2 series; one for controlled cooling and the other for rapid cooling. In order to do the test in low temperature range, thermal converter is set in cooling circuit to reduce He gas temperature to less than zero centigrade for spraying onto specimen. This is for making heat history in sub-zero treatment.

< Common >

1) Cooling method	: General temperature range Gas spray from nozzles on inner coil : Low temperature range Gas spray from independent/exclusive nozzles
2) Cooling signal	: Time signal ON/OFF signal from pattern generator

3) Cooling gas : General temperature range:
N_2, He Max. 0.7Mpa, 200 ℓ /min.
:Low temperature range
He Max. 0.7Mpa 200 ℓ /min.
LN_2 Max. 10 ℓ (DEWAR VESSEL Volume)

< Controlled Cooling Circuit >

1) Control method : PID operation method
2) Control object : Gas flow 0～ 70 ℓ /min.
3) Input signal : Temperature differential signal ±10V / ±200℃
4) Output signal : Signal to servo valve ±100mA /±100%
5) Monitor : ±100mA Analog Meter
6) Valve : Servo valve 58A

< Rapid Cooling Circuit >

1) Control method : 2 position (ON/OFF) control
2) Valve : Solenoid valve AC200V

Note: This mechanism prevents overshoot (undershoot) at the time of abrupt temperature change to stationary state in T.T.T. program and allows to reach desired temperature (constant temperature) in a short time.

< Cooling Stop Mechanism >

Cooling valve should be turned to "CLOSE" at the temperature set for a target temperature.

1) Cooling stop setting method: Temperature differential setting method by dial
2) Temperature differential setting range: 0～200℃ for target temperature

< Auto Reset Mechanism >

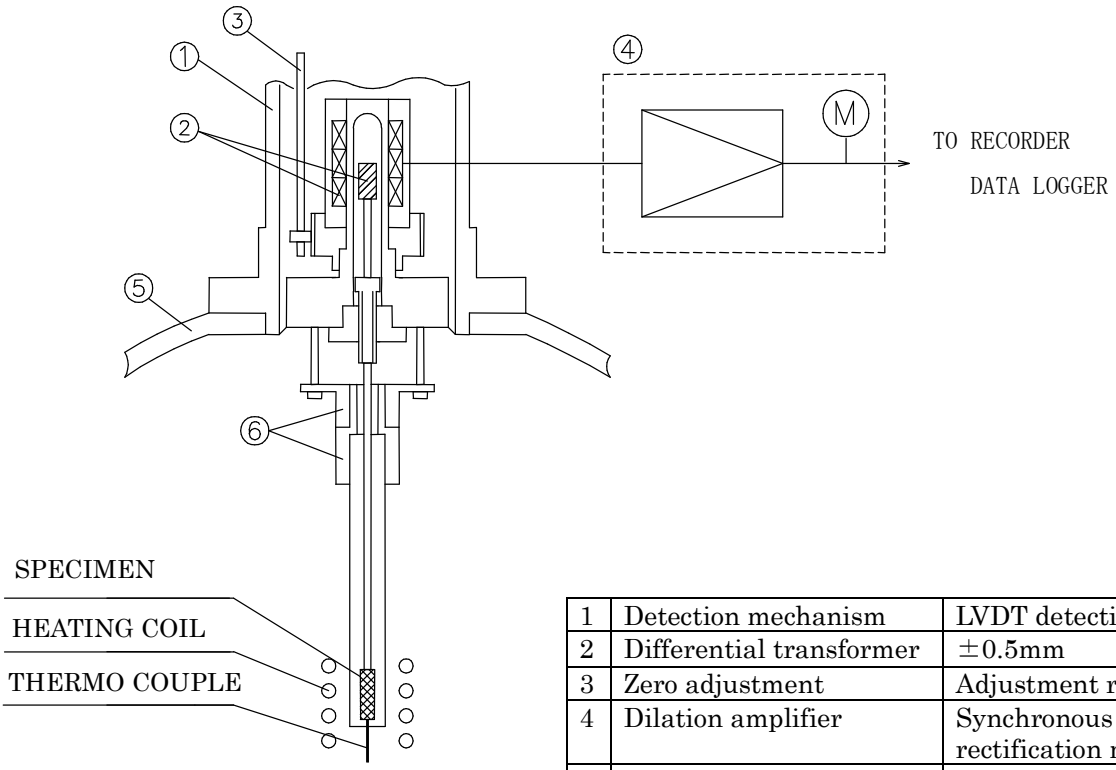
This is a mechanism rapidly to attain the target temperature, decreasing unnecessary time by altering integrating time.

