PROGRESS REPORT NO. 13

KINETICS OF OXIDATION AND QUENCHING OF COMBUSTIBLES IN EXHAUST SYSTEMS OF GASOLINE ENGINES

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LONG-RANGE OBJECTIVES

It is well-known that a significant amount of CO and unburned fuel may be consumed in the exhaust system of gasoline engines. Such combustion phenomena in exhaust reactors may be used to advantage to reduce the emission of these undesirable constituents. This process is the basis of exhaust air injection systems currently installed on some automobiles.

The overall objectives of this three-year research program are:

- To determine the chemical and physical processes which affect the emission characteristics of exhaust reactors installed on selected typical engines operating at various conditions on a dynamometer test stand.
- To identify the chemical species and significant chemical reactions present before, within, and after the reactor.
- To obtain information which will be helpful in predicting the design of the next generation of gasoline engine exhaust reactors.

GENERAL

A contract has not been executed for the second year at this writing. It is hoped that a contract can be negotiated next month.

PHASE I PROGRESS

Baseline evaluation of the 350 CID Chevrolet engine has been completed. It is felt that adequate data on the effect of speed, load, timing, and mixture ratio have been gathered. Moreover with the completion of the hydrogen meter,

the process instrumentation development has been virtually finalized.

Figure 1 shows a curve of corrected dry hydrogen as measured by our thermal conductivity meter versus measured dry CO. Data taken on two days is shown. Indolene fuel of approximately $CH_{1.86}$ was used. Plotted for comparison are theoretical curves for $CH_{2.00}$ and $CH_{1.75}$ from D'Alleva.[1] D'Alleva assumed the water-gas reaction with 'K' equal to 3.8. The greater than theoretical amount of hydrogen near chemically correct probably results from cycle-to-cycle and cylinder-to-cylinder mal-distribution. Similar behavior of CO and O_2 is common. At this time we have no explanation for the low H_2 readings (compared to D'Alleva) at high % CO. NO readings were not obtained for Run 1. Therefore the NO correction was estimated.

Experience with the hydrogen meter to date suggests that other exhaust gas constituents do interfere with the H_2 readings. These interferences are summarized in Table I. The most serious interference measured was that of NO. 1% NO appears to the meter as .5% H_2. This interference is most troublesome near chemically correct mixtures where H_2 is small and NO is approaching a maximum. The large NO interference has not been explained yet. The CO interference is the next largest and is in fact relatively small. It tends to be a constant percentage correction because of the water-gas equilibrium situation prevalent in exhaust gas. At 10% CO where hydrogen concentration is about 5% the CO correction adds about .25% hydrogen to the measurement, an interference of 5%. CO_2 and water vapor have large responses and are therefore removed prior to

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[1] D'Alleva, B. A. "Procedure and Charts for Estimating Exhaust Gas Quantities and Compositions," GM Research Report 372, 1960.

