TECHNICAL SPECIFICATIONS
OF
MOLD TAPER MEASURING SYSTEM
FOR
SLAB CASTER

FABER CO., LTD
1. PREFACE:

The on-line mold narrow face taper measuring system to be proposed hereinafter is to be designated so as to enable the monitoring of mold narrow face tapers during casting operation. The main purpose of the on-line mold narrow face measurement at User is supposed to be a trial investigation on whether or not the mold narrow face tapers are changed during casting so as to be a possible main cause of break-out occurrences. Taking into account such situations at User, in this technical specification, the Seller is proposing of the system which can meet a series of trial measurement at one of two slab casters of User as well as will be used as a permanent system, with adding necessary amounts of sensors, at the objective slab caster after the trials.

2. Scope of Supply

2.1 Supply of Mold Narrow Face Taper Monitoring System

The following equipment are to be supplied by the Seller with its engineering and design works:

(1) Eight (8) sensors for two mold assemblies
   Two sensors on one mold narrow face are supposed to be installed. In order to monitor the movements of both narrow faces during casting, four sensors are necessary for one mold assembly. In case of mold change due to some reason, a stand-by mold to which the other four sensors have been equipped at the maintenance yard is to be substituted so as to continue the measurement.

(2) Two (2) control unit with digital monitoring device
   One control unit has 2 channels of monitoring capability, in order to monitor 4 signals provided from 4 sensors on a mold assembly at a same time, 2 units will be necessary. After the trial measurements, the unit can be installed at each of two slab casters for monitoring two sensors on a strand, if the two sensors on mold assembly allow the operational requirements.

(3) Two (2) Off-line taper measuring devices (one for spare)
   Prior to every casting operation, the on-line taper sensors should be calibrated with an aid of off-line taper measuring device so as to ensure the accuracy of the on-line taper monitoring system.
The off-line taper sensor is to be touched properly to Cu-plate of narrow face after finishing the mold narrow face taper setting. Comparing the outputs from on-line taper sensors with that from off-line taper measuring device, the calibrations of each on-line taper sensors can be carried out.
This device can be used alone as a precise taper setting tool before or after the casting operation even when the on-line taper monitoring is not used.
When the off-line taper measuring device does not work, the total system cannot assure their accuracy at all. Considering such situation, the Seller is proposing two sets of the devices, one for operation use and the other for spare.

(4) One (1) calibration tool for off-line taper measuring devices
This tool is used for the calibration of off-line taper measuring device. In order to secure the accuracy of off-line taper measuring device, its calibration should be carried out with this calibration tool periodically in a certain time intervals.

(5) One (1) set of necessary accessories such as heat proof cables
The heat proof cable (approximately 10 meters long) is attached to each sensor. In addition to that the intermediate cable connection terminal box to be situated near the mold is to be supplied.

(6) One set of spare parts for trials
As spare parts for the trial measurement, the followings are included in the scope of Seller's supply.
Two (2) sensors with heat proof cable
   Fuses for control units

2.2 Engineering service

The following engineering and design works are to be scope of the Seller's supply;

(1) Installation of sensors on mold narrow face
The basic engineering work for the installation of sensors on mold narrow face frame is carried out with supply the drawing(s) for this purpose.
The detail engineering works for sensor installation on mold, field wiring and cooling water piping including valve stand, layout for control units in pulpit as well as intermediate connection terminal box on casting floor, and any other basic and detail design works will be scope of the Buyer's supply.
2.3 Supervisory service for trial measurement start-up

The Seller will dispatch one supervisor for the following purposes;

(1) Commissioning for total system and guidance for trial measurement start-up

The supervisory service will be supplied for the commissioning of the on-line taper monitoring system as well as start-up of trial measurement. During this period, the necessary training will be executed demonstrating the calibration and maintenance work. In case that the on-line mold taper monitoring system is to be relocated after the trial measurement, upon the request of the Buyer, the Seller will be ready to supply the supervisory service for this purpose.

3. Out of Supply Scope

The following items are out of the Seller's supply scope and should be provided by the Buyer at the Buyer's expenses.

3.1 Detail engineering and design works for installation of sensors

Based on the drawing(s) submitted by Seller, the detail engineering and design works for the installation of sensors to the mold shall be carried out by Buyer. The basic and detail engineering and design works for field wiring from mold to intermediate terminal box as well as between intermediate terminal box to control units, cooling water piping (Inlet and outlet) including valve stand, layout for control units in pulpit as well as intermediate connection terminal box on casting floor, and any other basic and detail design works will be scope of Buyer's supply.

3.2 Installation of sensors on the mold

The sensors are to be equipped on the mounting plates with tightening bolts. The manufacturing of mounting plates as well as Installation of these plates to the mold assemblies are scope of Buyer's supply along with supply of all the necessary materials including sensor tightening bolts. The installation works of cooling water piping and valve stand for this purpose are to be supplied by the Buyer along with all the necessary materials.

