Portable Heater Using Chlorinated Biphenyl

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Reprinted from
Industrial and Engineering Chemistry
Vol. 43, Page 782, March 1951

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PILOT PLANTS

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To fill the need for a heat transfer system providing high temperatures for pilot plant use, a portable heating unit, using chlorinated biphenyl as a heat transfer medium, was designed and built.

The unit involved the following elements: A reservoir for the chlorinated biphenyl heat transfer medium; a circulating pump; an electric oil immersion heater; a water-jacketed cooler; instrumentation to provide control of the circulating fluid temperature; and pipelines from the heating unit to and from the equipment to be heated.

The unit has been used in carrying out reactions on a pilot plant scale at temperature levels up to 300° C. for both heating and cooling. The use of electrical heating permits the use of the apparatus in hazardous atmospheres.

FOR many pilot plant operations there is need for a source of heat capable of reaching temperatures in excess of that obtainable with ordinary steam pressures. It is frequently undesirable or unsafe to make use of direct gas-firing or inconvenient to use direct electrical strip heating. In answer to this problem a portable electrically heated unit using Aroclor (Monsanto Chemical Co. chlorinated biphenyl and polyphenyls), a nonflammable, noncorrosive liquid heat transfer medium, was constructed. In such a system an inert liquid is heated in a suitable device and circulated with a pump through the coil or jacket of the vessel to be heated. Since the liquid does not boil, condenser and traps are unnecessary and the system may be vented to atmospheric pressure.

The unit to be described was built to service any one of several pilot plant reactors in the Organic Division research pilot plant of Monsanto Chemical Co., St. Louis, Mo. It was mounted on a portable frame so that it could be moved from one location to another as required and connected to a given vessel with short lengths of iron piping. The heated vessels were about 50 gallons working capacity.

McArdle *et al.* (*2*) have described design methods for indirect, gas-fired Aroclor heaters and present data on the stability and physical properties of Aroclor 1248. Additional data on the properties of other Aroclors are given elsewhere (*3*).

EQUIPMENT DESIGN

Premises of the design of the unit were:

1. Aroclor operating temperature: 300° C. maximum.
2. Capacity: approximately 40,000 B.t.u. per hour based on vaporizing about 200 pounds per hour of organic material having a heat of vaporization of 150 B.t.u. per pound and allowing for around 30% heat loss.

In order to meet the above requirements Aroclor 1248 was chosen as a heat transfer medium since it is the highest boiling Aroclor that can readily be pumped at room temperature. The recommended maximum operating temperature for this material is 300° C.

Portability was a desired feature of the unit and as a result it was mounted entirely on a four-wheeled truck with power received via an extension cord; watre for cooling, when required, was supplied by hoses. Aroclor piping was arranged so that short lines might be run to and from the jacket of any desired reactor.

In the particular pilot plant building for which this unit was designed it was necessary that the installation conform to Class 1, Group D requirements, and therefore the motor, heating elements, thermostat, and all wiring are explosionproof. For control and ease of operation the unit was provided with an on-off thermostat which controlled the Aroclor temperature within ±2° C. of the desired setting. A water-cooled coil was provided for quickly lowering the temperature of the circulating Aroclor stream if desired. To provide for the considerable expansion of the Aroclor on heating, a buffer tank was mounted on the unit. This tank served as a reservoir, a buffer, and a vent for the system.

The desired capacity of 40,000 B.t.u./hour equal to 11.7 kw. resulted in selection of a 15-kw. Chromalox electric oil immersion heater, Model DCH612-3XX.

The pump provided to circulate Aroclor through the heater, cooler, and jacket of the pilot plant reactors was sized to give a velocity in the heater high enough to prevent surface boiling at an operating temperature of 300° C. A 2 × 1.5 inch T4MD-7-1/2 Durco pump having a rated capacity of 60 gallons per minute at 20-foot head was selected. The unit was driven by a Louis-Allis, 5-hp., 1140 r.p.m., Class 1, Group D motor. Since the flow required in the heater exceeded that needed in the reactor jackets, a by-pass was provided so that some of the flow could be circulated back to the pump rather than passing through the reactor jacket, but it was arranged so that the full pump flow would always go through the heater.

Since hot Aroclor vapors are somewhat toxic it is imperative that the piping and pump stuffing box be completely free of leaks unless local exhaust ventilation can be provided. Drinker (*1*) has indicated that 0.5 mg. of Aroclor per cubic meter of air is the maximum safe concentration.

A photograph of the completed unit is shown in Figure 1 and a schematic flow diagram showing the piping arrangement is given in Figure 2.

