PROGRESS REPORT NO. 23

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

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PERIOD: January 1, 1971 to January 31, 1971

January, 1971

This project is under the technical supervision of the:

Coordinating Research Council
APRAC-CAPE 8-68 Steering Committee

and is work performed by the:

Department of Mechanical Engineering
The University of Michigan
Ann Arbor, Michigan

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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.

PROGRESS PHASE I

MULTICYLINDER REACTOR

Last month, an unexplained increase in hydrocarbon emission arose from the 350 $in.^3$ engine. Upon inspection severe scoring was evident in most cylinder bores. We have no explanation for the cause of the scoring, but feel it is probably not associated with the thermal reactors. A new 350 $in.^3$ engine has been obtained from Chevrolet and is currently being installed. The old cylinder heads, intake manifold, carburetor, and exhaust reactors have been installed. The comparison ratio of this

new setup will be nominally 8.8:1 as opposed to 9.0:1 previously.

Thermocouples have been received for measuring the reactor warm-up characteristics. These will be welded to the surfaces of the right-hand reactor.

Currently emission equipment and personnel have been shifted to the single cylinder reactor.

SINGLE CYLINDER REACTOR

The temperature control system described in the previous progress report was installed this month, the reactor system was reinsulated, and a series of runs was begun to determine the degree of uniformity of temperature in the reactor, the repeatability of the kinetic data, and the importance of wall effects. Early results indicate that the temperature in the reactor is reasonably constant and that the wall temperature is quite close to the gas temperature. The sum of the measured flow rates of air and fuel to the engine and injection air to the reactor agreed quite well with the measured flow rate through the sparger tube, and the system was checked after running and found to be free of leaks. The regression program to determine the kinetic constants has not been applied to the new data as yet, but will be when more runs are completed.

PROGRESS PHASE II

Primary efforts during the month involved literature research on mixing and turbulence, and finalizing the regression routine to be used

for the single cylinder reactor. Emphasis will next be concentrated on "second generation" models.

These models will not endeavor to simulate the detailed performance features of the DuPont reactor per se. Alternatively, models which permit evaluation of importance of design factors on performance will be employed.

Second generation models will likely treat only steady inputs. The alternative of treating time and spatial variation simultaneously is judged to be a formidable computational problem.

Models built up from components will assume premixing of air and exhaust. Extremes of micromixedness after premixing can be computed. The first step in this category will be the writing of a program for a simple steady-input tubular reactor, which gives the opposite extreme from the well-mixed model with respect to both micro- and macromixedness.

The random-coalescence-type model will treat the problem of intermediate micromixedness. It will derive its mixing parameters from the theory of turbulent mixing—subject to limitations on the size and permissible pressure drop in a reactor. The model will likely assume complete macromixing, as done by Curl. Evangelista had applied this model to combustors for arbitrarily selected kinetics. His approach for solving the integral differential equation for the model requires that all rate dependence (including temperature effects) be expressed as a polynomial with respect to extent of conversion. This is overly restrictive, and it is likely that a Monte Carlo solution will rather be employed. The mixing theory for jets used by Evangelista will be our starting point

in this effort. This being attributable to Cousins and earlier to Batchelor. A continuing literature survey is being conducted in this area. A reasonable extension of the theory would be to add a distribution for the size of the eddies undergoing mixing.

PROGRESS PHASE III

MEASUREMENT OF EXHAUST GAS VELOCITY

A new device to record the schlieren image, utilizing photodiodes as a light detector, was developed during the month of January in order to eliminate difficulties associated with the timing synchronization and manufacturing of a fast moving shutter for the measurement of the exhaust gas temperature.

Instead of using the streak photograph technique for the time measurement, several photodiodes will be mounted on the film plane with a fixed distance apart and the signal from the photodiode will be amplified and swept by an oscilloscope which is triggered by a signal from the engine.

Since the photodiode gives a continuous signal over any engine position and only the desirable portion of this signal is to be seen from the oscilloscope, the problem of complicated timing synchronization can be eliminated and the system does not require a shutter.

