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METHOD OF SIMULATING THERMAL STRESSES AND PRODUCING THE RESULTING PHOTOELASTIC FRINGE PATTERNS

Filed Jan. 28, 1963 2 Sheets-Sheet 1

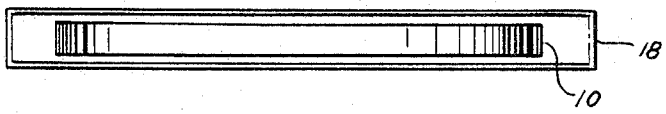


Fig. 2

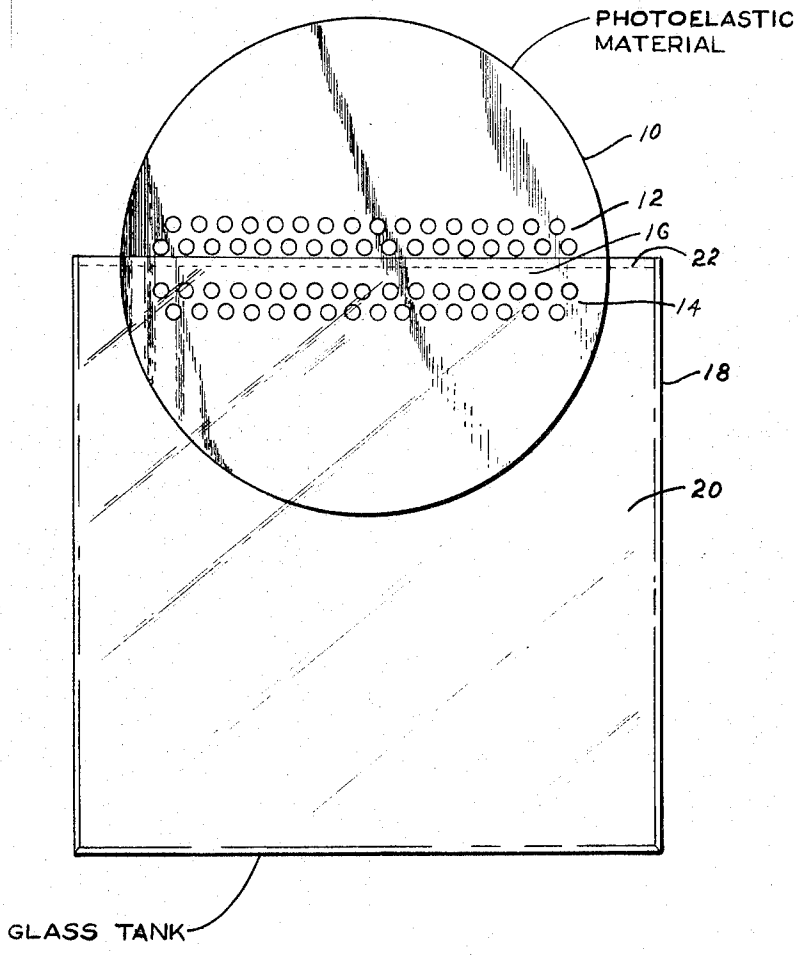


Fig. 1

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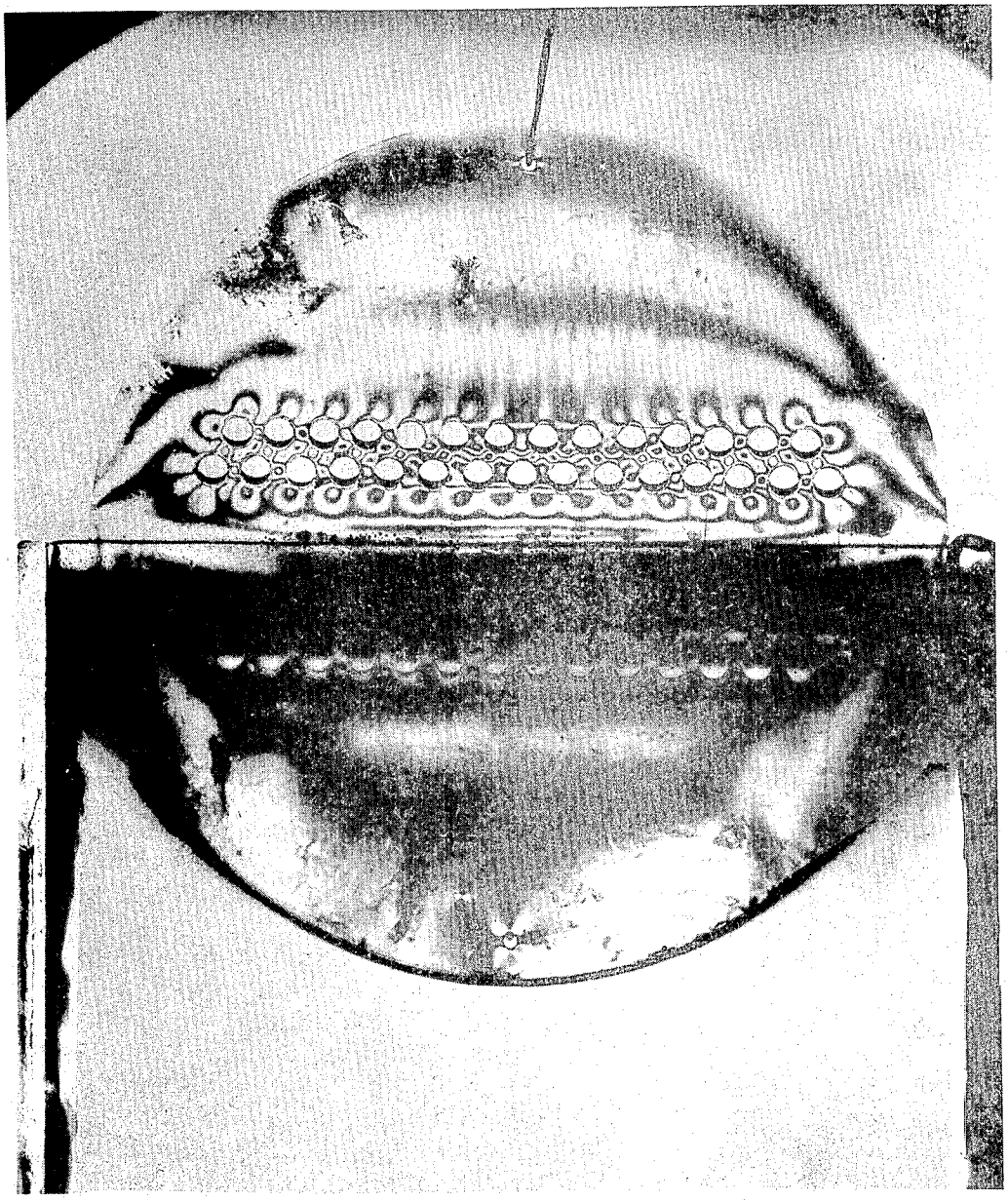


Fig. 3

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METHOD OF SIMULATING THERMAL STRESSES AND PRODUCING THE RESULTING PHOTOELASTIC FRINGE PATTERNS

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This invention relates generally to the art of stress analysis and has particular relation to a process for obtaining photoelastic fringe patterns for predicting the state of stress in a component of a prototype which component has a steep temperature gradient from one region to an adjacent region with the invention being specifically concerned with the production of a photoelastic fringe pattern useful in predicting the state of stress in a tube sheet which is provided with a tube dividing lane generally centrally located in the tube sheet and dividing the same into two halves and with there being a steep temperature gradient at this tube lane divider with one-half of the tube sheet operating at a much higher temperature than the other half.

