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METHOD OF REDUCING CARBON DEPOSITS ON SURFACES IN CONTACT WITH CARBONACEOUS GASES AND SUBJECTED TO ELEVATED TEMPERATURES

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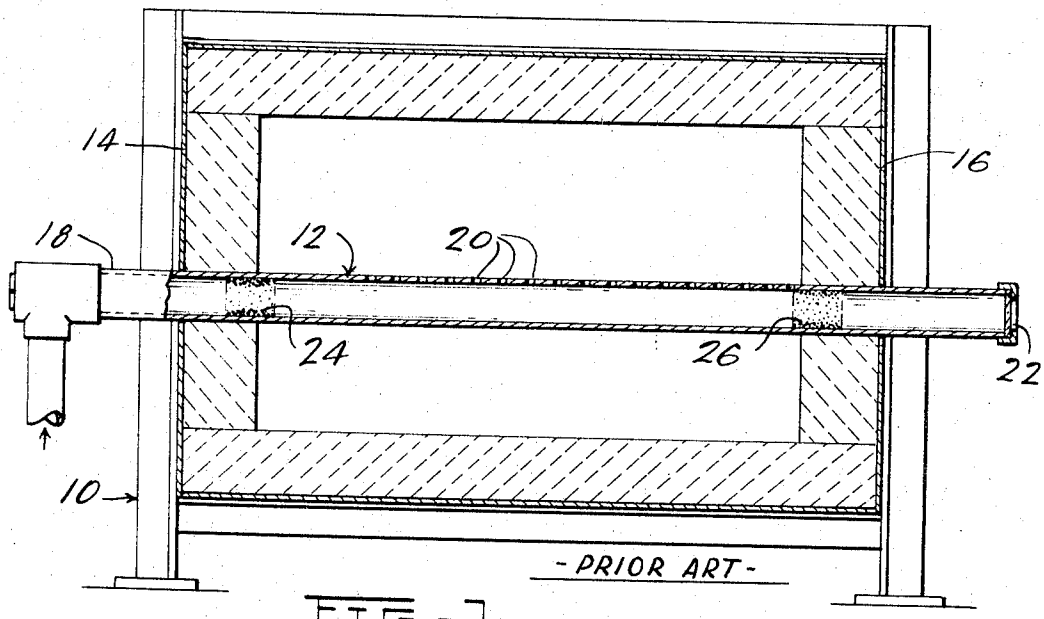


