rec'd 7-10-89

DOE/PC/79850--7

DE92 005209

Nitrogen Oxide Abatement by Distributed Fuel Addition

Contract DE-AC22-87PC79850

Quarterly Report No. 7

Received by OSTI

DEC 30 1991

for Period

February 1, 1989 through April 30, 1989

Prepared by

J. O. L. Wendt and J. B. Mereb
Department of Chemical Engineering
University of Arizona
Tucson, Arizona 85721
(602) 621-6045
c/o Dr. Jost O.L. Wendt

Submitted to

Diane Revay Madden, Project Officer
Environmental Control Technology Division
Pittsburgh Energy Technology Center
Department of Energy

June 20, 1989

ABSTRACT

The design and the rebuilding of a new combustor was completed. Several new features were incorporated in the new design so that it would last longer. The design and construction of the furnace are discussed in this report.

INTRODUCTION

Experiments for Task 2 resulted in the destruction of large sections of the inner lining of the experimental furnace. This was caused by the high temperatures and the erosive slagging conditions of the reburning experiments, especially in the reburn zone (furnace midsection). As the coal was burned, metal rich slag diffused into the inner surface of the fire tube and eventually became a part of it. Additional usage of the combustor caused further deposition of slag on the surface. Consequently, the slag buildup became heavy causing it to slump and collapse, taking with it a part of the furnace lining. As the destruction of the furnace wall became more pronounced, the support for the utility ports, consisting of 2 inch ID mullite tubes, became weak. Cracking of the mullite tubes and/or shifting of the port location followed. This slow process eventually resulted in the reduction of the insulating quality of the fire tube wall, in addition to changes in the geometry of the furnace and the flow patterns inside it.

In short, the slow destruction of the furnace lining due to slagging made it necessary to rebuild the combustor after the completion of Task 2. The design of the new combustor is a modified version of the previous one. The goal was to construct a longer lasting furnace and, if possible, to reduce the cost of maintaining it which is the focus of this report.

DESIGN AND CONSTRUCTION

The design of the new combustor, as seen in Figures 1 and 2, is similar to that of the previous one with two major modifications:

1. An inner layer of silicon carbide refractory replaced the inner layer of alumina cylinders.

2. A slab was constructed to support the utility ports of the combustor.

The inner layer of vacuum formed Zircar alumina cylinders was replaced by a layer of silicon carbide refractory. This material provides excellent resistance to abrasion and slag and thus protects the expensive two Zircar layers surrounding the refractory layer. Silicon carbide (Carborundum 11-LIG) was casted in place using hard cardboard forms. Information provided by the manufacturer (Sohio, Refractories Division) indicates that it has a low iron content of about 0.5% which assures good resistance to corrosive slag. It has a hydraulic bond which provides strength that is more than 10 times that of Zircar. The result is a solid structure that would prevent the bending and shifting of the fire tube. In addition, its non porous structure prevents the slag from penetrating the refractory. And its high conductivity, approaching that of alloy steel at high temperatures, would result in a uniform slag layer forming over the refractory which would act as an additional wear resistant shield.

Two layers of high purity Zircar cylinders (grade ASH, recommended to 1430 C) constitute the remainder of the combustor wall. The space between the wall and the surrounding steel shell was packed with Kaowool 2300 insulation fiber (Babcock and Wilcox) to a density of 0.20 # 0.02 g/cc.

A slab, 11.5 cm thick, was constructed of Kaolite 2200 (Babcock and Wilcox) insulating refractory extending from the outer surface of the combustor wall to the cylindrical steel shell. The purpose of this slab was to provide an alternative to the use of the expensive mullite tubes as utility ports which allows the insertion of various water cooled probes into the furnace for sampling, temperature measurement or injection. Cylindrical tunnels, 5.1 cm in diameter, supported by the structure of the slab and providing access into the furnace, would serve the same purpose, in addition to a much longer expected service time.

At the top of the furnace, an expansion cone, 22.9 cm high, was made from Kaocrete 28-Li castable refractory (Babcock and Wilcox) expanding from 5 cm at the entrance to the full 14.5 cm of the combustor internal diameter.

SUMMARY

A new combustor with a modified design was constructed. This combustor has two advantages over the previous one:

1. It is expected to have longer service time and reduced maintenance downtime. Silicon carbide has proved to give excellent erosive service as was shown by the performance of a similar type of combustor in our laboratory.