While two pin Hewlett-Packard Pin Photodiodes (response time less than 1 nsec) are ordered and the troubled laser unit was sent to the

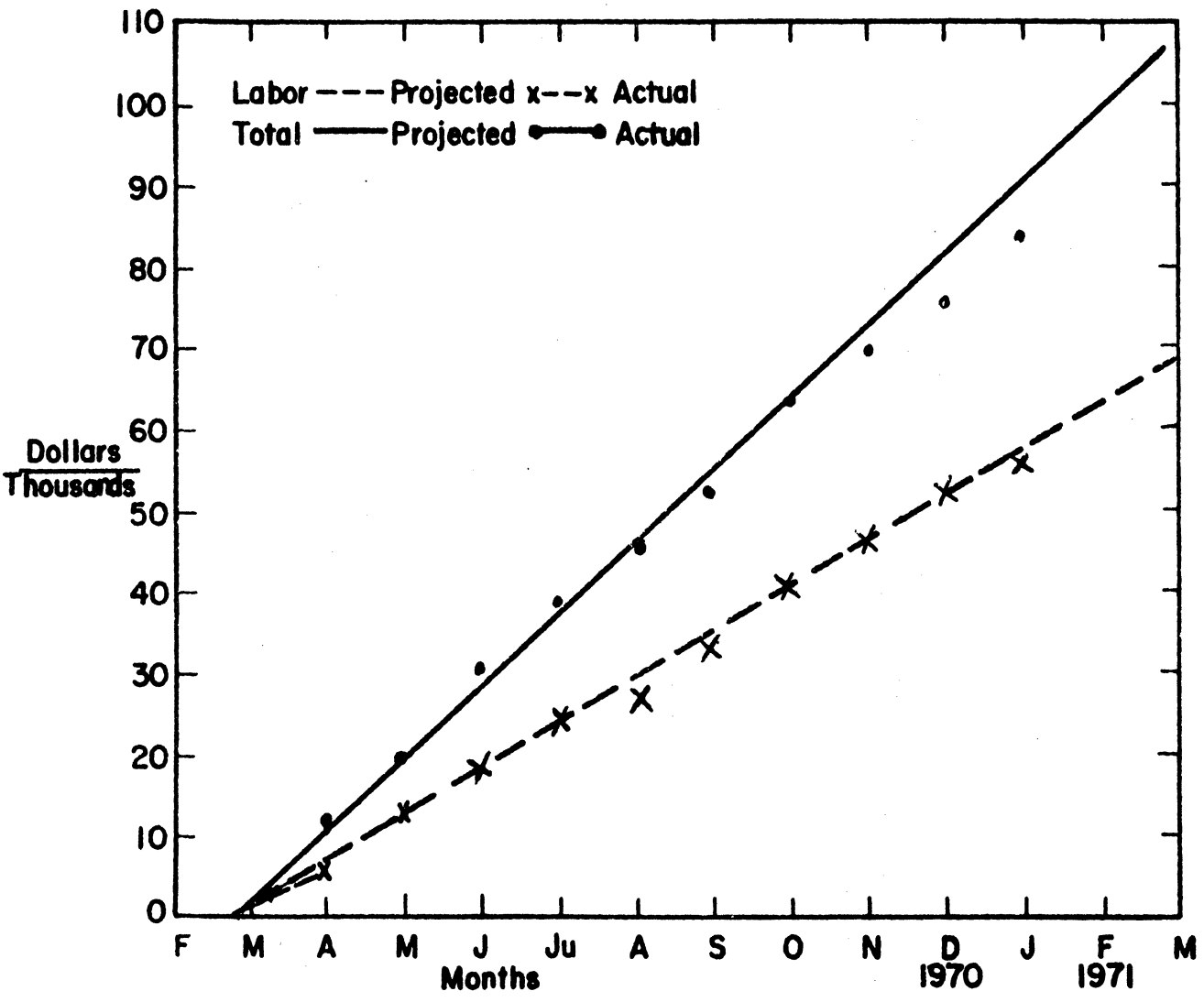
factory for repair, a photodiode assembly equipped with an amplifier is being fabricated. As soon as the ordered parts are received some preliminary data will be obtained from the new recording device.

GAS CHROMATOGRAPH

Work continues to upgrade our gas chromatograph.

CRC CAPE 8-68 PROGRAM
OVERALL FINANCIAL SUMMARY

Program Total: February 24, 1970 - February 23, 1971	$106,500
Cumulative Expenditure through December 1970	82,000
Balance	$ 24,500



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