In accordance with the present invention the desired photoelastic fringe pattern or patterns are obtained by providing a photoelastic scale model of the tube sheet. This model is loaded so that the state of stress therein is similar to that provided in the prototype component, i.e., the tube sheet as employed in the prototype. To obtain this loading the portion or region of the model that corresponds with the low temperature portion or region of the prototype during operation of the heat exchanger within which the tube sheet is a component, is immersed in a low temperature fluid bath (for example, acetone at a temperature lower than —100° F.) while the other region or other half of the model, which corresponds to the region or half of the tube sheet that is at a higher temperature, is disposed or bathed in an atmosphere that has a temperature considerably greater than that of the first mentioned bath, for example an air atmosphere at room (72° F.) temperature. The interface of this cold bath and this higher temperature atmosphere lies within the boundary of the tube lane divider of the model.

The photoelastic model has a very low coefficient of conductivity and thus a steep temperature gradient is produced in the model at the region of the tube lane divider thus loading the model in a manner which will produce a thermal stress pattern therein similar to that provided in the actual tube sheet during operation of the heat exchanger.

With the model thus disposed, it is placed between the two elements of a polariscope and the photoelastic fringe pattern thus produced may be photographed and analyzed permitting the accurate prediction of the actual stresses that will be produced in the tube sheet.

Accordingly, it is an object of this invention to provide an improved method for use in stress analysis.

Another object is to provide an improved method for simulating stresses in components having adjacent regions operating at different temperatures producing a steep temperature gradient therebetween.

A still further object of the invention is to provide an improved method useful in stress analysis for simulating thermal stresses and producing the resulting photoelastic fringe patterns in tube sheets which have adjacent regions operating at widely different temperatures producing steep temperature gradients therein.

Another object of the invention is to provide such a process which is simple yet highly reliable.

Other and further objects of the invention will become apparent to those skilled in the art as the description proceeds.

With the aforementioned objects in view, the invention comprises an arrangement, construction and combination of the elements of the inventive organization in such a manner as to attain the results desired as hereinafter more particularly set forth in the following detailed description of an illustrative embodiment, said embodiment being shown by the accompanying drawings wherein:

FIG. 1 is a front elevational view showing the photoelastic scale model of the tube sheet with the lower portion thereof emersed in the body of cold fluid in accordance with the method of the invention;

FIG. 2 is a top elevational view of the organization of FIG. 1; and

FIG. 3 is a picture of the photoelastic fringe pattern in accordance with the method of the invention.

In the method of the present invention whereby the desired photoelastic fringe patterns are produced representative of the stress pattern found in the tube sheet prototype which has the steep temperature gradient hereinbefore mentioned, a model of the tube sheet is first made with this model being to a desired scale and being fabricated of a photoelastic material. This model is identified in FIGS. 1 and 2 as **10**. The model is provided with a pair of rows of openings **12** in the upper region or upper half of the tube sheet as oriented in FIG. 1 and a lower pair of rows of openings **14**. Intermediate these pairs of rows is the portion of the tube sheet referred to as the tube lane divider with this portion being identified generally as **16**.

The photoelastic model has its lower half, as viewed in FIG. 1, emersed in a cold fluid while the upper half is bathed in the ambient atmosphere. The difference in temperature of the fluid surrounding the lower half and the atmosphere surrounding the upper half is very substantial and corresponds to the temperature difference between the corresponding halves of the tube sheet prototype in one of the operating conditions which it will encounter.

The cold fluid is contained in a suitable container **18** with this container, in the illustrative organization being fabricated of glass.

The model **10** is positioned within the container **12** such that the upper level **22** of the fluid **20** in this container lies within the tube lane divider **16**. Thus there is a very steep temperature gradient created in the photoelastic model at the interface of the fluid **20** and the ambient atmosphere i.e., at the level **22**.

One of the simplest ways of creating this very large temperature difference in the upper and lower halves of the model is to have the lower half inserted in a liquid in the container **20** that is of a very low temperature (preferably less than —100° F.) and have the upper half in the ambient atmosphere i.e., in the air at room temperature (72° F.). The liquid in the container **20** may be cooled in any manner, such as by refrigeration and the temperature of the liquid may vary so that the full range of temperature gradients over which the prototype of the model may be subjected can be produced and the resulting photoelastic fringe patterns obtained.

