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Radiation losses in metallurgical furnaces

Frank Richard Loveridge

RADIATION LOSSES IN METALLURGICAL FURNACES.

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The conduction and radiation of heat are of great importance in metallurgy. Metallurgical operations require, in the great majority of cases, temperatures above those of normal atmospheric conditions. Loss of heat is loss of dollars. Furnaces of all kinds allow to pass their walls a greater or less amount of heat, i.e. heat is lost by conduction and by radiation. This heat is often spoken of as radiation loss. It is due to the heat being conducted from the inside to the outside of the furnace.

The materials of construction, and manner of building the furnace has much to do with the loss by radiation. Thick walls lessen radiation by increasing the heat conduction resistance.

Some materials are good conductors, others are relatively poor conductors. An ideal furnace would have no loss of heat by radiation. The outside walls would be no hotter than the atmosphere.

The purpose of this thesis is to study the heat conductivity of some bricks and other materials, and some combinations of materials that could be used in the construction of furnaces.

The amount of heat passing through a unit volume, (a centimeter cube) per second, per degree difference in temperature, is the meaning of the term heat conductivity used in this thesis. This is analogous to the conductivity as used in electricity. In this thesis heat resistance is analogous to the resistance used in electrical work.

METHOD OF PROCEEDURE.

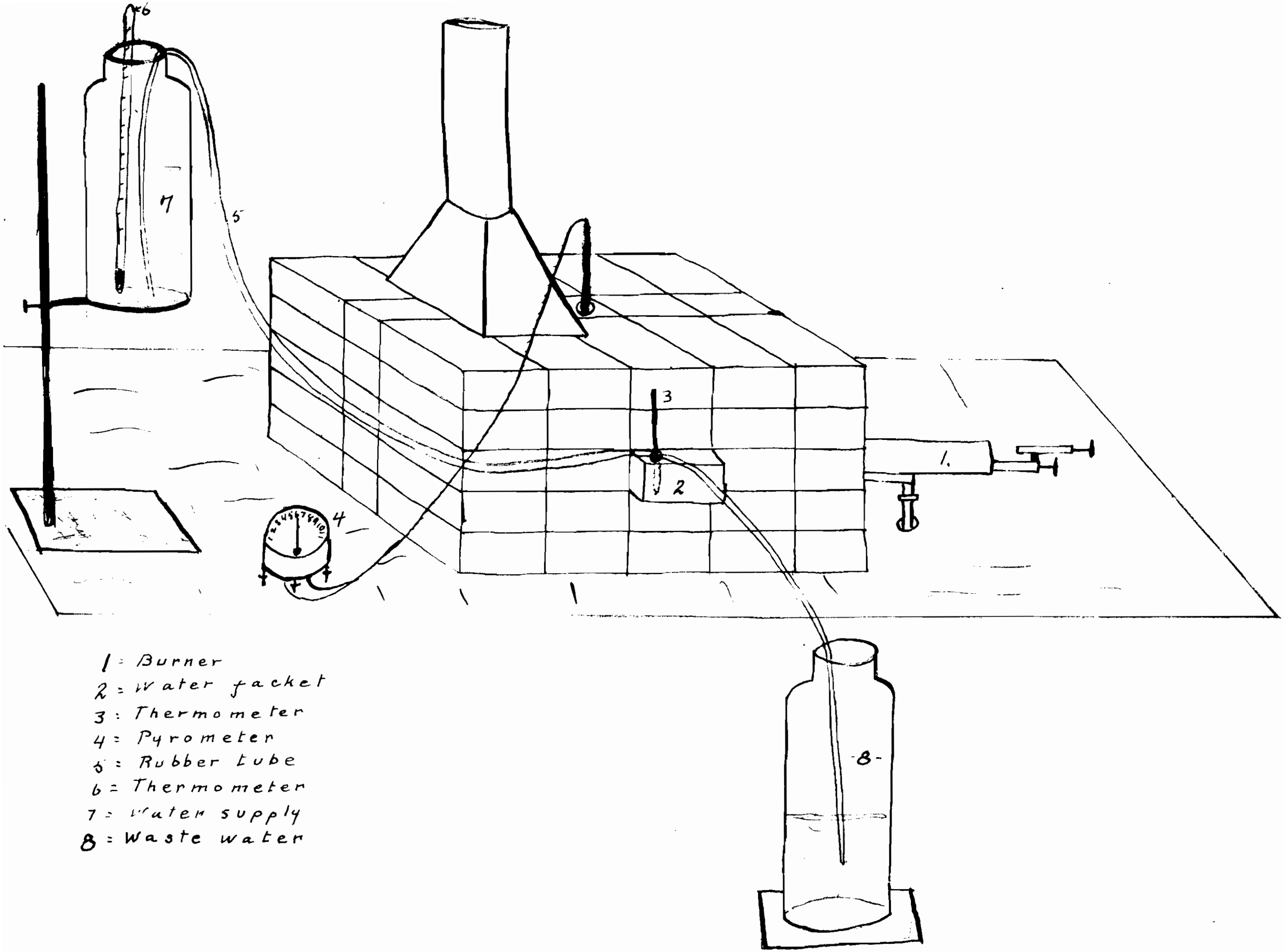
A furnace was constructed as shown in sketch of ordinary fire brick and was about two and one-half feet long by two feet wide. The walls were one brick(eight inches) in thickness. An opening,large enough to insert two bricks,was left in the side of the furnace. In this opening the different materials to be tested were placed. A water jacket,just large enough to cover the end of a brick and three-fourth of an inch thick,was constructed of thin sheet brass and was so arranged that it could be fastened to the end of a brick.

