EMISSIONS MEASUREMENTS IN INTERNAL COMBUSTION ENGINES

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ABSTRACT

Analysis of emissions such as oxides of Nitrogen, carbon monoxide, carbondioxide was conducted. Their knowledge and measurement in the emission may be used to determine how they can be reduced or eliminated.

1.0 INTRODUCTION

A full analysis of the performance of internal combustion engines is complex, and it involves consideration of the combustion process.
In practical engines and power plants the source of heat is the chemical energy of the fuels. This energy is released during the chemical reaction of the fuel with air. The fuel elements combine with oxygen in an oxidation process which is rapid and is accompanied by the evolution of heat. The combustion process results in the emission of chemical compounds some of which are poisonous and dangerous to human health. These emission are pollutants of the atmosphere. The knowledge of these pollutants in the emission and their measurements may be used to determine how they can be reduced or eliminated. In this work, analysis of pollutants such as oxides of Nitrogen No_x, carbon monoxide CO, and carbon dioxide $C0_2$ was conducted. Analytical methods have been developed for all gases of concern in air pollution. The analyst has to select the optimum method for his objective. The orsat gas analyser was used for the analysis in the present work.

An approach to the reduction in pollutant formation in engines is to increase the proportion of air, this was discovered by Springer and Patterson (1971), in this way they were able to reduce the No_x formation. A principal mechanism for removing No is shown by the folowing reaction.

$$0 + No = N + 0_2$$
$$N + No = 0 + N_2$$

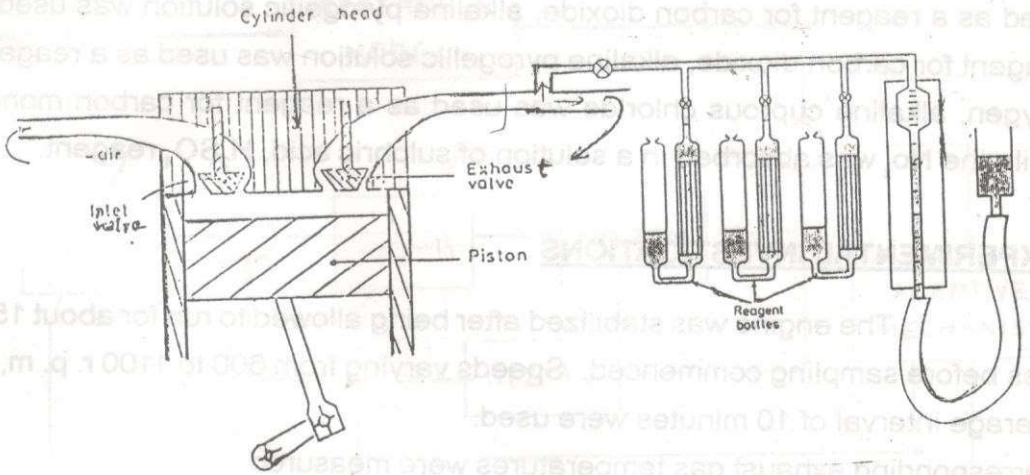
generally called the Zel ' dorich Mechanism.

As technology progresses, improved analytical methods for pollutants became availabe. Recent analytical methods generally have better sensitivity and reliability thus advancing knowledge concerning air pollution and its effect.

In the chemical analysis of multicomponent mixtures, two basic approaches are available which are, firstly, the mixture can be separated into individual components each of which can be indentified and measured quantitatively. In this method it is ensured that the separation is complete. The second approach is to determine a method of analysis in which the test gas is sensitive to only one compound (or group of compound). The latter method shall be used in this experimental investigation which is through the use of the orsat gas analyser.

EXPERIMENTAL APPARATUS

The apparatus used are the Gardner Diesel engine, stop clock, thermometers and the Gallen Kamp orsat gas analyser (this has different reagents in the absorption pipettes for absorbing the different gases released from the diesel engine).