With the photoelastic model thus disposed, as aforementioned, with the lower half at a much lower temperature than the upper half and with a steep temperature gradient produced at the tube lane divider the model is positioned between the elements of a polariscope and the desired fringe pattern produced from which the actual stresses in the prototype are predicted.

The results of the method of the invention are shown by the photoelastic fringe pattern of FIG. 3. This pattern was produced by placing a model that is 10 inches in diameter and approximately ¼ inch thick in a bath of acetone contained in a glass tank that had the approximate dimensions 12″ x 12″ x 1″. The model was made of epoxy resin and had two pairs of rows of ¼″ diam-

eter holes therein with the pairs of rows being spaced so as to form a tube lane approximately 2 inches wide across the diameter of the circular model. The lower half of the model was emersed in the acetone so that the level of the acetone was within this tube lane. The acetone was cooled to a temperature of —109° F. by placing within the acetone solidified CO_2. The ambient temperature or air temperature which surrounded the upper portion of the model was at approximately 72° F. The model as thus emersed in the acetone was placed between the elements of a polariscope and a photograph taken (FIG. 3) of the resulting photoelastic fringe pattern thus produced.

It will be noted that the fringe pattern adjacent to the upper pair of rows of perforations in the model is extremely clear and well defined and since this is the high temperature portion, this is the portion that is of interest to the stress analyst.

It will thus be apparent that with the present invention there is provided a relatively simple and yet highly satisfactory method of simulating thermal stresses and producing photoelastic fringe patterns for use in the stress analysis of components having adjacent regions at widely varying temperatures.

While we have illustrated and described a preferred embodiment of our invention it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. We therefore do not wish to be limited to the precise details set forth but desire to avail ourselves of such changes as fall within the purview of our invention.

What we claim is:

1. The method of producing a photoelastic fringe pattern from which the stress condition of a component of a prototype having one region that operates at a much higher temperature than an adjacent region can be predicted comprising providing a photoelastic scale model of the component, surrounding the region thereof corresponding to said one region with a first fluid, surrounding the region thereof corresponding to said adjacent region with second fluid maintained at a much lower temperature than said one temperature, while in this condition placing the model between the elements of a polariscope.

2. In the stress analysis of a tube sheet one region of which operates at a substantially higher temperature than another developing a relatively steep temperature gradient

that extends thereacross, the process comprising forming a photoelastic scale model, emersing said one region in one fluid, emersing said other region in another fluid, maintaining the temperature difference of the two fluids at a desired value, and while thus emersed placing said model between the elements of a polariscope.

3. The method of producing a photoelastic fringe pattern from which the stress condition of a component of a prototype having one region that operates at a much higher temperature than an adjacent region can be predicted comprising providing a photoelastic scale model of the component, providing a cold fluid bath immediately adjacent which is an ambient temperature atmosphere, placing the region of the model corresponding to said one region in said atmosphere and the region corresponding to said adjacent region in said bath and while thus disposed placing the model between the elements of a polariscope.

4. The method of claim 3 whrein said atmosphere is air at room temperature.

5. The method of claim 3 wherein said bath is acetone at least at —100° F.

6. The method of claim 3 wherein said atmosphere is air at room temperature and said bath is acetone at least at —100° F.

7. The method of producing a photoelastic fringe pattern from which can be predicted the stress condition of a tube sheet having a tube lane diivder with the region on one side of the tube lane divider operating at a much lower temperature than the region on the other side of the tube lane divider comprising providing a photoelastic scale model of the tube sheet and immersing the region thereof on said one side of the tube lane divider into a fluid bath having a temperature much lower than that of the ambient atmosphere while the other region is disposed in said ambient atmosphere with the interface of said bath and the ambient atmosphere being within the tube lane divider, and while thus disposed placing the model between the elements of a polariscope.

8. The method of claim 7 wherein said fluid bath is acetone at a temperature of at least —100° F. and said ambient atmosphere is air at room temperature.

No references cited.

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