From these facts it would appear that the attack of atmospheric oxygen on Bruceton coal is different from its attack on Wyoming coal. The oxygen reacts with structures in Bruceton coal to give oxygenated materials that are quite susceptible to hydrogen attack leading to easy elimination of oxygen.

Gasification of Coal

Vortex Combustion Studies for Powdered-Coal Gasification

In an experimental unit of the vortex type, the gasification of coal with oxygen and steam was studied, and a specially designed coal distributor was used, which spread the coal throughout the unit by means of a spinning plate. Despite a very great improvement in gas composition and an increase in carbon conversion of more than 15 percent at the same oxygen-to-coal ratio with the spinning-plate distributor, it was soon evident that some other means of increasing carbon conversion must be sought. The most promising method of doing so was to decrease the size of the particle to bring its equilibrium radius within the vortex, or, correspondingly, by increasing the tangential velocity. The vortex design used up to this point - that is a vortex 2 feet in diameter, 8 inches deep, and containing nine slots each 3/8-inch by 2-inches - was selected because it gave the maximum tangential velocity for the gas throughputs required for gasification. However, if a shallower vortex were used, the tangential velocity should increase. From a theoretical standpoint, reducing the depth of the vortex by half will reduce the size of the particle, leaving the reaction zone by one-half if both the radial and tangential velocities are doubled.

Accordingly, after suitable changes in equipment design, experiments were carried out that showed that no change occurred in the carbon conversion when the vortex was reduced to 4 inches. Further reduction in depth to 2 inches decreased the carbon conversion by 9 percent. As the reduction in depth also decreased the time available for gasification and increased the coal throughput per cubic foot of reactor volume, these results possess considerable significance. Tests made with the 2-inch vortex showed that, as was the case with the 8-inch vortex, the carbon conversion remained essentially constant when the coal throughput was varied at the same oxygen-to-coal ratio.

To provide greater flexibility for determining the effect of the geometry of the reactor on carbon conversion, major design alterations were made that resulted in a vortex 24 inches in diameter, 24 inches deep, and containing an outlet diameter of 4 inches, with nine slots, each 3/8 inch by 2 inches, at the top of the reaction chamber. Contrary to the results found by previous investigators, tests made with a "forced" vortex in a reactor containing a concentric silicon carbide tube produced carbon conversions much lower than those obtained with a "free" vortex in a reactor unmodified by the center tube. In a test made to determine the effect of introducing the gases through slots at the bottom of the reactor, the carbon conversion was found to be about 10 percent lower than for the same feed conditions with slots at the top of the reactor.

Experimental work with the vortex reactor is thus being directed toward solution of the following problems:

1. To determine whether the thermodynamic method of correcting for heat losses in terms of an equivalent amount of oxygen can be experimentally verified for the vortex reactor. This problem can be attacked by (a) varying the throughput to the reactor, thereby changing the heat losses per pound of coal, (b) preheating the oxyg