The Gardner Diesel engine is a Compression - Ignition Engine where air only (which is provided through an air-filter system) is compressed, and the fuel is injected into the air in the engine cylinder by means of an atomizing nozzle injector. The compressed air-fuel mixture is usually at a sufficiently high temperature so as to

initiate combustion. The Diesel Engine also consists of a heat exchanger and an exhaust system through which the pollutants are emitted to the atmosphere. Diesel fuel is supplied to the Engine from a reservoir which is controlled by a pressure regulator needle valve. The engine is cooled by water which circulates internally round the engine block before passing through an outlet pipe to the atmosphere. Provisions are made for the insertion of thermometers to measure both water inlet and outlet temperatures as well as the exhaust gas temperature. The cooling water flow rate was determined by measuring the quantity of water that was collected in a bucket within a period of time. The fuel consumption rate was measured by timing the consumption of a constant fuel volume. The brake - power of the engine was obtained from the brake load applied to a hydraulic dynamometer and the engine speed. The engine speed was controlled by a hydraulic governor which is provided with the fuel injection system and this is measured with a laboratory tachometer.

The Orsat gas analyser has a varying number of absorption vessels for different gases, but the several versions of the analyser all operate on the same principle. The orsat gas analyser is usually used for the analysis of combustion gases in which case the absorbents are potassium hydroxide, alkaline pyrogallic acid and amoniacal cuprous chloride. The potassium hydroxide solution was used as a reagent for carbon dioxide, alkaline pyrogellic solution was used as a reagent for carbon dioxide, alkaline pyrogellic solution was used as a reagent for oxygen, alkaline cuprous chloride was used as a reagent for carbon monoxide while the No_x was absorbed in a solution of sulphric acid, H_2SO_4 reagent.

3.0 EXPERIMENTAL INVESTIGATIONS

The engine was stabilized after being allowed to run for about 15 minutes before sampling commenced. Speeds varying from 600 to 1100 r. p. m, at an average interval of 10 minutes were used.
Corresponding exhaust gas temperatures were measured.

The engine load was varied from 0 to 251b. Samples of the emissions (exhaust gas) were obtained from the exhaust pipe using by-pass valves. The Gallen Kamp orsat gas analyser was used.
The reagent in the absorption pipettes (which are numbered from left to right) are as follows: the first pipette had H_2SO_4 as its reagent and was to absorb No_x. Pipette No 2 had Alkaline cuprous chloride as its reagent to absorb carbon monoxide (CO). The third pipette containing potassium hydroxide solution as its reagent absorbed carbon dioxide (CO_2).

After carrying out the normal proceedure for operating the Orsat apparatus the products of the gas sample were absorbed one after the other.

The effectiveness of the emissions under varying engine operation conditions was determined by measuring No_x, CO, CO_2.
These measurements were taken at 10 minutes internal with and without overheating. This is obtained turning the cooling water flow valve to minimum and maximum levels which enables substantial quantities of No_x to be obtained and therefore allows for accurate confirmation of the existing theory that No_x formation is favoured by high temperature combustion of fuels. Upon Comp'etion of a series of tests, the experimental data were normalized.

These measurements were taken for cases of normal engine operation and overheated engine operation. The overheated engine operation was achieved by reducing the normal cooling water flow rate by about 50% in order to allow for the formation of a substantial quantities of No_x as a result of high temperature.

4.0 DISCUSSION OF RESULTS

The results are presented in graphical forms in Figs. 1 to 6. From the results obtained it was observed that at reduced water flow rate (50%), reminiscent of the overheating condition, No_x, CO & CO_2 formation rates were higher than when the water flow rate was normal (i.e. full cooling water flow rate, Figs. 1, 2 & 3). The reason for this is that undersirable emission from internal combustion engines especially No_x, are usually formed at high temperature of combustion. The condition was achieved by reducing the cooling water flow rate so that the engine operated at an elevated temperature. Fig. 4, the emissions of No_x, CO and CO_2 increase with increase in combustion temperature justified by increase in exhaust gas temperature. From Figs. 5 and 6 it can be observed that increase in speed or load increase the emissions of No_x, CO and CO_2.