1) Reset setting method: Time differential setting method by dial
2) Temperature differential setting range: 0～100℃ for target

5.2 Dilation Measurement System

formastor-FII detects transformation start and finish points through dilation change to the length direction of specimen .

In order to increase detection accuracy, high sensitivity and high accuracy linear variable differential transformer (LVDT) is used and in order to remove as much affects like changes in room temperature as possible, low dilation material such as quartz, super invar, etc. are used.



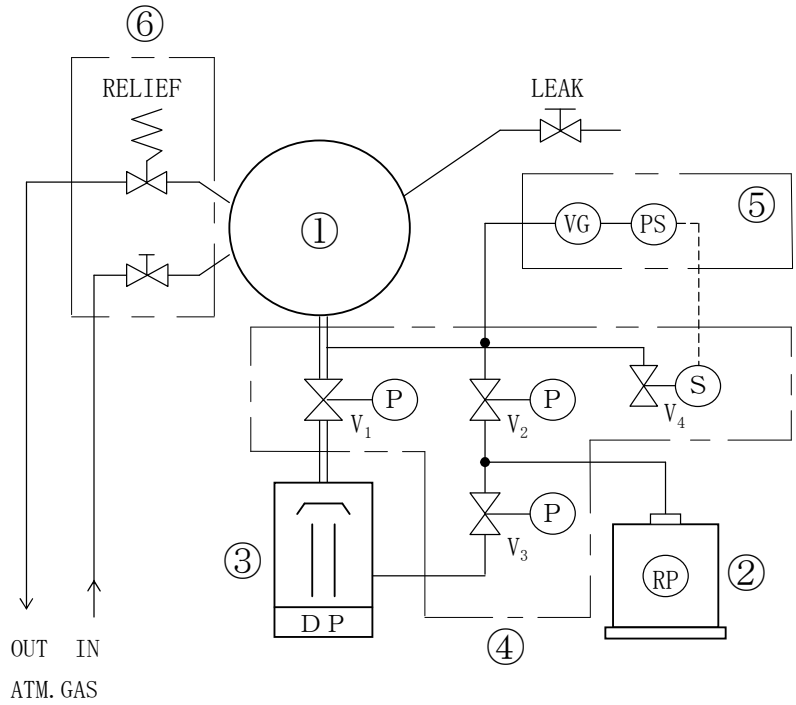
1	Detection mechanism	LVDT detection
2	Differential transformer	±0.5mm
3	Zero adjustment	Adjustment range 5mm
4	Dilation amplifier	Synchronous rectification method
5	Chamber	SUS304
6	Holder	Invar

Fig. 9　Dilation detection system constitution

1) Measuring range　:0.5mm, 0.2mm, 0.1mm and 0.05mm/±5V
2) Detection accuracy　:±1.0% / F.S.
3) Initial drift　:Approx. 30 min.
4) Stability　:1 μ m / 4hour (room temperature)
5) Output signal　:±5V / each range
6) Indication　:Digital indication　±100.0% / each range

5.3 Test Atmosphere Adjustment System

In order to prevent specimen under heating process from degeneration of being oxidized, de-carbonized and so on, heating/cooling system and a part of dilation detection system are put in the vacuum chamber. This system has the structure allowing atmosphere adjustment by vacuum or inert gas.



PS : Pressure Switch
P : Pneumatic Valve
RP : Rotary Pump
VG : Vacuum Gauge
S : Solenoid Valve
DP : Diffusion Pump
V_1 : Main Valve
V_2 : Roughing Valve
V_3 : Fore Valve
V_4 : Leak Valve

Fig.10 Atmosphere adjustment system structure

1	Vacuum chamber	Approx. 14 ℓ
2	Rotary pump	Exhaust Volume 162 (50Hz) /197 (60Hz) ℓ/min.
3	Diffusion pump	Exhaust Volume 360 ℓ / sec
4	Vacuum valve	Main valve, roughing valve and fore valve
5	Pressure gauge (Vacuum gauge)	Pirani and Penning gauges
6	Atmospheric gas	Gas flow valve, gas pressure control (relief) valve

5.3.1 Chamber

1) Material	: SUS304
2) Size	: ϕ 300 x D200
3) Port	: ① cooling and atmospheric gas induction port
	: ② leak gas exhaust port
	: ③ Gauge port
	: ④ Thermocouple port
	: ⑤ High frequency induction lead-through port
	: ⑥ Dilation detection port
4) Observation window	: ϕ 50
5) Protector	: ⑦ Door switch