2. The cost of rebuilding the combustor (about $2100) was reduced by 35%.

The performance of the combustor is expected to be similar to that of the previous combustor. The thermal properties of the new combustor would be different from those of the previous one due to the addition of the highly conductive silicon carbide and the slab. The effects of these changes on the temperature profiles inside the furnace are expected to be of minor significance for our experimental purposes. Nevertheless, these expectations remain to be experimentally verified. Radial concentration and temperature profiles along the length of the combustor can provide information about the flow patterns and the thermal properties of the combustor.

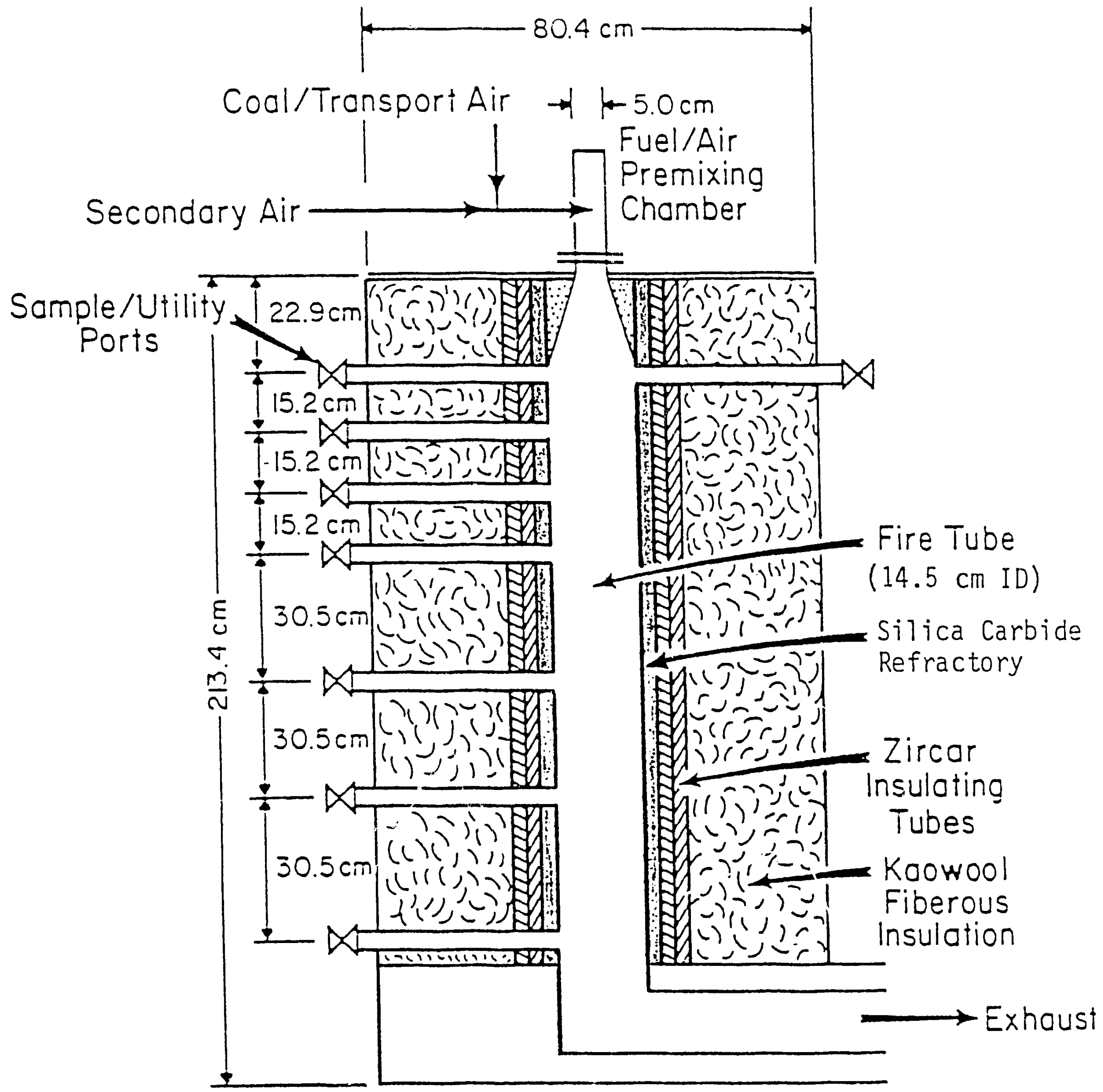
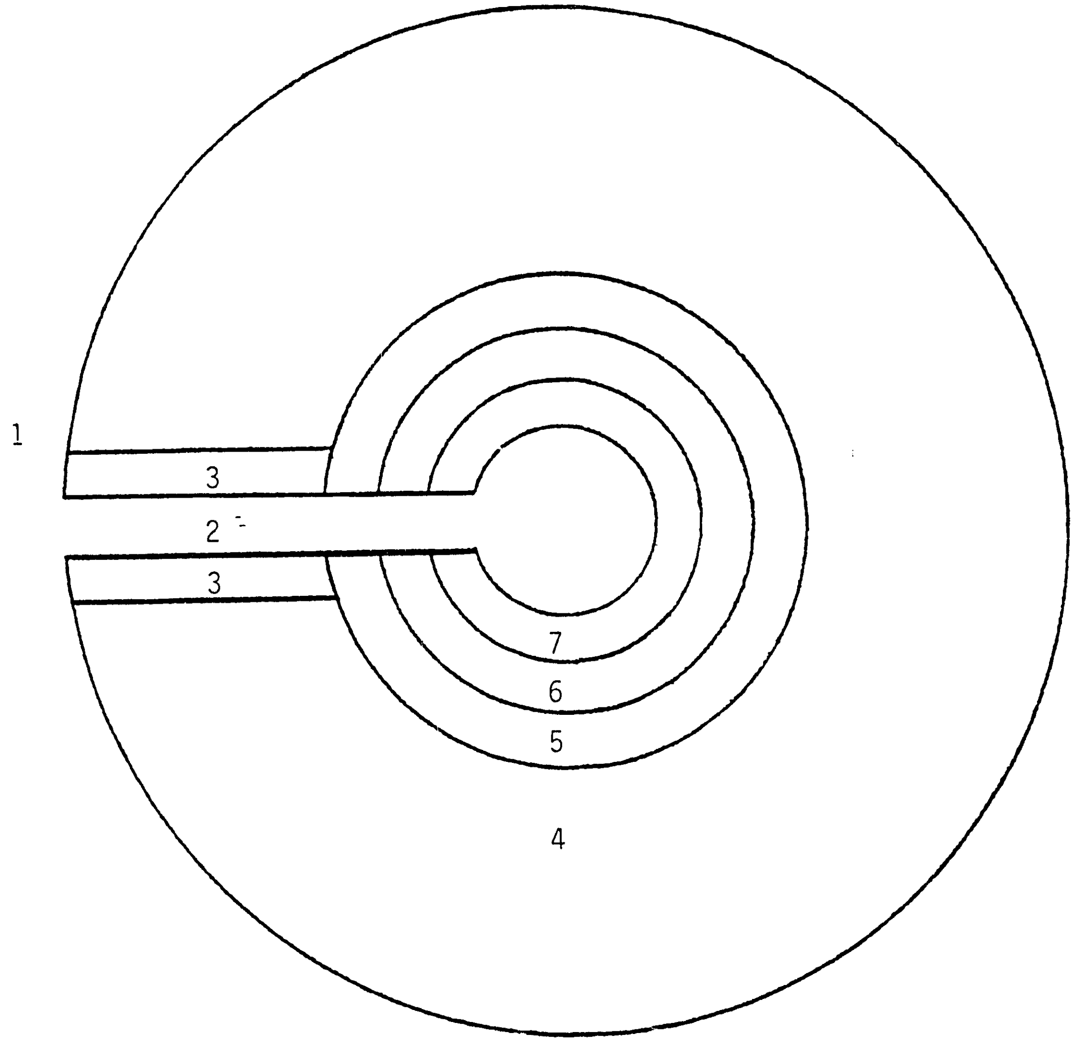


Figure 1. Experimental Combustor



1. Cylindrical Steel Shell, 80.4 cm O.D., 0.635 cm thick
2. Cylindrical Tunnel, 5.1 cm Diameter
3. Slab, Insulating Refractory, 11.5 cm thick
4. Kaowool Fiberous Insulation
5. Zircar Insulating Tubes, 22.9 cm I.D., 27.9 cm O.D.
6. Zircar Insulating Tubes, 17.8 cm I.D., 22.9 cm O.D.
7. Silica Carbide Refractory, 14.5 cm I.D., 17.8 cm O.D.

Figure 2. Combustor Schematic

END

DATE
FILMED
2/10/92