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HEAT EXCHANGER FLOW CONTROL

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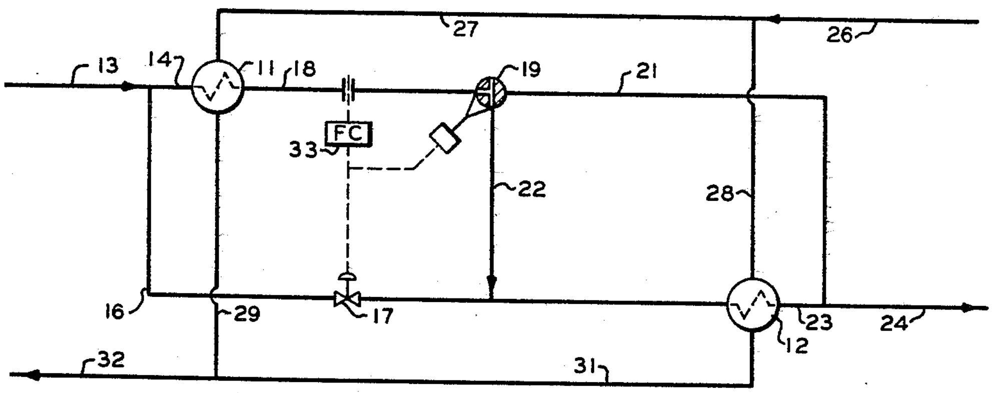

FIG. 1

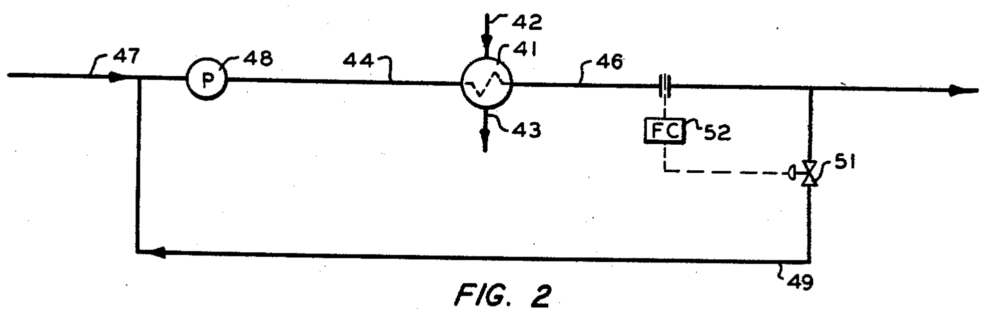

FIG. 2

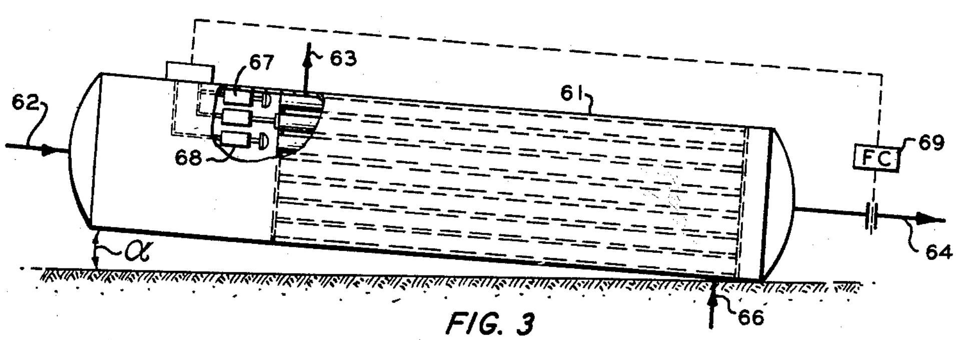

FIG. 3

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HEAT EXCHANGER FLOW CONTROL

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This invention relates to heat exchange systems wherein material flow is maintained above that at which tube fouling becomes a problem.

When the velocity of a fluid flowing through a heat exchanger is too low, fouling of the heat exchange surfaces is a problem. This is primarily due to an increase in the film temperature which causes a deposition of scale on these heat transfer surfaces. This further decreases the heat transfer and greatly reduces the efficiency of the heat exchanger. Flow should be maintained above about 3 feet per second to prevent excessive fouling of the heat exchange surfaces.

The following are objects of my invention.

An object of my invention is to provide a heat exchange system wherein fouling of heat exchange surfaces is substantially decreased. A further object of my invention is to provide a heat exchange control system wherein fluid flow is maintained above 3 feet per second. A further object of my invention is to provide an automatic control system which senses the rate of flow and automatically adjusts the system to maintain the desired rate of flow.