3.3 Installation of terminal box and control units

The installation of intermediate terminal box as well as control units is to be carried out by Buyer. As for the control units, they will be supplied as shown in the referential drawing attached hereinafter. If the Buyer intends to install the control units in the existing control panel, the modification works for this purpose are to be the Buyer's supply scope along with supplies of necessary materials.
In addition to above, the wiring works of cables between terminal box and control unit are to be scope of the Buyer’s supply, including all the materials.

3.4 Modification works of existing facilities

If there needs modification work of existing facilities in order to install the system, such modification works will be prepared by the Buyer.

3.5 Utilities supply

Supply of utilities (cooling dry-air and electric power) along with piping and wiring works up to the take over points is to be supplied by the Buyer.

3.6 Recording apparatus beyond the contrail units

The control units display the signals sent from the sensors with LED displays to be set on the front face of the unit. When the Buyer needs to take these signals out of control units so as to record, for example, them on a pen-recorder along with casting velocity, the extension work shall be executed by the Buyer. For this purpose, the Seller will prepare either digital (BCD) or analogue (current of 4-20mA) output terminal on the control units. The choice of output type (digital or analogue) will depend upon the Buyer’s requirement, otherwise the digital output terminals are to be equipped.

3.7 Relocation and/or modification works of the system

In case that after the trial measurement; the Buyer intends to relocate and/or modify the system as permanent monitoring systems at either or both slab casters, all the necessary works for this purpose will be scope of the Buyer’s supply. The Seller will cooperate such modification work with supplying necessary design works, additional equipment, and supervisory services, all of whose scope of supply are to be mutually agreed by the Buyer and Seller at that time.

3.8 Any of those which is not specified in above Para. 2 ”Scope of Supply”.

4. Design Conditions

The system will be designed and manufactured to enable the monitoring of mold narrow face taper during casting operation, utilizing the inclinometer sensor and signal conversion control unit.

4.1 Main features of on-line mold taper monitoring system

The on-line mold taper monitoring sensor is an application use of inclinometer whose principle is described blow: The heart of the closed loop, gravity referenced sensor is a flexure supported torque balance system as shown in the figure below.
When the inclinometer tilts with an angle of $\theta$, a paddle "A" tries to move in tilting direction due to the gravity force. Position sensor "B" catches any resultant motion and converts it to the electrical signal to be fed into an electric amplifier, whose output current is to be applied to a torque motor "C". This develops a torque equal and opposite to the original one so the pendulous mass moves no longer, but assumes a position minutely different from its original to provide the required error signal. The torque motor current is directly and accurately proportional to the tilt, and by allowing it to flow fixed resistor $R_0$ an equally accurate output voltage is obtained.

The output of the inclinometer is an analogue DC signal proportional to the sine of tilting angle. The DC output is zero at the vertical position. When tilted, to one direction, the Inclinometer outputs 0 to +5V DC signal in full scale. At tilting to an opposite direction, the output ranges from 0 to -5V in full scale. These DC signal is to be fed into control unit, where the data conversion is carried out so as to display the mold narrow face taper on LED display.

The inclinometer sensor to be applied as the mold taper sensor is enclosed in the sealed housing so as to permit the measuring in the strict environments of continuous casting machine.
4.2 Main specifications of mold taper monitoring system

The main specifications of the mold taper monitoring system are as shown below in order to achieve the above features of the system.

(1) Detecting sensors

(a) Quantity
   Eight (8) sensors

(b) Type
   FM1-292 (Air cooling type)

(c) Main specifications
   Detecting range: +14.5° (+250mm/1000mm)
   Frequency response: +DC-15Hz, 3dB down
   Resolution: +0.01mm/1000 mm
   Measuring accuracy: +0.1mm (combined)
   Shock survival: 1500g, 11 msec
   Vibration tolerance: 120mm/p, 240rpm (max)
   Atmosphere temperature: -10~+70 °C
   Temperature coefficient: 0.009%FS/*C (worst case)
   Size of enclosure: Approximately 120×65×60mm (referential)
   Cable* connected: Teflon, FEP-FEP-SB, 1.25sq x 4C
   Connector: NWPC448-PM12 (detector side)
               NWPC448-AdF12 (control unit side)

(2) Control Units

(a) Quantity
   Two (2) sets

(b) Type
   FCS-219A (2 channels)

(c) Main specifications
   Power supply to sensors: +15V, 0.1A for each sensor
   Taper calibration: Approximately +50mm/900mm (mold length)
   Gain adjustment: 0.9~1.1 times
   Low pass filter: Cut-off frequency 0.2 Hz
   Input signal: +5VDC per +250mm/1000mm
   Taper indication: 3.5 digits indication on LED display
   ( -199.9 ~+199.9mm/mold length)
   Sampling frequency: 4 times per second
   Output terminal: 4 ~20mA /+- 99.99mm / mold length
   Power source: DC 12V, 1A / each unit
   Atmosphere temperature: -5~+45 degree C
   Outline dimension: 75w x 160h x 260d mm / each unit
Self check function: The control unit has a self check function to figure out abnormal phenomena such as cable disconnection, short circuit power failure and so on, indicating them with LEDs on the front panel.