The furnace was heated by means of a gasoline bruner. The temperature inside was taken with a LeChalelier Platinum Rhodium Junction.

The temperature on the outside of the brick(the same as the water jacket) was taken by an ordinary thermometer in the water jacket.

To determine the heat loss,water was slowly syphoned from a bottle through the water jacket and thence into another bottle. The temperature of the jacket was kept as near room temperature as possible. The temperature of the water was taken before entering the jacket and in the jacket. The amount of water was measured. Arrangement of of apparatus is shown in Figure I.

From the number of cubic centimeters, of water passing, the rise of temperature of the water and the length of time of test the number of calories absorbed per second by the water was calculated. The heat carried through the brick was assumed to be the heat absorbed by the water. The water was fed to the jacket sufficiently fast to keep it at room temperature.



1 = Burner
2 = Water jacket
3 : Thermometer
4 = Pyrometer
5 = Rubber tube
6 = Thermometer
7 = Water supply
8 = Waste water

Table I

Red Brick.

Temperature of brick. inside	outside.	Diff. in Temp.	Temperature of Water. entering	leaving.
96,0 C	19	941	16	19
"	19	941	17	19
"	19.5	940.	17	19.2
"	19.5	940.	17.5	19.5
"	20	940	18	20
"	20.5	939.	19	20.5
I000	21	979	18.5	21
"	21	979	18.5	21
"	21	979	18.5	21
"	21	979	18.5	21
"	21	979	18.5	21
"	21	979	19.	21
"	21.5	978.	19.5	21.5
"	22.	978	20	22
I040	21.5	1018.	19.5	21.5
"	21.5	1018.	19.5	21.5
"	21	1019	19.5	21
"	20.5	1019	19.5	20.5
"	20.5	1019	19.5	20.5
"	21	1019	20.	21.

Table I (continued)

Length of Time of test	1440 sec.
Amount of Water	3300 cu.cm.
Average temp of water in jacket	20.8
Average temp. of water entering jacket	18.4
Rise in temperature of water	2.4
Calories ofnheat lost per sec.per brick	5.4
Calories lost per sq.in surface	0.6

Table 2

Temp. of Brick. inside	outside	Difference in temp.	Temperature of water entering	leaving.
1025	17	1008	17	19
"	17	1008	17	18.5
"	17	1008	17	19
"	17.5	1007.	17.5	19.5
"	18	1007	18	19.5
"	18	1007	18	20
"	18.5	1006.	18.5	20
"	19	1006	19	21
"	19	1006	19	21
1075	17	1058	17	18.
"	17.5	1057.	17.5	18.5
"	17.5	1057.	17.5	18.5
"	18	1057	18	19
"	18	1057	18	19.5
"	18.5	1056.	18.5	20.5
"	18.5	1056.	18.5	20.5
"	19	1056.	19	20.5
1090	18	1072	18	18.5
"	18	1072	18	18.5
"	18	1072	18	18.5
"	18.5	1071.	18.5	19
"	19	1071	19	20
"	19	1071	19	20

Table No.2 (continued)

Length of time of test	810
Amount of water used	3300 cu.cm.
Average temp. of water in jacket	19.2
Average temp. of water entering jacket	18.2
Rise in temp of water	1.1
Calories of heat lost per sec. per brick	4.6
Calories of heat lost per sq.in. surface	0.51

Table III

Fire brick- Air Space- Fire Brick.

