

[54] **METHOD FOR DIAGNOSING
MALFUNCTIONS IN INTERNAL
COMBUSTION ENGINES**
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[57] **ABSTRACT**

A method for diagnosing mechanical malfunctions of internal combustion engines resulting in unnecessarily high emissions of carbon monoxide and/or hydrocarbon is disclosed. The method comprises analyzing engine exhaust gases for carbon monoxide and hydrocarbon content while the engine is operated at both the idle and power carburetion circuits and comparing the analytical results obtained.

10 Claims, No Drawings

METHOD FOR DIAGNOSING MALFUNCTIONS IN INTERNAL COMBUSTION ENGINES

This invention relates to a method for reducing air pollution from internal combustion engines. More particularly, this invention relates to a method for diagnosing mechanical malfunctions which can exist in internal combustion engines and which can result in unnecessarily large amounts of carbon monoxide and hydrocarbons in the engine exhaust gases.

The internal combustion engine is used to power, among other things, practically all the transportation vehicles in use today. For example, this type of power system is used in 90 million automobiles in the United States alone. With the automobile population continually increasing, the problem of diagnosing and correcting mechanical malfunctions of internal combustion engines in order to maintain each of these vehicles at maximum operating efficiency is becoming more and more difficult. This problem is accentuated by the limited supply of trained mechanics and technicians. Many of the techniques used to diagnose engine malfunctions are expensive, cumbersome and time-consuming which further limits the number of malfunctions which can be properly diagnosed, as well as inconveniencing the auto owner to the point where he may actually avoid having engine malfunctions diagnosed and corrected.

The internal combustion engine manufactures useful power by the explosive combustion of fuel, normally of the hydrocarbon type, such as natural gas, gasoline, kerosene, diesel fuel, etc., and oxygen, normally taken from air. It is almost inherent that a certain amount of carbon monoxide and hydrocarbon will be present in the exhaust gases from these engines. The carbon monoxide and hydrocarbons emitted from internal combustion engines add significantly to the overall problem of air pollution. Therefore, it would be advantageous to minimize the amounts of these harmful pollutants emitted in the exhausts of internal combustion engines.

One method of reducing these harmful emissions is by properly maintaining the internal combustion engine. A mechanically malfunctioning engine gives off substantially increased amounts of carbon monoxide and hydrocarbons. However, because of the previously noted complexity of current diagnostic techniques, many engine malfunctions remain uncorrected and a potential substantial reduction in air pollution is not attained.

Various procedures for testing exhaust emissions from internal combustion engines are known to the art. Many of these procedures may be used as diagnostic tools to pinpoint engine malfunctions. However, each of these techniques are of limited use in the routine maintenance surveillance of motor vehicle engines because such techniques can be unduly expensive, cumbersome and/or time-consuming.

The most comprehensive of these emissions testing procedures is commonly referred to as the "California Cycle" and involve operating the engine being tested at idle and at six conditions using a chassis dynamometer to simulate actual road loading. Not only is the chassis dynamometer an expensive piece of equipment, but it also is complex, requiring substantial time and a skilled technician to operate it properly. The "California Cycle" involves analyzing the engine exhaust gas for various components (such as carbon monoxide and hydrocarbons) at each of the seven operating conditions. These individual emission values are multiplied by

weighting factors, which adjust the emission value by the time normally spent operating the engine at the particular condition, and added together to give an overall emission profile for the engine. The table below gives the seven engine operating conditions and the corresponding weighting factors for the "California Cycle."

TABLE I

Engine Operating Condition	Weighting Factor
1. Idle	0.042
2. 0 - 25 Miles Per Hour (mph.) Acceleration	0.244
3. 30 mph. Cruise	0.118
4. 30 - 15 mph. Deceleration	0.062
5. 15 mph. Cruise	0.050
6. 15 - 30 mph. Acceleration	0.455
7. 50 - 20 mph. Deceleration	0.029

Using arbitrarily set standards for carbon monoxide and hydrocarbon emissions, it can be determined by operating an engine through the California Cycle whether the engine emits unacceptably large amounts of contaminants. However, since the California Cycle is a time-consuming and involved procedure requiring seven sets of analyses and the use of a chassis dynamometer, routine emissions surveillance of the approximately 90 million automobile engines presently in use in the United States is impractical using this procedure. Furthermore, the primary purpose of the California Cycle is to determine the level of emissions and not what the causes of excessive emissions might be. Therefore, the usefulness of the California Cycle as a diagnostic tool is very much limited.