Other objects and advantages of my invention will be apparent to one skilled in the art upon reading this disclosure, which includes a drawing comprising

FIGURE 1, a schematic diagram of a heat exchange system wherein parallel flow is used when fluid flow is above a certain amount and series flow is used at lower total fluid flow rates;

FIGURE 2, a modification of the invention wherein a portion of the fluid is returned to the heat exchanger when necessary to maintain the desired fluid flow rate; and

FIGURE 3, a cross section view of a further modification of my invention wherein a portion of the heat exchanger is rendered inoperative at low flow rates so as to maintain the desired rate of flow of fluid material in the remaining portion of the heat exchanger.

The basic feature of my invention is to provide a system by which flow in the heat exchange system can be maintained above 3 feet per second. Various systems are presented for achieving this result. Broadly, the invention resides in a heat exchange system comprising at least one heat exchanger containing heat exchange surfaces comprising a plurality of tubes in a shell, means to measure rate of flow of material through at least one of said tubes and said shell, and means responsive to said last-mentioned means to maintain said rate of flow of material in contact with said heat exchange surfaces above a predetermined minimum.

The invention can best be understood by reference to the drawing.

FIGURE 1 illustrates my invention wherein a plurality of heat exchangers are arranged for parallel flow in normal operation but wherein provision is made for series flow if the fluid material flow rate falls below the desired rate of 3 feet per second. My invention is applicable to adaption to control of the cooling water, the material being cooled or both. In this figure, I have shown control of the flow of cooling water. For ease in explanation, I have shown two heat exchangers **11** and **12**. The cooling water is supplied by conduit **13**, this conduit splitting into conduit **14** to supply heat exchanger **11** and conduit **16** which supplies heat exchanger **12**. Conduit **16** has valve **17** therein. The outlet conduit **18** extends from heat exchanger **11** to three-way valve **19**, this valve providing for

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communication with conduit **21** and conduit **22**. Conduit **23** extends from heat exchanger **12** to conduit **24** by which the heat exchange liquid is removed from the heat exchange system. The material being cooled is supplied to conduit **26**, this conduit communicating with conduit **27** extending to heat exchanger **11** and conduit **28** extending to heat exchanger **12**. These heat exchangers are, respectively, provided with removal conduits **29** and **31**, these being connected to removal conduit **32**.

Flow controller **33** measures the flow in conduit **18**, this flow controller being operatively connected to valves **17** and **19**. The system is designed for division of the cooling fluid and operation of the heat exchangers in parallel. However, when the flow in conduit **18** is below that at which the velocity of 3 feet per second is present in the heat exchangers, flow controller **33** closes valve **17** and sets valve **19** so that series flow is obtained. In other words, all of the cooling fluid passes through conduit **14**, heat exchanger **11**, conduits **18** and **22**, heat exchanger **12**, and conduit **24**. This results in some sacrifice of total cooling but this loss in cooling is preferable to fouling of the heat exchange surfaces.

FIGURE 2 illustrates a modification of the invention wherein a recycle line is provided to maintain the desired flow in a heat exchange system comprising one or more heat exchangers. More specifically this figure shows heat exchanger **41** provided with inlets **42** and outlet **43**. The other side of the heat exchanger has inlet conduit **44** and outlet conduit **46**. The feed supply conduit **47** is connected to pump **48** which pumps into conduit **44**. Conduit **49**, provided with valve **51**, extends from the outlet conduit **46** back to the inlet conduit **47**. Flow controller **52** measures the flow in conduit **46**, this flow controller being operatively connected to valve **51**.

In the operation of the system of FIGURE 2, there is no flow through conduit **49** in normal operation. If the amount of fluid material supplied falls below that which provides the flow of 3 feet per second in heat exchanger **41**, this causes flow controller **52** to open valve **51** and a portion of the liquid is recycled to the heat exchanger. Once again, there is some lowered efficiency because the recycled material has previously served as the heat exchange material and is not available for further heat exchange.

The invention is also applicable to a single heat exchanger as shown in FIGURE 3. In this figure the heat exchanger **61** is mounted at a small angle, α, above the horizontal. The heat exchanger is provided with inlet conduits **62** and **66** and outlet conduits **64** and **63**. Within the heat exchanger are a series of valves **67** and **68**. While only three valves are shown in the drawing, any desired number can be, of course, used. Flow controller **69** is operatively connected to the valves within the heat exchanger and serves to close these valves consecutively as the flow in conduit **64** is reduced. This maintains the flow in the remaining conduits at or above the desired 3 feet per second. By having the heat exchanger positioned at a small angle, such as 1 to 10°, the tubes so closed drain and fouling is prevented.