5.0 CONCLUSIONS

High temperature of combustion resulting sometimes from overheating of the engine is undersirable as it can lead to increased No_x and CO formulations. These compounds are not suitable for Human Consumption. Increase in engine load leads to increase in combustion chamber temperature and hence increase in No_x and co formulations.

Increasing speed can also result in temperature and hence increase in No_x and co formulations.

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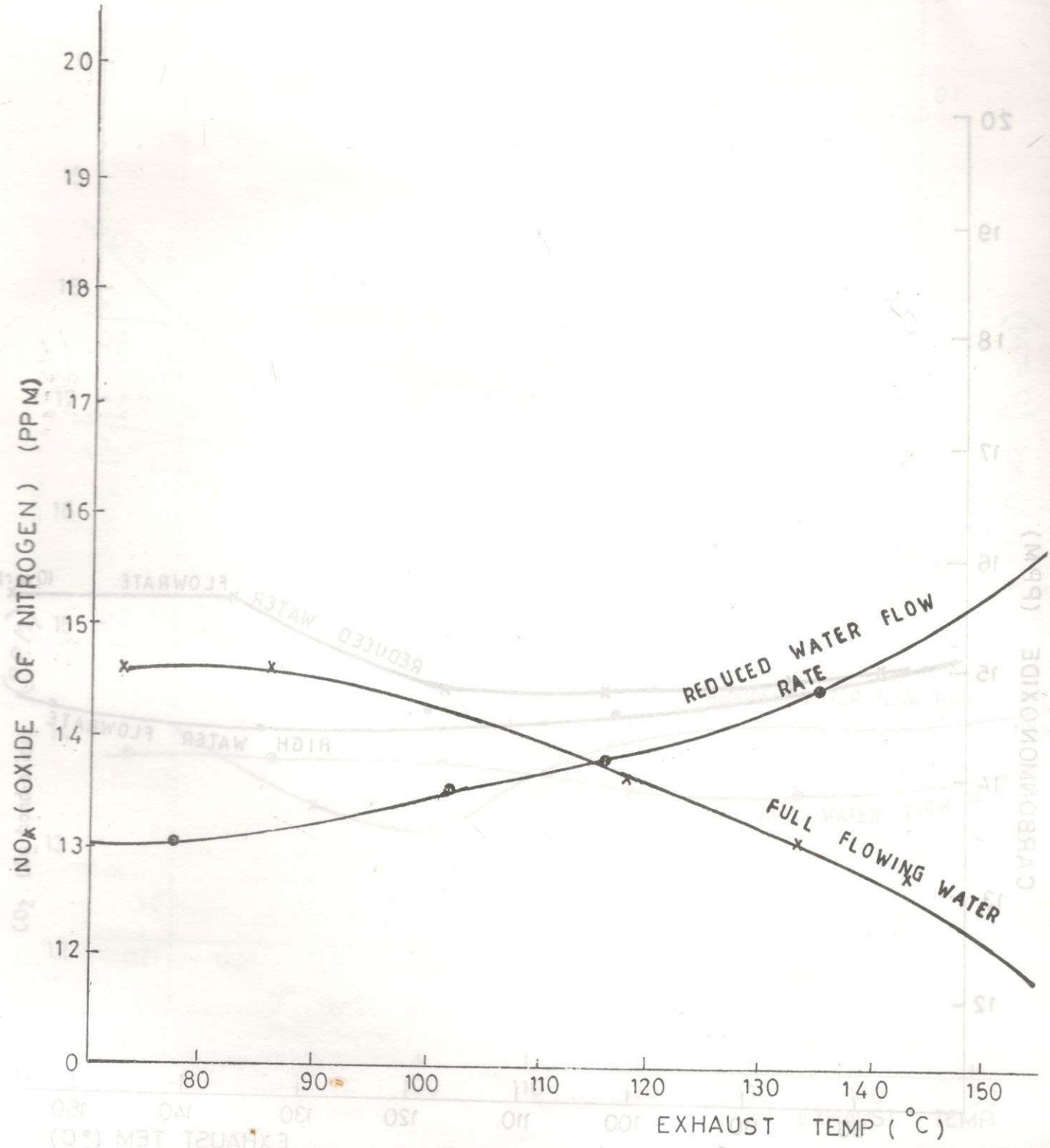