FIG - 1 -

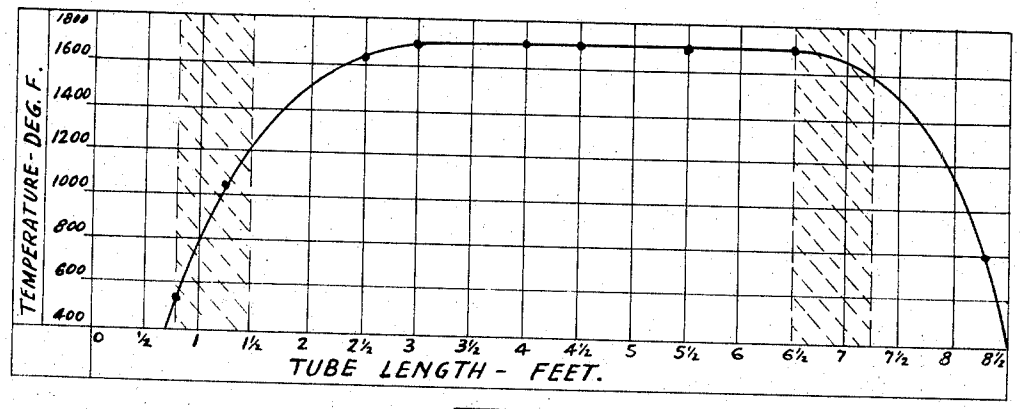


FIG - 2 -

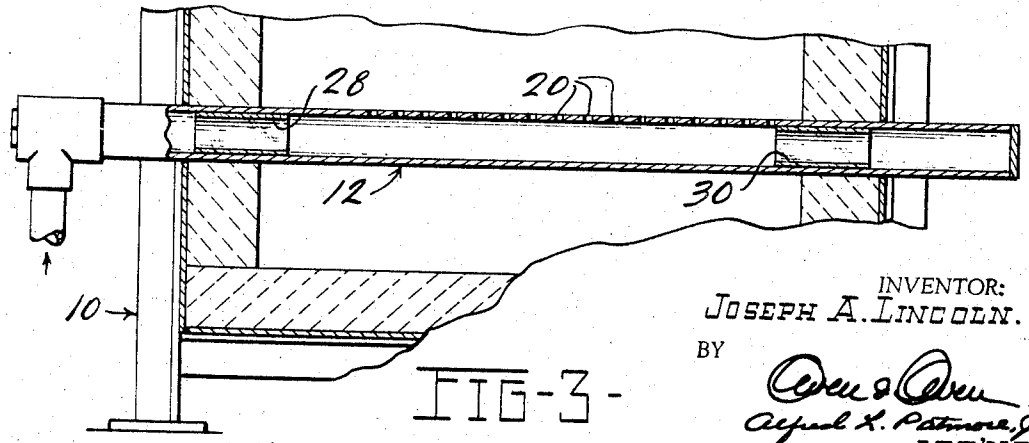


FIG - 3 -

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METHOD OF REDUCING CARBON DEPOSITS ON SURFACES IN CONTACT WITH CARBONACEOUS GASES AND SUBJECTED TO ELEVATED TEMPERATURES

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This invention relates to a method for substantially reducing undesirable carbon deposits onto surfaces from carbonaceous gases, and more particularly to a method of providing a means at the inner surface of at least a certain portion of a passage for reducing deposition of carbon from carbonaceous gases carried in the passage.

The use of a carbonaceous gaseous atmosphere in a heat-treating furnace to aid in the treatment of parts therein, for example, to cause an extremely hard surface to be formed on the parts, is well known. In such furnaces, the carbonaceous gas is usually supplied through an inlet passage or tube extending through a wall of the furnace. In these furnaces and also in other applications using carbonaceous gases, it is common to remove part of the carbonaceous gases from the furnace or from other heated regions through sampling tubes, to determine the compositions of the gases.

In both the inlet passages or tubes and in the sampling tubes, it has been known that carbon is deposited from the gases and that the deposits occur almost exclusively in portions of the tubes where the temperature is within the range of 1100°–1300° F. For years, such deposits have been attributed to cracking of the gases and were considered to be impossible to eliminate, other than by periodic cleaning by physically removing the deposits from the tubes. In some instances, the deposits have occurred with sufficient rapidity that cleaning several times a week has been necessary, involving substantial labor costs and even sometimes requiring shutdown of the entire heat-treating operation. In other instances, proposed systems for handling the carbonaceous gases in certain ways have had to be discarded because of the deposition problem.

The present invention is based upon the discovery that certain material can be applied to the inner surfaces of passages or tubes through which carbonaceous gases flow to substantially reduce build-up or deposition of carbon therein. More specifically, it has been found that materials effective in accomplishing this result are those having a positive standard electrode potential, based upon the standard electrode potential of sodium as being negative. Apparently, the effectiveness of the materials at the inner surface of the passages is achieved because the deposition of the carbon is caused by an electromotive force and not by cracking of the gases, as has heretofore been commonly believed. In retrospect, it is believed that one part of the tube may act as an anode and another part, contiguous with the first or spaced therefrom by a greater or lesser distance may act as a cathode. The carbonaceous atmosphere must undergo a composition change at temperatures within the indicated range to initiate the galvanic action and then serve as the electrolyte through which an electric current flows to cause erosion of the anode. On the other hand, although less likely, the carbonaceous gas may simply act as an anode and the passage or tube in which the gas is carried may act as a cathode of a galvanic cell to cause the carbon deposition. Apparently, the substantial reduction and, in most instances, elimination of the carbon deposition occur because of the passive nature of the material used, which tends to prevent the galvanic action. This result does not explain which type of galvanic action is involved.

Specifically, tests have shown that copper, quartz, and

carbon inserts can be used in those portions of a tube or passage subjected to a temperature within the range of 1100°–1300° F. to produce the desired effect. In addition a coating of aluminum can be provided in the corresponding portion of the tube with substantially equal effectiveness, the exposed surface of the aluminum subsequently oxidizing. These materials have been found to be most effective not only from the standpoint of deposition reduction but also from the standpoint of material costs.