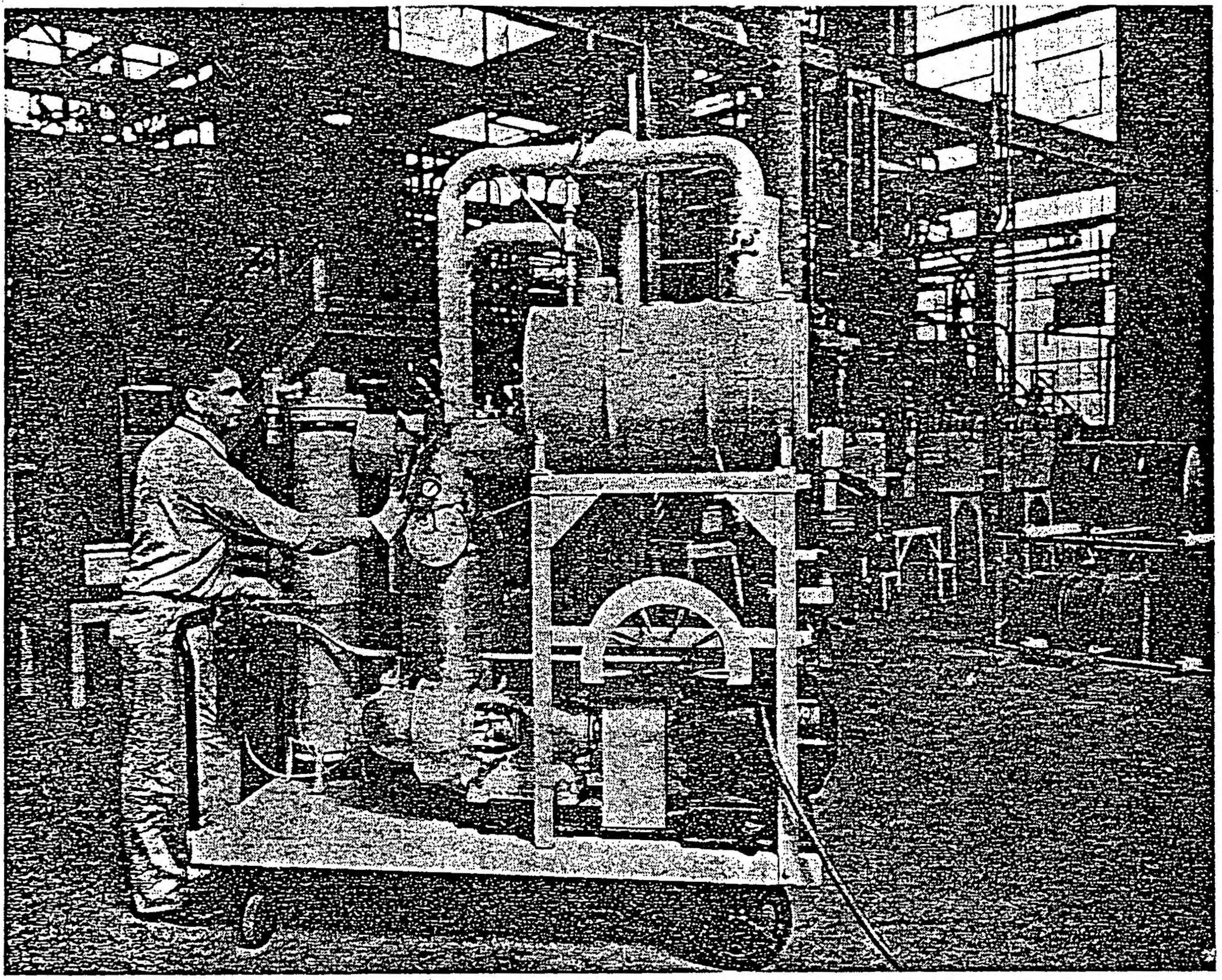

Figure 1. Portable Electrically Heated Aroclor Unit

EXPERIMENTAL RESULTS

The unit as previously described was hydrostatically tested for leaks, then dried by flushing with acetone, followed by extended purging with air. Approximately 25 gallons of Aroclor 1248 were charged to the unit and preliminary tests were made to determine its capacity.

The value of insulation was strikingly demonstrated by the fact that the maximum temperature attainable with the uninsulated unit at no load was only 257° C. After insulation, two methods were used to determine the useful heat output of the unit. These involved:

1. Measurement of the rate and temperature rise of cooling water when using the heater and cooler simultaneously.
2. Measurement of the electrical input (with a tong tester) to the heater correcting for the fraction of the time the heaters operated to maintain the set temperature.

Results of the cooling water measurements are summarized in Table I. Table II gives the electrical input to the heaters while operating at various temperatures, and Table III gives the data on the heater operating cycle as controlled by the "on-off" thermostat. In Table III, the per cent of the thermostat cycle during which the heater was off is considered to represent the useful heat output of the unit, and this percentage is multiplied by the kilowatt rating of the heater interpolated from Table II to give