FIG.1. GRAPH OF NOx EMISSION AGAINST EXHAUST TEMPERATURE

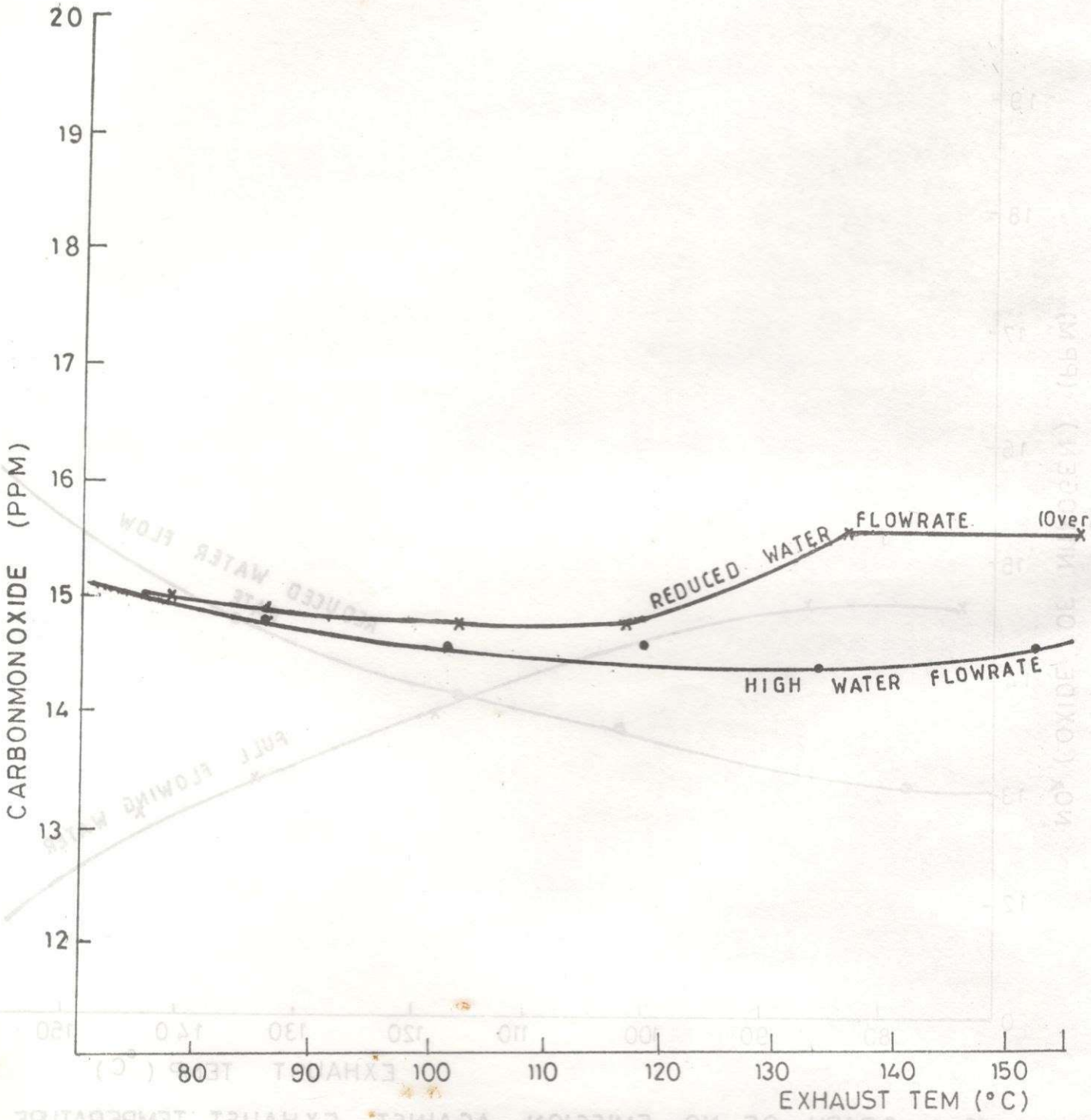