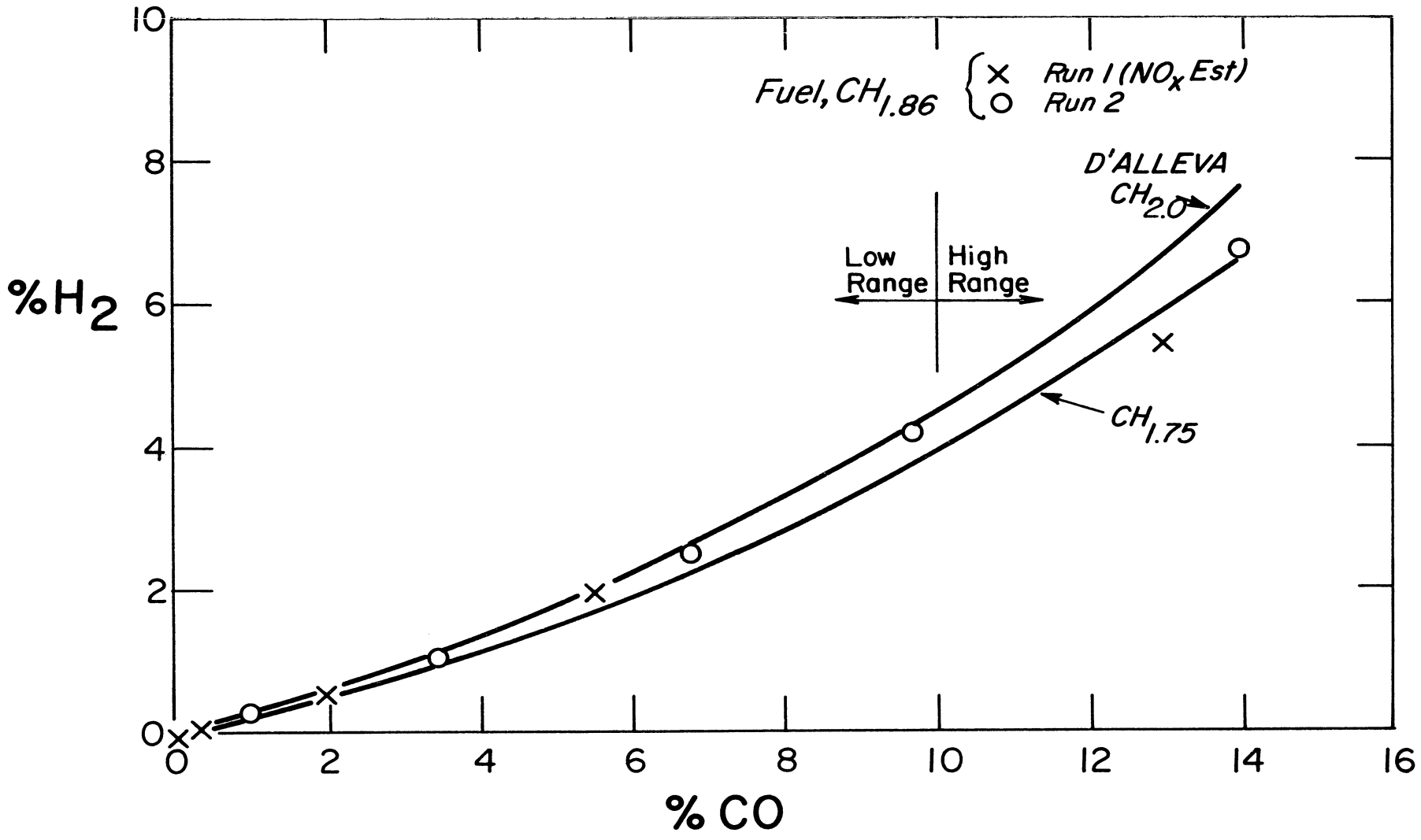

Figure 1. % H_2 versus % CO. Solid lines are theoretical values from D'Alleva, Reference 1. 350 CID V-8 1200 rpm, 50% FL, MBT spark.

measurement. The final hydrogen values are corrected to a dry basis containing CO_2, the same basis upon which the other constituents are reported. The next step in Phase 1 is to install the du Pont reactors.

TABLE I

RESPONSE OF HYDROGEN METER TO EXHAUST GAS CONSTITUENTS

Constituent X	Laboratory Gas Concentration, % X in N_2	Meter Reading, mv	% H_2/% X
H_2	4.1	8.20 (set point)	1.00
O_2	21.0 (air)	.42	.01
CO	5.0	.25	.025
NO	0.3	.3	.5
N_2	100.0	0	0
HC	.072 (720 ppm hexane)	0	0
CO_2	removed	---	---
H_2O	removed	---	---

PHASE II PROGRESS

Attempts to apply the stirred tank reactor model developed earlier to higher levels of exhaust gas combustibles (represented by approximately 8% CO, 4% H_2 and 500 ppm CH_4) met with computational difficulties due to "chattering" as the conversions approached unity. In particular, the computed concentrations for oxygen and oxidation products (water and carbon dioxide) were found to increase without bound due to extents of reaction over one computational step that proceeded to large negative values of the combustibles rather than approaching zero as desired. Unrealistically high temperatures also resulted.

Efforts are being made to correct the instability in the model without

its flexibility in handling cyclic input. Corrections have been added to offset negative extents of oxidation reaction, and in the case of carbon monoxide the reverse reaction has been added. Work on this aspect of the program will continue.

During the following month regression routines will be investigated to obtain a program well suited to treatment of kinetic data from the two-tank experimental reactor.

PHASE III PROGRESS

A man has been engaged to continue the gas chromatographic work. The two-tank reactor has been received from Walker Manufacturing Company. Next this reactor will be installed on a single cylinder engine.

OVERALL FINANCIAL SUMMARY

Program Total: February 24, 1969 - February 23, 1970		$106,455
Cumulative Expenditures through February 23, 1970		106,569
	Balance	$ (114)