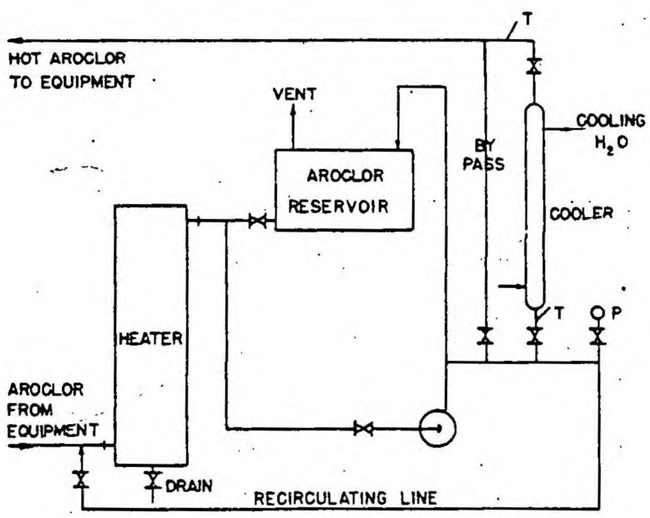

Figure 2. Flow Diagram for Aroclor Heater

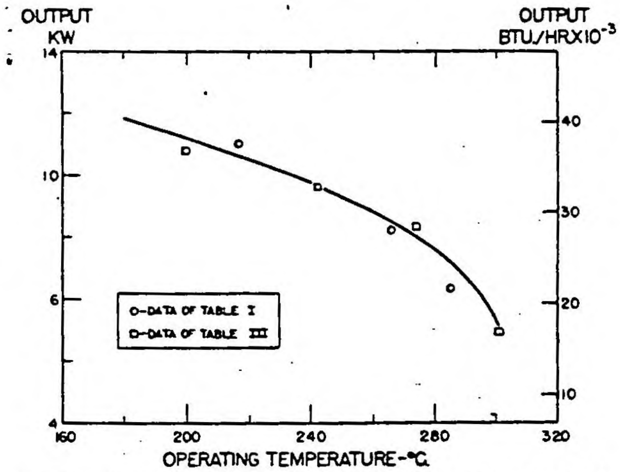

Figure 3. Temperature-Capacity Curve for Portable Aroclor Heater

the "useful load" figures. The results of both methods are plotted in Figure 3 which gives the capacity of the unit as a function of operating temperature.

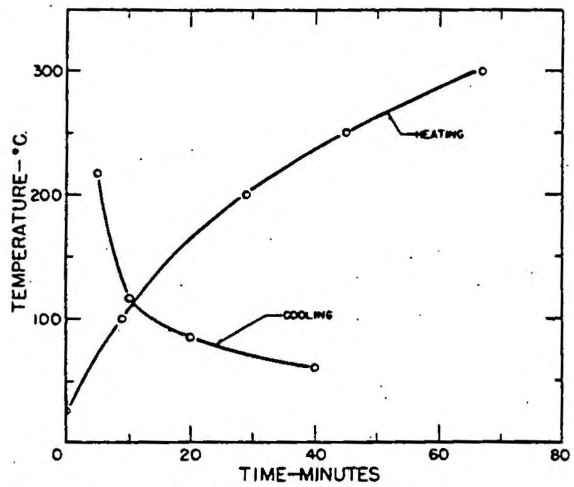

Figure 4. Typical Heating and Cooling Curves for Aroclor Heating Unit

Of interest also is the heating and cooling rate of the unit at no load. This data is presented in Table IV and Figure 4.

DISCUSSION

The unit as described previously has been successfully used for over 2 years on a wide variety of pilot plant jobs requiring high temperature heating and has proved both versatile and effective. A unit has been designed for a similar application where the heat requirements are greater. This design is the same as the unit described here except for the addition of a second 15-kw. heater in series with the first.

Although piping details and selection of auxiliaries will necessarily be modified for larger installations, units up to several million B.t.u. per hour capacity have been designed by commercial fabricators and good operation has been achieved.

Table I. Capacity of Aroclor Heater by Heating Water in Cooler

Aroclor Temp., °C.	Water Temp., °C. In	Water Temp., °C. Out	Water Rate, Lb./Hr.	Test Duration, Min.	Capacity B.t.u./Hr.	Capacity Kw.
217	14	44	697	60	37,500	11.0
266	16.6	75	266	30	28,000	8.2
285	16	57	293	10	21,500	6.3

Table II. Capacity of Aroclor Heater by Tong Tester

Aroclor Temp., °C.	Volts	Av. Amp.	Kv. Amp.	Kw.
100	450	17.5	7.9	13.6
200	450	17.2	7.7	13.4
250	450	17.0	7.6	13.2

Table III. Capacity of Aroclor Heater by Thermostat Cycle

Aroclor Temp., °C. Max.	Aroclor Temp., °C. Min.	Heater Cycle, Seconds On	Heater Cycle, Seconds Off	Useful Load % of full load	Useful Load Kw.	Useful Load B.t.u./hr.
202	197	57 58	240 247	80.8 81.0	10.8	36,900
244	240	62 63	168 166	73.0 72.5	9.6	32,800
274	272	65 65	115 113	63.9 63.5	8.3	28,400
302	300	75 72	45 45	37.5 38.5	4.9	16,700

Table IV. Heating and Cooling Rates with Aroclor Heater

Heating Rate Time, Min.	Heating Rate Temp., °C.	Cooling Rate Time, Min.	Cooling Rate Temp., °C.
0	26	5	217
9	100	10	116
29	200	20	85
45	250	40	60
67	300	..	...

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(2) McArdle, M., Garrett, L. C., and Benignus, P. G., Ind. Eng. Chem., 41, 1341 (1949).
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Received June 12, 1950

Printed in U. S. A.