FIG.2 GRAPH OF CO EMISSION AGAINST EXHAUST TEMPERATURE

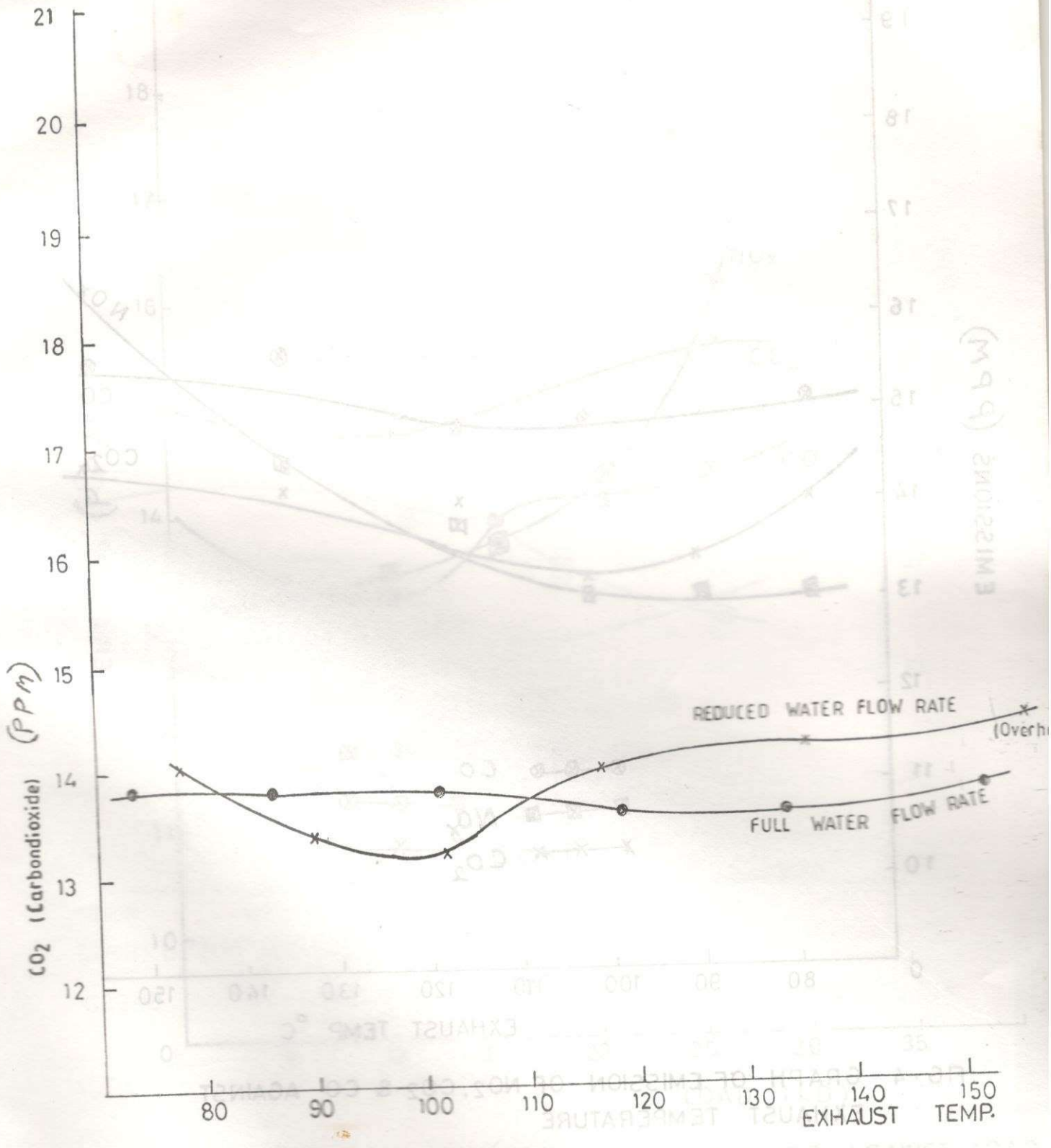


FIG. 3 GRAPH OF CO_2 EMISSION