While the copper has been found to be effective in deposition reduction, it does have the disadvantage that it tends to oxidize when there are no carbonaceous gases passing through the tube and the copper is subjected to oxygen from the atmosphere. Other materials with a positive standard electrode potential, and which could also be used, include silver, platinum, gold, silicon, and metal and metalloid oxides.

It is, therefore, a principal object of the invention to provide means for substantially reducing deposition of carbon from carbonaceous gases in the interior of passages or tubes through which gases are carried.

Other objects of the invention will be apparent from the following detailed description of a preferred embodiment thereof, reference being made to the accompanying drawings, in which:

FIG. 1 is a schematic view in vertical cross section of a furnace and a tube made of a common material, showing typical carbon deposition within the tube after a short period of operation;

FIG. 2 is a graph showing the temperature along the length of the tube of FIG. 1; and

FIG. 3 is a view similar to FIG. 1 of a furnace and a gas-carrying tube according to the invention, after operation for the same period of time.

Referring to FIG. 1, a furnace indicated at **10** has a tube **12** for carrying a carbonaceous gas. The tube **12** extends through a back wall **14**, through a heating chamber **15**, and through a front wall **16** of the furnace, but it is to be understood that the invention is not limited to a furnace or tube of a particular design. Carbonaceous gas is supplied to a rear inlet **18** of the tube **12** and enters the chamber **15** thorugh orifices **20**. The front end of the tube beyond the front furnace wall **16** is closed by a cap **22**. With this arrangement, the gas between the inlet **18** and the orifices **20** is constantly in motion whereas the gas between the front orifice **20** and the cap **22** is relatively stagnant.

As shown in FIG. 1, a carbon deposit **24** accumulates in a portion of the tube subjected to a temperature ranging from about 1100° to about 1300° F. and a somewhat smaller but still significant deposit **26** is formed at the stagnant end of the tube where a similar temperature range exists. The extent of the deposits depends upon a number of factors, including the concentration of carbon in the gas, the volume or rate of flow of gas, and the length of the tube in the 1100°–1300° F. temperature range.

In a specific example of operation of the apparatus of FIG. 1, the furnace **10** was maintained at a temperature of 1700° F. and the tube **12** was 8½ feet long with 1½ inch I.P.S. Twenty-four of the orifices **20** were drilled centrally in the top of the tube **12** on two-inch centers and with 3/16 inch diameters. The carbonaceous gas used was produced by adding 5% methane, by volume, to a gas which has a typical composition, by volume, of 0.1% CO_2, 20.7% CO, 40.6% H_2, 0.4% CH_4, 0.3% H_2O, and 37.9% N_2. The gas was supplied through the tube **12** at a rate of 120 cu. ft. per hour. The tube **12** was made of an alloy steel containing 15% of chromium, 35% of nickel; 0.25% maximum carbon, balance iron. The deposits **24** and **26** are shown as they existed after the carbonaceous gas was supplied to the furnace **10** for a period of eight hours.

Thermocouples were located along the tube 12 to measure temperature distribution which was as shown in FIG. 2. As can be seen from a direct comparison of FIGS. 1 and 2, the tube temperature ranges from near ambient at the inlet 18 to a high temperature of about 1700° F. at a point approximately three feet from the inlet 18, which point is approximately one-and-one-half feet from the inner surface of the back wall 14. Consequently, an intermediate part of the tube 12 extending through the wall 14 is subjected to temperatures within the critical range of 1100°–1300° F. and it is in this area that the carbon deposition 24 occurs. Similarly, a portion of the opposite end of the tube falls within the 1100°–1300° F. range, although this portion is shorter since the temperature differential is sharper at the right hand end of the tube where the gas is stagnant.

Referring more particularly to FIG. 3, the components are identical to those shown in FIG. 1 except that the tube 12 now has a thin cylindrical quartz insert 28. This insert has a length sufficient to cover the inner surface of the tube in the region which is at a temperature between 1100°–1300° F. when the furnace is in operation. Preferably, the insert 28 has an outer diameter equal to the inner diameter of the tube 12 and has a thickness sufficient to provide adequate strength and integrity for the insert. Another quartz insert 30 is also located in the tube at the right hand portion which is subjected to temperatures within the range of 1100°–1300° F.