5.3.2 Rotary Pump

1) Model	: RV8
2) Exhaust rate	: 162 (50Hz) / 197 (60Hz) ℓ /min.
3) Attainable pressure	: 1.3 x 10^{-1}Pa order
4) Oil volume	: 750 cc
5) Motor	: 3 ϕ 200V 450W (50Hz) / 550W (60Hz)
6) Protection Circuit	: Auto-leak

5.3.3 Diffusion Pump

1) Model	: DSS-321 (DPF-3Z 3 inch)
2) Exhaust rate	: 360 ℓ / sec
3) Attainable pressure	: 1.3 x 10^{-4}Pa
4) Oil volume	: 100 cc
5) Heater	: 1 ϕ 200V 500W
6) Cooling water	: 2 ℓ /min. 0.25Mpa (2.5kgf / cm^2)
7) Protection Circuit	: ① Flow switch
	: ② Over-heat

5.3.4 Valve

1) Method	: Pneumatic method
2) Air pressure	: 0.4Mpa (4kg/cm^2)
3) Main valve	: 3 inch butterfly valve
4) Rough/Back valve	: 1 inch 3way valve
5) Leak valve	: 3/8 inch solenoid valve
6) Protection circuit	: ① Air pressure detection
	: ② Main valve open/close LS
	: ③ Rough/Back valve open LS

5.3.5 Vacuum Gauge

<Pressure switch – Digital Indication>

1) Model	: PIS-PO1K
2) Measuring pressure	: 0～ 0.1 MPa
3) Contact	: 0.01MPa

<Pirani gauge>

1) Model	: ① Sensor P-3
	: ② Amplifier VS-10P
2) Measuring pressure	: 10^2 ～10^{-1}Pa
3) Contact	: 10Pa

<Penning gauge>

1) Model	: ① Sensor C-1
	: ② Amplifier VS-5P
2) Measuring pressure	: 10^{-1} ～10^{-4} Pa (ON)
3) Contact	: 1.3 x 10^{-2}Pa

5.3.6 Atmospheric Gas Relations

1) Atmospheric gas	: Inert gas (Ar, N_2)
2) Gas flow-through valve	: 1/4 inch solenoid valve
3) Gas exhaust valve	: 1/4 inch valve

5.4 Computer System

This system consists of DOS/V and the "Windows" OS type computer as the main items, Display, Printer connected with RS-232C, Pattern generator and Data logger controlled by GP-IB.

5.4.1 Computer

1) Model	: * Optiplex GX755(DELL)
2) C P U	: * Pentium 4
3) Memory	: 512 MB
4) Memory equipment	: ① Floppy Disk 3.5 inch
	: ② Hard Disk * GB
	: ③ CD R/W 12X / 8X / 32X
5) O. S.	: Windows * XP
6) Interface	: USB, RS-232C, GP-IB

5.4.2 Display (Separate Setting)

1) Model	: * E178WFP (DELL)
2) Size	: 17 inch Color
3) Control	: Brightness/contrast/size/position

5.4.3 Printer (Separate Setting)

1) Model	:* CLJ3600 (HP)
2) Printing method	: laser Jet Method
3) Resolution	: 3600 dot/inch *
4) Printing rate	: 16 sheets / min: color *

Note: * mark stands for model no., function, item, etc. available at the time of discussion and/or contract.

5.4.4 Pattern Generator

1) Model : PSG-104 (1 channel Pattern generator)
2) Programming method : Program transfer from computer
3) Channel : 1 (Temperature)
4) Address : 99 points
5) Time setting : (1～9999 sec) x 1/100, 1/10, 1 and 10
6) Temperature setting : -200～1600℃ 1℃ step
7) Controlled signal : 8 series (RT1～RT8)
8) Controlled signal setting : 1 / series / each address
9) Output voltage : –0.5～4v
10) Output voltage accuracy : ±0.1% (16 bits)
11) Output time accuracy : ±0.1 sec at " x 1 " magnification
12) Interface : GP-IB

5.4.5 Data Logger

1) Model : NR-500 (4 channel data logger)
2) Channel : ① 1 ch (Temperature)
: ② 2 ch (Dilation)

Note : 3 and 4ch are for spare use.

3) Resolution : 14 bits
4) Input signal : ① 1ch (Temperature) 0～5V/ 0～1600℃
: ② 2 ch (Dilation) ±5V/±100%
5) Sampling time : 1μs～60s
6) Accuracy : DC volt 0.1% of F.S
7) Interface : USB (Ver 1.0)
8) Accessory : AC adapter, USB cable

5.5 Recorder

1) Model	: 3712-21 (YEW)
2) Pen	: 2 pens (red and green)
& signal	Temperature and dilation
3) Recording paper width	: 250mm
4) Accuracy	: ±0.25% / recording paper width
5) Pen rate	: 1600mm/sec
6) measuring range	: Direct current (DCV) 10mV～200V F.S.
7) Recording paper	: Folding type approx. 20m (DIN chart)
8) Chart speed	: 10～1200mm/min and mm/hour
9) Remote function	: Pen up・down
	Chart start, stop
	Chart speed 2 kinds

6. Safety Protection Mechanism

In order to secure safety and protection of the system during operation, following safety/protection mechanism are incorporated.

