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TUBE PROFILING SYSTEM MODEL TPS-2000

The Jodon Tube Profiling System, Model TPS-2000, is designed to inspect heat exchanger tubes produced by a tube mill. Typically, a tube mill will produce a metal tube for use as a liquid or gas conduit in radiators, heaters, condensers, etc. The cooling tubes exit the tube mill at a very high rate of speed, making an on-line measurement extremely difficult. As a consequence, the TPS-2000 is used as an off-line measuring system for precisely gauging dimensional characteristics against published tube specifications. The TPS-2000 can be used to gauge virtually any cooling tube using appropriate fixturing and programming.

The Tube Profiling System includes a highly accurate visible laser emitter, and an integral reflected light collector and imaging array. The laser emitter and imaging array combination is called a precision distance measuring transducer (DMT). The laser DMT is rigidly mounted within the TPS-2000 protective enclosure in such a manner as to prevent laser light from exiting the enclosure.

The sample holding fixture is essentially a precision mechanical linear stage with clamping "jaws" which operate in opposition to each other. A tensioning spring causes the jaws of the sample clamp to close towards each other when the "finger pull" is released. To insert a sample, the "finger pull" is drawn towards the operator until the clamp opening is large enough to receive the intended sample. Releasing the "finger pull" after the sample is installed causes the "jaws" to close gently on the tube.

Four translation stages are used to allow the DMT to see the entire tube profile. The sample holding fixture rests atop a precision rotary stage, which is mounted atop a pair of precision linear stages placed orthogonally (i.e., 90-degrees) to each other. One linear stage moves the sample holding fixture in the longitudinal direction of the sample. That is referred to as the X-axis. The other stage moves the fixture in the transverse direction (i.e., opposite to the long or longitudinal orientation of the sample). That is referred to as the Y-direction.

A third linear stage moves to DMT in the vertical "Z" axis.



**TPS-2000 Standard Unit shown with
TIS-3 Tube Imaging System**

HOW THE TPS-2000 OPERATES

To inspect (gauge) heat exchanger tube samples (i.e., audit testing), the product of a tube mill is randomly selected, measured for the "as produced" length, cut to a 100mm long sample length, and inserted into a spring-loaded holding fixture. The operator then selects the type of test to be performed, and enters certain "operator response" information (e.g., machine number, operator name, etc.). Then, with a "mouse-click" the test is initiated. Initiation of a test causes the sample manipulator to translate (2-stages) and rotate (1-axis) so as to optimize the presentation of the sample to the integral scanning laser device. The overall scanning process permits precise measurement data to be taken for parameters such as the tube height, the radii of curvature of the two end radii, and the overall crown. A typical sample scan takes approximately 1 minute to complete.

The ancillary system computer acquires the measurement data and graphically compares the test results with pre-programmed tube measurement specifications. A variety of graphical presentations are available to the operator to permit a systematic analysis of tube mill performance. Stored measurement data is also available for evaluating long-term tube mill performance, especially as it relates to anomalous trends.

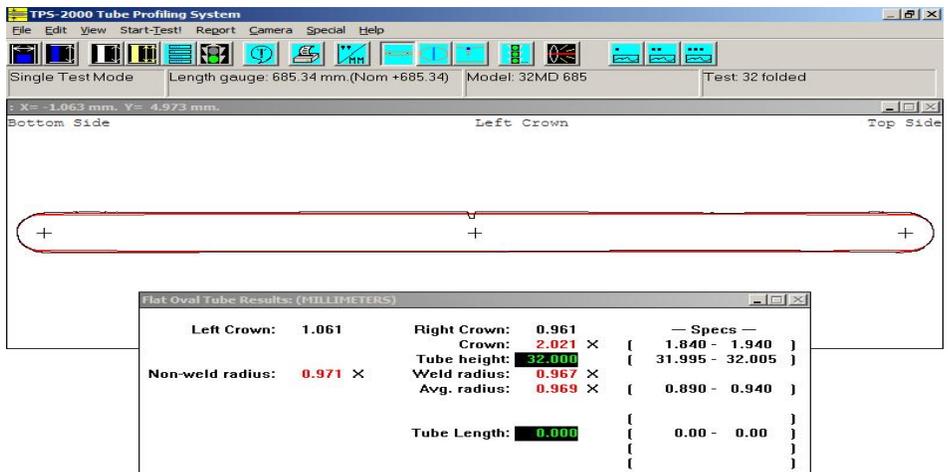
When the TPS-2000 is initially powered up, it is necessary to calibrate the system using a special calibration block. The calibration block fits into the sample holding fixture in the same manner as a cooling tube specimen. When the calibration sequence is initiated, the computer causes the staging units to present the calibration block to the DMT so that the exact center of rotation of the stage can be determined. That calibrated input is stored in the computer memory until the TPS-2000 is powered-down, or until a new calibration cycle is initiated by the operator. When not in use, the calibration block is stored in a convenient "holster" adjacent to the DMT.

The TPS-2000 Standard Unit is housed in a stand-alone, floor mounted industrial enclosure (NEMA 4). The enclosure is designed to protect the staging assembly, laser, computer, and all ancillary devices from airborne particulate contamination, and to protect operators against injury. The enclosure includes a NEMA 4 industrial flat panel 800 x 600 SVGA color computer monitor, an industrial keyboard, and mouse. The enclosure also includes electrical protection against power surges and overload. Provisions are included for the installation of the optional tube length measuring subsystem and the optional color printer, which can provide multi-colored graphics.

TUBE LENGTH MEASUREMENT SYSTEM

Some tube manufacturers require close tolerances on the overall length of the tubes exiting the tube mill. To accommodate the measurement of that parameter, a subsystem has been added to the TPS-2000. It is called the Tube Length Measurement Subsystem. It consists of a precision mechanical linear stage with a travel of slightly over 1 Meter. The length measurement range is 140mm to

1,000mm. It will resolve tube length measurements to 0.01mm. The measured value is displayed on the computer monitor. It can be displayed in either English or metric units. Tube length measurement data can be stored together with tube profile data (i.e., the same database) by making appropriate keyboard entries.



TPS-2000 Tube Profiling System Software, Graph #1

SPECIFICATIONS

System Type: Non-contact electro-optical, multi-axis precision gauging system

Method of Measurement: Test piece placed in fixture on computer controlled rotary stage which is mounted on orthogonally oriented computer controlled linear stages (2). Programmed motion of the three stages presents test piece to laser gauge so as to optimize the dimensional scanning and profiling of the sample. Actual optical distance measurements are obtained through optical triangulation.

Louver Substrate Materials: Metal heat exchanger tubes

Light Source: Visible laser diode

Light Detection: Imaging on PSD

Computer (Minimum):

CPU: Intel Core 2 Dual

Ram: 1GByte

Hard Drive: 80GB, High Reliability

Floppy Disk: 3.5 inch, 1.44MB

Backup: 1GByte Flash

Monitor: LCD Flat Panel, 19 Inch

Enclosure: Mid-Tower



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