It was found that when the apparatus of FIG. 3 was operated as described above, referring to FIG. 1, no carbon deposit build-up whatsoever occurred in eight hours either on the insert 28 or on any part of the inner surface of the tube adjacent the insert 28. While a very fine layer of carbon appeared on the insert 30, it was much too fine to measure. As indicated previously, the latter layer apparently was caused by reduced solubility of the carbon in the gas at the lower temperatures. Even after the furnace was operated for approximately one week, no carbon deposit was found on or near the insert 28 and the deposit on the insert 30 was only slightly more than that existing after eight hours.

While the problem of carbon deposit has been discussed in connection with a ported tube, the deposit also is a problem with other tubes which are subjected to the 1100°–1300° F. temperature range and which carry carbonaceous gases. This includes direct inlet tubes which supply gas directly into a carburizing furnace, for example, and also to sampling tubes by means of which carbonaceous atmosphere gases are withdrawn from a furnace chamber for purposes of testing.

In some instances, the problem of carbon deposit is so great that carbonaceous gas-carrying tubes cannnot be used at all. For example, in rotary retort furnaces, a long alloy cylindrical retort extends horizontally through a furnace and is rotatably supported at its ends. The retort has an internal helical ridge which causes parts in the bottom of the retort to be moved along as the retort rotates. A carbonaceous gas is fed into the retort at one end for the purpose of carburizing parts, while the furnace is heated by enclosed radiant tubes, as is well known in the art. It has heretofore been suggested that a ported carbonaceous gas-supplying tube be used in place of the usual tube which merely supplies the carbonaceous gas at one end of the retort. The ported type of tube would enable the carbonaceous gas to be supplied at particular portions of the retort in which the parts can be most effectively carburized. However, the heavy carbon deposits formed within ported tubes have rendered such use impractical. With the inserts according to the invention, such tubes can be used to advantage and without any plugging problem.

It has also been proposed heretofore that atmosphere gas be recirculated through atmosphere furnaces so that more effective use of the gas could be achieved. However, the problem of carbon deposits again made such proposals impractical since the tubes through which the gases were to be recirculated would quickly plug. With the tube inserts according to the invention, however, the use of such tubes is feasible.

While the inserts 28 and 30 in FIG. 3 have been described specifically as being quartz or silicon dioxide, the inserts can also equally effectively be made of carbon. Further, copper inserts have also been effective for the purpose but have the disadvantage that they oxidize when they are hot and are subjected to oxygen of the atmosphere. It has been found also that a coating can be applied to the interior surface of the tube to reduce or eliminate carbon deposition. For this purpose, a coating of aluminum can be applied to the tube in the critical portion thereof and no carbon deposit will be found in the coated portion of the tube. It is important in the case of aluminum that no de-oxidizer be used in order that the aluminum surface is oxidized to alumina. If a de-oxidizer is used with the aluminum so that the oxide of the aluminum is not present, the carbon will build up even more rapidly than in the case of the bare alloy. Actually, as mentioned previously, any material can be used at the inner surface of the carbonaceous gas-carrying tube to reduce carbon deposits, if the material has a positive standard electrode potential, based upon the potential of sodium as being negative. This includes gold, platinum, and silver which are not commercially practical from a cost standpoint but, nevertheless, are effective from the standpoint of substantially reducing carbon deposits.

Various modifications of the above-described embodiments of the invention will be apparent to those skilled in the art, and it is to be understood that such modifications can be made without departing from the scope of the invention, if they are within the spirit and tenor of the accompanying claims.

I claim:

1. In the method of preventing deposition of carbon from a heated carbonaceous gas, the steps comprising: securing a tube in confluent relationship with a furnace, providing that portion of the tube having a temperature between 1100° and 1300° F. with a lining having a positive standard electrode potential, based upon the standard electrode potential of sodium as being negative, and passing the carbonaceous gas through said tube.

2. The method of claim 1 wherein said lining is a metallic oxide.

3. The method of claim 1 wherein said lining is a metalloid oxide.

4. The method of claim 1 wherein said lining is aluminum oxide.

5. The method of claim 1 wherein said lining is carbon.

6. The method of claim 1 wherein said lining is quartz.

7. The method of claim 1 wherein said lining is copper.

8. In the method of preventing the deposition of carbon from a heated carbonaceous gas, the steps comprising: securing a tube in confluent relationship with a furnace, providing a positive electrode potential, based upon the standard electrode potential of sodium as being negative, to that portion of the tube having a temperature range of 1100° to 1300° F. and passing the carbonaceous gas through said tube.

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