**MEASURING READY** lights up green when the following 3 LEDs are on green

**DETECTING HEAD** lights up green only when the input signal from the sensor varies in appropriate range, +/-5VDC

**POWER SOURCE** lights up green only when the power supply to the sensor ranges between +13 ~+16V

**OUTPUT RANGE** lights up green only when the taper indication is inside the proper range

(3) Off-line taper measuring device

(a) Quantity
   Two (2) sets

(b) Type
   FMI-10 (Portable type)

(c) Main specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring range</td>
<td>+99.99mm/ 1000mm(or mold length)</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.01mm/ 1000mm</td>
</tr>
<tr>
<td>Frequency response</td>
<td>DC ~0.5Hz (low-pass-filter cutoff)</td>
</tr>
<tr>
<td>Measuring accuracy</td>
<td>+0.05mm/ 1000mm (between +30.0mm/1000mm)</td>
</tr>
<tr>
<td>Zero adjustment range</td>
<td>5% full scale</td>
</tr>
<tr>
<td>Span adjustment range</td>
<td>5%</td>
</tr>
<tr>
<td>Shock survival</td>
<td>1500g, 11msec</td>
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<tr>
<td>Vibration tolerance</td>
<td>120mmp_p, 240rpm (max)</td>
</tr>
<tr>
<td>Atmosphere temperature</td>
<td>-5~+70 degree C</td>
</tr>
<tr>
<td>Temperature coefficient</td>
<td>0.05mm/ 1000mm/ degree C</td>
</tr>
<tr>
<td>Power supply</td>
<td>AC85-250V, 47-440Hz, 1A</td>
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<tr>
<td>Outline dimension</td>
<td>120x320x60mm (body dimension)</td>
</tr>
<tr>
<td>Weight</td>
<td>2.5kg</td>
</tr>
<tr>
<td>Accessories</td>
<td>Power supply cable (10m long)</td>
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<tr>
<td></td>
<td>Suspension tool</td>
</tr>
<tr>
<td></td>
<td>Trunk-case</td>
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</tbody>
</table>
(4) Calibration tool for off-line taper measuring devices

(a) Quantity
One (1) set

(b) Type
FCA-11

(c) Description of calibration tool

The calibration tool for off-line taper measuring device consists of the following components:
- Horizontal surface plate : Granite
  450 x 300 x 100 mm, 41kgs
  Flatness / within 6 micrometers
- Referential taper block : Granite
  390 x 250 x 150 mm, 33kgs
  Square-ness of vertical face
  / within +-1/500 degree
  Grade of reference taper face
  / within +-0.005mm
- Leveling blocks     : 145 x 100 x 70 mm, 4.7kgs x 3
- Precision level      : Resolution / 0.01mm/1000mm
  150 x 44 x 40 mm, 1.3 kgs

4.3 Requirements on ambient temperature

(1) For taper sensors   : -10~+70°C
(2) For control units    : -5~+45°C

4.4 Electricity requirements

(1) Power to be supplied by Buyer
   Please refer to above specifications
(2) Take over point
   Power receiving terminal in control unit supplied by the Seller

4.5 Utility requirements

(1) Cooling air for sensors
   Flow rate : 50 liters/min per each sensor
   Supply pressure : 1.4 kg/cm² under
   Supply temperature : 0 ~ +35°C
   Humidity : 50% under
   Take over point : Inlet of sensors
5. Terms and Conditions

These terms and conditions shall apply to the supply contract of mold narrow face taper monitoring system between the Buyer and the Seller (sometimes hereinafter collectively called "the Parties", or "both Parties").

5.1 Standards

All the materials, designing, manufacturing method and testing method of equipment will conform to the following standards.

(1) Japanese Standards
   Japanese Industrial Standard (JIS)
   Standard of the Japanese Electrotechnical Committee (JEC)
   The Standard of Japan Electrical Manufacturer's Association (JEM)

(2) Seller's Standard and Codes

5.2 Weight and measures

Weights and measures in design and manufacture of equipment shall be metric system.

5.3 Painting

(1) All equipment will be painted according to the painting standard of the Seller
(2) The colors will be mutually agreed upon between the parties after signing the contract in due consideration of Buyer's requirements.