Various control systems can be provided to close the valves within the heat exchanger successively. One simple method is to provide a source of air under pressure and to adjust the various valves so that they are closed as this pressure increases. Between the valves in the heat exchanger and the source of air pressure there is provided a valve operated by flow controller **69** and between this valve and valves **67** and **68**, there is a bleed conduit or orifice. As the flow in conduit **64** decreases, this last mentioned valve opens and the air pressure is supplied to valve **67** and/or valve **68** to close the same.

This invention can be successfully used to regulate flow in the heat exchange system over a considerable range of fluid flow. For instance, removal of supply from a small number of water pumps would cause a small decrease in cooling water and the system could be used to permit continued operation without shutting down operation.

However, if there is a complete breakdown of the cooling tower or cooling water supply, other measures would, of course, be necessary.

The invention is illustrated by the following examples which are presented to provide a complete understanding of the invention.

Example I

This example illustrates specific operation when using the system of FIGURE 1. The heat exchangers **11** and **12** are designed so that 50 gallons per minute of water passing therethrough gives the desired rate of flow of 3 feet per second. In operation, 100 gallons per minute of water are supplied at 90° F., this water being supplied at a rate of 50 gallons per minute to each of the heat exchangers. To these heat exchangers, there is supplied a hot hydrocarbon stream at 240° F. By the heat exchange, the hydrocarbon stream is cooled in each of the heat exchangers to 105° F. and the water is heated to 110° F.

When the cooling water supply drops to 90 gallons per minute, it will be seen that the desired rate of flow is no longer possible. When this happens, flow controller **33** closes valve **17** and adjusts valve **19** so that the heat exchangers are connected in series. In heat exchanger **11**, the hydrocarbon stream is cooled to 98° F. while the water is heated to 103° F., all 90 gallons of water passing through heat exchanger **11** each minute. This water then passes to heat exchanger **12** where it is heated to 114° F. The hydrocarbon stream passing through this second heat exchanger is cooled to 118° F. and the hydrocarbon streams, when mixed, have a temperature of 108° F.

Example II

In the operation of the system of FIGURE 2, the heat exchanger is again designed so that 100 gallons per minute will supply the desired rate of flow therein. This water, supplied at 90° F., will cool the hydrocarbon stream from 240° F. to 105° F. When the cooling water flow drops to 90 gallons per minute, flow controller **52** opens valve **51** sufficiently to provide 10 gallons per minute return flow to conduit **47**. This water is heated to 113° F. and recycled through the heat exchanger and, because of this recycle, the hydrocarbon stream is only cooled to 109° F. With this recycle, the effluent from the heat exchange system rises to the stated 113° F. instead of the cooler 110° F. when 100 gallons per minute of water are available.

Example III

In the system of FIGURE 3, the normal operation gives the same result as Example II, that is, the 100 gallons per minute of 90° F. water is heated to 110° F. while cooling the hydrocarbon to 105° F. When the flow drops to 90 gallons per minute, a portion of the tubes are closed so that all of the heat exchange takes place at the remaining

heat exchange surfaces. The water is heated to 118° F. and the hydrocarbon cooled to 112° F.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A heat exchange system comprising at least one heat exchanger having an inlet and outlet conduit and containing heat exchange surfaces comprising a plurality of tubes in a shell, means for measuring total flow of material through said plurality of tubes, means for varying the number of heat exchange surfaces available for transfer of heat and flow control means operatively connected to said means for varying and responsive to a signal from said flow measuring means to decrease the number of heat exchange surfaces available when said total flow decreases and vice versa and maintain said rate of flow of material through each of tubes thus remaining open above a predetermined minimum.

2. A heat exchanger comprising a shell containing a plurality of tubes, a first shell inlet conduit, a first shell outlet conduit, a plurality of valve members within said shell to close individually the inlet ends of said tubes, flow measuring means to determine flow in said outlet conduit, a flow controller being responsive to a signal from said flow measuring means and operatively connected to said valve members to actuate the valve members so as to close a sufficient number of said tubes when the flow in said outlet conduit decreases and opens more tubes when said flow increases so as to maintain flow through tubes not so closed above a predetermined value.

3. A heat exchanger comprising a shell, a plurality of tubes disposed in said shell and having inlet and outlet conduits, said tubes being displaced at an angle from the horizontal to permit draining of fluid material therefrom, a shell inlet conduit and a shell outlet conduit in communication with the above inlet and outlet conduit, a plurality of valve members within said shell to close individually the inlet ends of said tubes, a flow measuring means to determine flow in said shell outlet conduit, a flow controller operatively connected to said valve members and responsive to a signal from said flow measuring means to actuate said valve members so as to close a sufficient number of said tubes when the flow in said outlet conduit decreases and opens more tubes when said flow increases so as to maintain flow through tubes not so closed above a predetermined value.

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