AGAINST EXHAUST TEMPERATURE

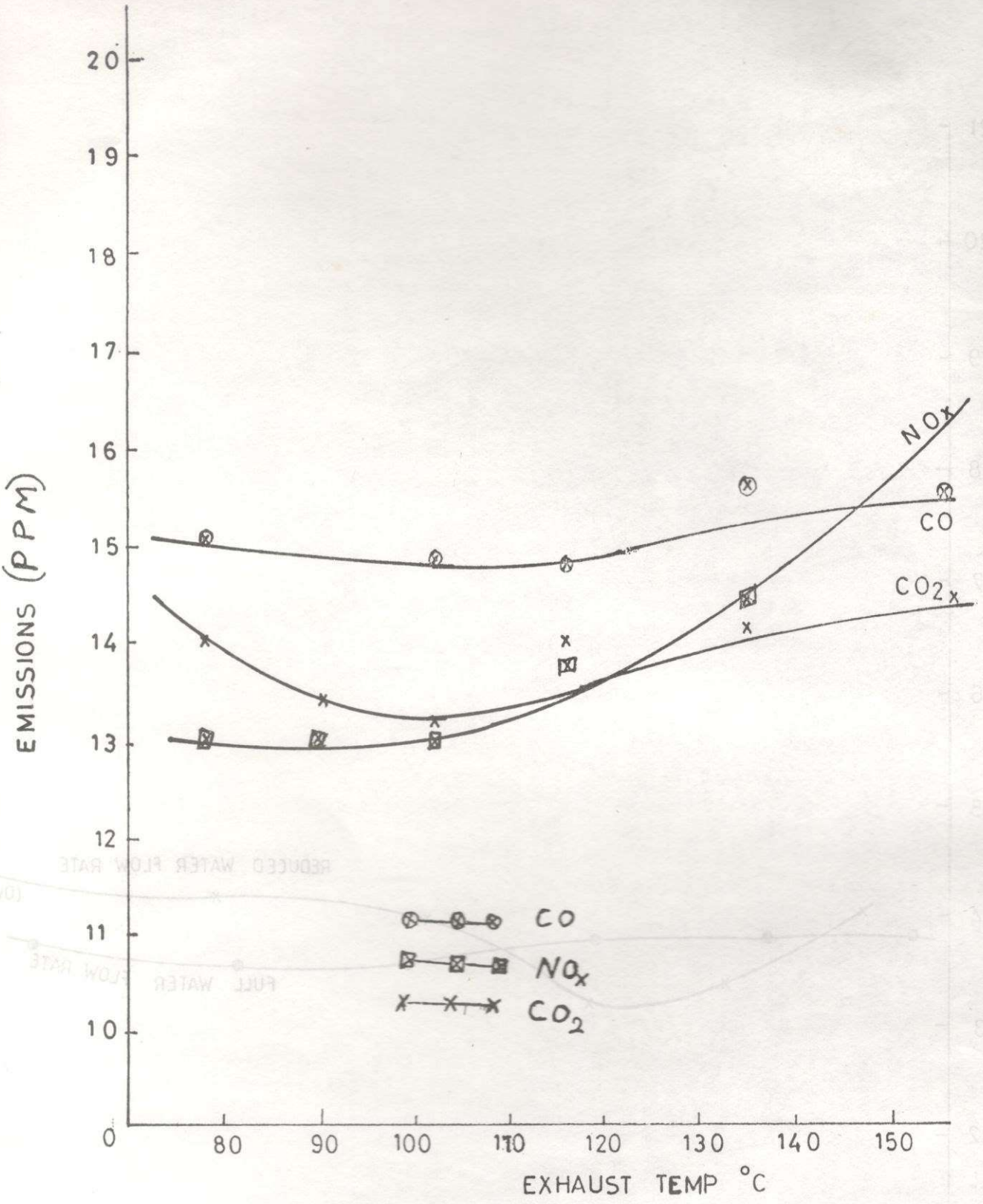


FIG. 4 GRAPH OF EMISSION OF NO_2, CO_2 & CO