5.4 Inspection before shipment

(1) Inspection to be made by Seller at manufacturing site in accordance with the usual practice prior to shipment will be taken as final.
(2) In the event that Buyer desires to inspect equipment by itself or through an independent Inspection company or association, such Inspection shall be made at the manufacturing sits on a date to be agreed upon later between Buyer and Seller and all inspection charges and fees thereof shall be borne by Buyer.

5.5 Packing

Manufacturers' standard packing win be adopted.

5.6 Delivery

The delivery of the equipment shall be executed on FOB at Japanese port or airport.
The delivery date will be 90 days after the approval of system specifications by the Buyer.

5.7 Passing off title & risk

In accordance with FOB conditions provided for in INCTERMS 1990, the title to and the risk of loss or damage of materials and equipment shall be transferred to Buyer from the time when they snail have effectively delivered at FOB site.
5.8 Installation of sensor and control units

(1) The Buyer shall execute installation work of the supply equipment by itself in accordance to the guidance provided by the Seller, if necessary.
(2) The Buyer shall begin test adjustment of the system under the supervision of Seller after the supervisor has confirmed the completion of the installation work. Test adjustment shall be executed by the Buyer in accordance with the guidance of supervisor.

5.9 Warranty

The Seller will warrant, for the period of twelve (12) months from the date of shipment, the control units, off-line taper measuring devices, and calibration tool for the off-line taper measuring devices.
Should any part(s) of the supply equipment mentioned above prove defective due to faulty design, material and workmanship within the warranty period stated above, the Seller will, at his own expense, repair or replace such detective part(s) on the basis of "FOB" at manufacturing site.
Seller will not assume the cost of assembling and erection nor be liable for delay, loss or direct. Indirect, consequential or contingent damages resulting from such Regarding the sensors and heat proof cables, due to their characteristics, the Seller’s warranting responsibility is to be exempted.
Seller will not be liable for the defects arising from :
(1) The causes, such as inadequate storage, ill handling, Improper erection, disoperation, bad maintenance, etc. on the part of Buyer.
(2) Overload operation in excess of the design conditions for the supplied equipment
(3) Normal wear and tear, and corrosion
(4) Any change and/or modification of any part(s) of the supplied equipment without written approval by Seller
(5) Other causes not attributable to Seller

5.10 Documents and drawings

After contractual agreement, the Setter will submit the following documents and drawings to the Buyer :
(1) Basic engineering (drawings) for the installation of sensors on the mold assemblies, sufficient for the Buyer to execute the detail engineering.
(2) Assembly drawings of each item of equipment to be supplied by the Seller containing the main characteristics and dimensions
(3) Final specification of the system
(4) Handling manual
(5) Maintenance manual
(6) Inspection data before shipment.
(7) Packing list.
(8) Any other documents and drawings requested by Buyer and agreed to submit by Seller.
The delivery time and numbers to submit of the above mentioned document and drawings will be decided upon mutual agreement between both Parties.

5.11 Observance of secrecy

Both parties hereto shall keep in strict confidence from any third party(s) any and all important matters as to the business affairs and transactions. Any drawings or technical documents intended for use in the construction of the equipment or of part thereof and submitted to the Buyer by the Seller prior to or subsequent to the formation of the contract remain the exclusive property of the Seller. They may not, without the Seller’s consent, be utilized, copied, reproduced, transmitted or communicated by the Buyer or to a third party.

5.12 Communication and language

All communication, including documents and drawings, required in this contract shall be made in the English language.

5.13 Acceptance

Within the period of the test adjustment, an acceptance test will be carried out to prove the function of the equipment specified in this technical specification. The acceptance test will be completed when the test report will be submitted by Seller to Buyer after a confirmation of the acceptance test results.

6. Supervisory Services

6.1 The Seller will send his engineer(s) to the site to supervise the test adjustment and start-up of measurement of the supplied equipment.
6.2 The liability of the Seller’s supervisors shall be limited to giving technical guidance, instruction, suggestion and advice to the Buyer’s engineers. All works shall be carried out by the Buyer.
6.3 The Seller will provide additional assistance and cooperation as required by the Buyer, under the terms and conditions to be mutually agreed upon, including the submission of relevant technical data and information.
6.4 The Buyer shall provide the Seller’s engineer(s) with the following facilities and services at no cost to Seller while they are working for Buyer under this contract:
   (1) Accommodation to be reasonable and comfortable for staying
   (2) Space and such other facilities as are reasonable and necessary for the execution of such supervisory services
   (3) Telephone and telex, including the usage charges
   (4) Safety outfits
   (5) Transportation between the places of accommodation and work
   (6) Technical assistance and other services to be discussed and agreed between the Buyer and the Seller which are necessary for the proper performance of the contract.