6.1 Countermeasure for Electricity Service Interruption>

1) Oscillation, heating and cooling stoppage
2) Exhausting system shut down
3) Prevention of rotary pump oil from adverse flow

6.2 Countermeasure for Cooling Water Failure

1) Oscillation・heating stoppage
2) Diffusion pump shut down

6.3 Countermeasure for Pressure Rise in Chamber

When pressure in chamber should rise over specified setting point during cooling, safety valve (pressure control valve) opens to discharge gas and prevents abnormal pressure rise.

6.4 Countermeasure for Oscillation・Heating Problems

Alarm indications are on for problems during oscillating and heating. When the followings should happen, heating immediately stops.

1) Chamber door opens.
2) Current is over rated current.
3) Either cooling water supply stops or is less than specified requirement.
4) Abnormal situation happens with vacuum/exhaust relations.
5) Temperature differential limit starts working.
6) Operation finishes as programmed.

6.5 Countermeasures Vacuum/Exhaust Relations.

6.5.1 Countermeasures for Opening/ Closing of Valves

1) As pneumatic method is adopted for this apparatus, alarm lamp is on when compressed air is not supplied.
2) Limit SW is incorporated with valve for main valve opening and closing. Upon definite confirmation of detection of opening/closing, sequences works.
3) Interlocks allows to open/close valves when the following conditions are met.
   - ① Leak valve : Main and roughing valves are "'closed"
   - ② Roughing valve : Main and fore valves are "closed"
   - ③ Fore valve : Roughing valve is "closed"
   - ④ Main valve : Roughing valve is "closed" and fore valve is "open"
   - ⑤ Start of cooling makes roughing or main valve "closed"
   - ⑥ When vacuum does not reach less than 1.33×10^{-2}Pa within 30 min. after start with main valve "open" , main valve will be "closed"
   - ⑦ During electricity service interruption, all valves are "closed"

6.5.2 Countermeasures for Rotary Pump

1) When Magnet Contactor thermal relay starts working, pump stops.
2) When electricity service is interrupted, pump stops.
3) When rotary pump stops, mechanism to prevent operation oil from adverse flow starts working.

6.5.3 Countermeasures for Diffusion Pump

Pump stops in the following case

1) When cooling water supply stops or is less than specified requirement
2) When thermal relay for prevention of over heating starts working
3) When rotary pump stops
4) When electricity service is interrupted
5) When vacuum does not reach less than1.33×10^{-2}Pa within 20 minutes after start

6.5.4 Countermeasures for Vacuum Gauge

For protection of sensor in vacuuming gauge, power will be output when the gauges indicate the following vacuum attained:

1) Pirani gauge : Compound gauge indicates "-0.1Mpa"

2) Penning gauge : Pirani gauge indicates "1.33 x 10Pa"

6.6 Power Supply Relations

1) Earth leakage breaker (ELB)		: For main electricity supply switch.	Cut-off:	over 30mA
2) Over-current relay	(NFB)	: For control relatives.	Cut-off:	over 10A
3) Over-current relay	(NFB)	: For rotary pump.	Cut-0ff:	over 10A
4) Over-current relay	(NFB)	: For diffusion pump.	Cut-off:	over 10A