AGAINST EXHAUST TEMPERATURE

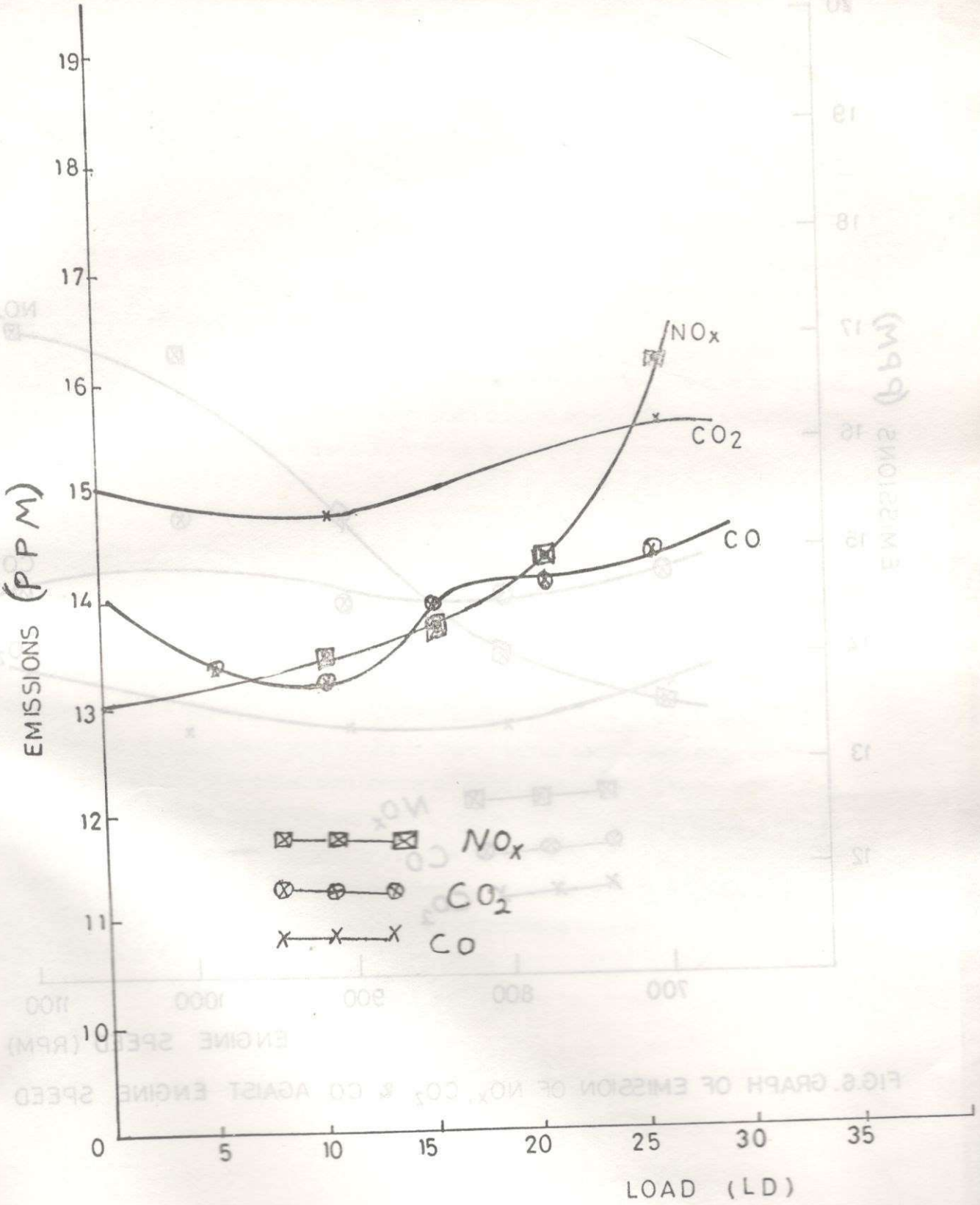


FIG 5 GRAPH OF EMISSION OF NO_x, CO_2, CO AGAINST LOAD