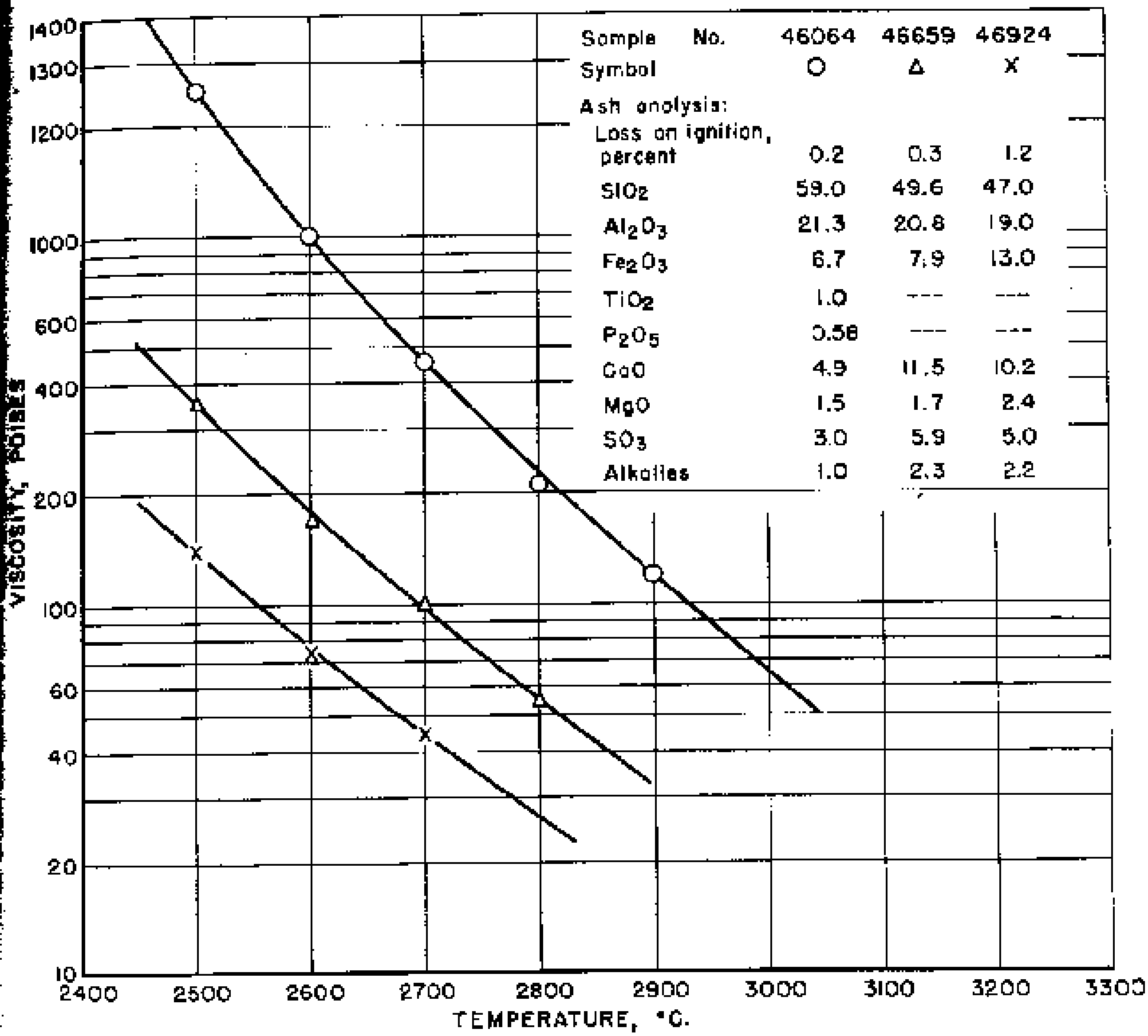

Figure 46. - Effect of temperature on viscosity of three coal-ash slags from Rock Springs coal.

at constant throughput, and (c) lagging the reactor to reduce the heat loss per hour from the reactor.

2. To determine systematically the effect of reactor depth on carbon conversion at constant oxygen- and steam-to-coal ratios and at constant heat loss per pound of coal. It is expected that this information will yield an empirical expression for the kinetics of the gasification reactions for this type of reactor.

3. To investigate the effect of diameter-to-depth ratio of the reactor and the effect of the number of inlet tangential ports on the carbon conversion. The results of these tests should lead to a rational design of the vortex-type reactor.

4. To operate a newly constructed coal distributor in which oxygen and coal can be fed together and thereby determine whether the introduction of oxygen with the coal will affect the carbon conversion with all the other process variables maintained constant.

One test was run with the vortex reactor using a low coal throughput. As predicted by the thermodynamics of the process, the higher heat losses per pound of coal at these conditions resulted in decreased carbon conversions. Tests were made with preheated oxygen and steam, from which preliminary calculations indicate that the resulting increase in carbon conversion is approximately that predicted by the thermodynamics of the process.

Preliminary work on a mock-up of a vortex reactor indicates that (1) the roughness of the vortex walls has a marked effect on the tangential velocity in the vortex; (2) there is fair agreement between the static-pressure method and the pitot-tube method of determining tangential velocity; (3) increasing the number of tangential gas ports from two to eight did not change the tangential velocity in the vortex, but when only a single port was used, the tangential velocity in the vortex was decreased; and (4) increasing the vortex reactor depth from 8 to 24 inches did not change the tangential velocity in the vortex.

The probable viscosities of the slags of various temperatures from the ash of three different Rock Springs coals were computed and compared from the standpoint of their ability to be tapped from gasifiers. Figure 46 shows the slag viscosity in poises as a function of the slag temperature. These curves are based upon the assumption that the slag is completely liquid at any given temperature. If, however, a solid phase begins to separate, the slag no longer behaves as a Newtonian fluid, and the part of the curve in that temperature range is not applicable. The calculated temperatures of critical viscosity, T_{cv}, for the three samples were: No. 46064, 2,900° F.; No. 46659, 2,250° F.; and No. 46924, 2,250° F. If 100 poises is assumed as the maximum viscosity that can be tapped without difficulty, it appears that sample No. 46924 could be tapped at 2,550° F., whereas No. 46659 would require 2,700° F. and No. 46064, 2,930° F. As the slag temperature may be higher or lower than the gas temperature at the tap hole, depending on the design of the unit, optical pyrometer measurements of slag temperatures afford the best means for correlating these data with actual performance.