Temp. of Brick Inside	outside	Difference in temp.	Temperature of water Entering	Leaving
990 C	17	973	17	18
"	19	972	18	19
"	19	971	19	21
"	20	970	20	21.5
1000 C	15	985	15	15.5
"	15	985	15	16.5
"	15.5	984.	15.5	16.5
"	16.5	983.	16.5	18.5
"	17	983	17	20.5
"	18	982	18	21
"	15	985	15	16
"	15	985	15	17
1025	15	1010	15	16
"	15.5	1009.	15.5	16
"	16.5	1008.	16.5	18.5
"	17	1008	17	19.5
"	17	1008	17	19.5
"	18	1007	20	17
"	16	1009	19.5	16.5
"	16.5	1008.	20	16
"	17	1008	21.5	17
"	18	1007	23	18

Table III (continued)

Length of time of test	1880 sec.
Amount of water used	3300 cu.cm.
Average temp. of water in jacket	18.6
Average temp. of water entering jacket	17.
Rise in temp. of water	1.6
Calories of heat lost per sec.per brick	3.6
Calories of heat lost per sq.in surface	0.4°

Table IV.

Fire Brick-Asbestor- Fire Brick.

Temp. of Brick		Difference	Temperature of Water	
inside	outside	in temp.	entering	Leaving.
1100 °C	16.5	1083.	16.5	17.5
"	16.5	1083.	16.5	18
"	17	1083	17	18.5
"	17	1083	17	19.5
"	17	1083	17	20
"	17	1083	18	21
"	18	1082	18	21
"	18.5	1080.	18.5	22
"	19.5	1080.	19.5	22
"	20	1080	20	23
"	20.5	1079.	20.5	23
"	21	1079	21	24
1175	21.5	1053.	21.5	24.5
"	21.5	1053.	21.5	25
"	16.5	1058.	16.5	18
"	17.5	1057.	17.5	20.5
"	18	1057	18	21
"	18.	1057	18	21.5
"	18.5	1056.	18.5	22
"	20	1055	20	21
"	20	1055	20	21.5
"	22.	1053	22	23
"	22.5	1052.	22.5	23.5
"	23	1052	23	24.5

Table IV. (Continued)

Length of time of test	2520 sec.
Amount of water used	2200 cu. cm.
Average temp. of water in jacket	22 C
Average temp. of water entering jacket	19.5 C.
Rise in temp. of water	2.5 C
Calories of heat lost per sec.per brick	2.25
Calories of heat lost per sq.in surface	0.25

Table V.

Fire Brick-Infusorial Earth-Fire Brick.

Temperature of Brick Inside	Outside	Difference in Temp.	Temperature of Water Entering	Leaving
950 °C	17	933	17	18.5
"	17	933	17	19
"	17.5	932.	17.5	18.5
"	18	932	17.5	18.5
"	18	932	18	19
"	18.5	931.	18	19
"	18.5	931.	18.5	19.5
"	19	931	18.5	20
1000	19.5	980.	19	20.5
"	21	979	19.5	21
"	21	979	21	22
"	21	979	21	22.5
"	21.5	978.	21.5	23
"	22.5	977.	22.5	24
1100	23	1077	23	24.5
"	23	1077	23	24.5
"	23.5	1076.	23.5	24.5
"	24	1076	24	25
"	24	1076	24	25
"	25	1075	25	25.5
"	26	1074	26	25.5

Table V. (Continued)

Length of time of test	1800 sec
Amount of water used	1100 cu. cm.
Average temp. of water in jacket	22.5
Average temp. of water entering jacket	20.5
Rise in temp of water	2.°
Calories of heat lost per sec.per brick	1.44
Calories of heat lost per sq. in surface	0.16

From the table it will be seen that the red brick has a loss of 0.60 calories per second per square inch of surface. The fire brick shows a loss of 0.52 calories per square inch. The one with one-third fire brick, with one third of a brick air space and another one third fire brick shows a loss of 0.4 calories per square inch. The one with one-third fire brick, one third asbestos and another one third fire brick shows a loss of 0.23 calories per square inch. The one with one third fire brick, one third infusorial earth and another one third fire brick shows a loss of only 0.16 calories per square inch per second.

This would show that the last combination of fire brick and infusorial earth is much the best combination. The loss here is only about one third of that lost in fire brick alone.

Assuming a furnace of two thousand square feet area, the number of calories of heat lost, if constructed of fire brick would be,

0.46 X 144 X 2000 or 132480 per sec.

or 476928000 per hour.

Assmuing one pound of coal to be equal to eight thousand gram calories, a loss of one hundred and thirty-one pounds of coal per hour by radiation is found. In the same way the loss when infusorial earth is used is only forty-five pounds of coal. This shows a saving of eighty-six pounds of coal per hour.