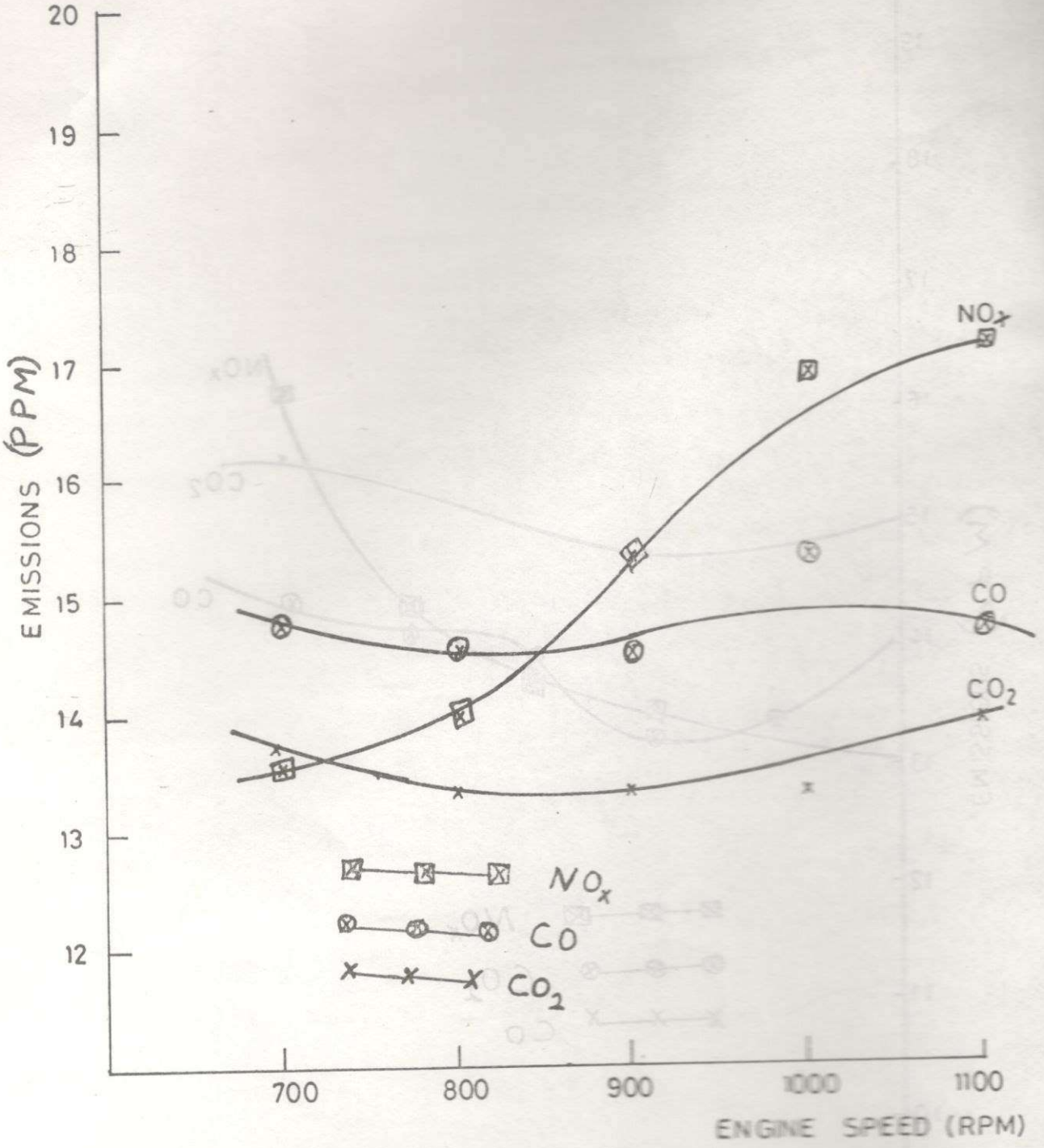


FIG.6. GRAPH OF EMISSION OF NO_x, CO_2 & CO AGAIST ENGINE SPEED