7. STANDARD ACCCESSORIES

1	Temperature Detection			
	1	Thermocouple welder	APW AC100V 1kW	1 unit
	2	Thermocouple	R ϕ 0.2 x 1 m	2 pairs
			K ϕ 0.2 x 5m	2 pairs
	3	Insulation tube	Single tube OD 1.2 x L 100	100 pcs
			Double Tube OD 1.6 x L 25	30 pcs
	4	Temp. keeping tube	SUS ϕ 2.0 x L 25	10 pcs
	5	Adhesive	Aronceramic C	1 pc
	6	Vinyl tube	Red, Black ϕ 1.0 x L 3m	1 pair
2	Record			
	1	Recorder	Chart paper B9619AM 10rols	1 box
			Cartridge pen B9586	3 sets
			Ink ribbon	1 pc
	2	Printer	Print paper A4 500sheets	1 vol
			Ink cartridge (Black, color)	1 pc
	3	Floppy disk	2HD 3.5 inch	10 pcs
3	Heating and cooling			
	1	Heating Coil	For ϕ 3	1 pc
	2	Specimen holder	Quartz tube & rod for ϕ 3	5 pairs
	3	Cooling nozzle	For sub-zero	2 pcs
	4	Cooling tube	Silicon & urethane	3 m each
	5	Dewar vessel	6ℓ	1 pc
	6	Cebell vessel	20ℓ	1 pc
4	Vacuum			
	1	Vacuum grease	H1-VAC	1 pc
	2	O - ring		1 set
	3	Gauze		1 pack
5	Utility			
	1	Elec. power cord	4 core 3.5sq 5m	1 pc
	2	Cooling water hose	Vinyl ID9 x 10m	1 pc
	3	Air hose	Rubber ID6 x 5m	1 pc
6	Others			
	1	Check Cord	BNC 1.5m	2 pcs
	2	Fuse	1A 3A	1 set
	3	Lamp	DC24V small lamp	1 set
	4	Grounding rod		1 pc
	5	Tools	Packed in tool box	1 set
7	Documents			
	1	Software	FDCPRG (CD)	1 pc
	2	Operation Manual	formastor - FII	3 copies
	3	Test Report	formastor - FII	3 copies
	4	Packing List	formastor - FII	2 copies

8. ADDITIONAL SPARE PARTS

1) Cooling water supply unit : add 1set
2) Step down transformer : add 1set

9. CONSTRUCTION WORKS (UTILITY)

Following facilities are necessary for operation of this apparatus.

9.1 Scope of works to be carried out by customer

1) Preparation and arrangement of accommodation room and installation basement.

2) Delivery of the apparatus to the user's accommodation room and installation works.
Please install in accordance with the details as per the drawing (No.EE02032B) – System Arrangement Drawing hereto attached.

3) Water supply and drain facility for Cooling water supply unit (refer to the drawing No.EE02032B)
Required cooling water supply : 0.12m^3 / hr (2 ℓ /min)
0.1～0.2MPa (1.0～2.0kgf / cm^2)
Back pressure : no back pressure
Note: Please refer to the attached sheet of "Standard Requirements" for water quality, water temperature and dewing temperature.

4) Power supply
① Required power : 3 phase 380V 50Hz 7.5kVA
② Grounding construction : less than 10Ω Cable size: 8 sq
Independent power distribution board shall be provided on primary power supply side, install switch in conforming to receiving power and connect to the apparatus.
Note: Power voltage fluctuation shall be within ±10%.

5) Cooling gas and atmosphere adjustment gas facility
Gas : N_2, Ar, He
①Pressure : 0～0.7MPa (0～7kgf /cm^2)
②Flow : Max. 200Nℓ /min
③Diameter : φ7 connection end shape: bamboo trunk knot
④For low temperature range test: Liquidities N_2
Note: Follow legal and also company's own rules for handling of high pressure gas.

6) Exhaust pipe facility
Facility for discharging exhausting gas from rotary pump and chamber is suggested.
Note: In case that much cooling gas is used and gas ducting facility is not enough, there might be possibility of serious danger to death due to lack of oxygen occurring from repletion of exhausting gas

10. GENERAL MATTERS

10.1 Warranty

The guarantee period is 12 months after signing the Final Acceptance Report. During the guarantee period,

A. The Buyer will bear the expenses of replacing and mailing items and sending technicians for maintenance provided that the product is improperly operated by the Buyer.

B. The Seller agrees to be responsible for whole – life maintenance of the equipment. The seller shall reply within 48 hours (by telephone, email, fax or through Mr. Wang Daoyuan) after receiving notice from the Buyer for any problems happened after acceptance.

10.2 Dispatch of engineer(s) to the user

The manufacturer will dispatch engineer(s) to the user's premises at the time of apparatus delivery to the user for instructions for delivery to the operating premises and installation as well as instructions for setting/commissioning, test operation, training of user's operators including handling of the apparatus. All expenses necessary for this shall be paid by the user.

10.3 Documents to be submitted to the user

Following documents (English) will be submitted to the user;

1) Operation test report : 3 copies
2) Operation manual : 3 copies
3) Packing list : 2 copies

10.4 Environment conditions for operation

As the apparatus is precision machine, the user shall pay attention to the following environmental conditions.

1) Installation site : In a building room, clean and no dust place. Exposure direct to the sun shall be avoided.
2) Environmental temperature : 10℃～40℃
3) Environmental moisture : less than 75% RH, no dew drop.
4) Sea level height : lower than 1000m