Cline and Tinkham have disclosed one method by which mechanical malfunctions which result from excessively high carbon monoxide and hydrocarbon emissions can be diagnosed. See: "A Realistic Vehicle Emission Inspection System," Journal of the Air Pollution Association, 19, 230, 1969. This method involves analyzing engine exhaust gases for carbon monoxide and hydrocarbon content while operating the internal combustion engine of a motor vehicle at idle, and also at low cruise and high cruise under load conditions, obtained using a chassis dynamometer. The Cline - Tinkham method sets arbitrary limitations on the amounts of both carbon monoxide and hydrocarbon emissions permitted. If the engine emits more carbon monoxide than is acceptably permitted at any of the three operating levels, an overly rich (i.e., high fuel) air-fuel mixture is indicated. If, on the other hand, the amount of hydrocarbon emitted exceeds the arbitrary amount permitted at any one of the three points of the Cline - Tinkham cycle, fuel is escaping from at least one of the combustion chambers of the engine into the exhaust system without having been properly subjected to combustion

Although the Cline - Tinkham method requires fewer exhaust gas analyses than the California Cycle, it does have a number of disadvantages. In particular, like the California Cycle, the Cline - Tinkham method requires the use of a chassis dynamometer to provide the load conditions during testing and therefore, it burdened with many of the above noted disadvantages inherent in the California Cycle. Also, the Cline - Tinkham procedure places total reliance upon arbitrarily set levels of carbon monoxide and hydrocarbon engine emissions. This total reliance may lead to unsound or, at

best, incomplete results. For example, the Cline - Tinkham procedure may determine that a particular internal combustion engine is a non-high emitter since it fails to emit either carbon monoxide or hydrocarbons at a level greater than arbitrarily set for testing, and still the engine may be emitting these harmful gases in amounts much above the minimum possible. Such an engine would be declared a completely acceptable emitter by the Cline - Tinkham method and still may be producing unnecessarily large amounts of carbon monoxide and hydrocarbons. Substantial reduction in the amount of carbon monoxide and/or hydrocarbon emitted might be realized if certain mechanical malfunctions existing in this "non-high emitting" engine were corrected.

As is apparent from the foregoing, there is a need for a procedure which can be used to simply, inexpensively and quickly diagnose malfunctions that can exist in internal combustion engines to cause the emission of unnecessarily large amounts of carbon monoxide and/or hydrocarbons in the engine exhaust gases.

It has now been discovered that mechanical malfunctions of internal combustion engines which cause unnecessarily high carbon monoxide and/or hydrocarbon exhaust gas emissions can be diagnosed by analyzing the exhaust gases from an internal combustion engine operated at only two engine speeds without using a load simulating device, such as a chassis dynamometer. The exhaust gases to be analyzed for carbon monoxide and hydrocarbon content are sampled while the engine is being operated at: (1) idle, i.e., while the engine is being operated on the idle carburetion circuit; and (2) a speed on the main carburetion circuit of the engine.

Therefore, in one aspect, the present invention is a method for diagnosing malfunctions of internal combustion engines which result in exhaust gases having unnecessarily high concentrations of carbon monoxide and hydrocarbons comprising:

- (1) analyzing for the carbon monoxide and hydrocarbon concentrations of the exhaust gases from the engine sampled while the engine is being operated in modes (A) and (B), the two engine operational modes being at essentially constant no load conditions at normal operating temperatures and (A) on the idle carburetion circuit and (B) on the main carburetion circuit, the engine being operated in modes (A) and (B) in any chronological sequence; and

2. comparing at least one of said carbon monoxide and hydrocarbon concentrations, wherein engine malfunctions resulting in an overly rich air-fuel mixture to the engine are indicated when the carbon monoxide concentration obtained from operational mode (B) exceeds that from operational mode (A), and engine malfunctions resulting in improper fuel combustion are indicated when the hydrocarbon concentration obtained from operational mode (B) exceeds that from operational mode (A).

In order to practice the present invention, it is necessary to operate the engine at only two speeds. One speed is idle, i.e., the engine is operated on the idle carburetion circuit. The other engine speed is on the main carburetion circuit, rather than the idle circuit. Idle carburetion circuit operation is normally achieved at engine speeds from about 400 rpm. to about 1100 rpm. For many internal combustion engines, in particular engines of motor vehicles, i.e., automobiles, trucks,

etc., main carburetion circuit operation can be achieved by running the engine at a speed of at least about 1200 rpm. In order to insure that the engine is off the idle and on to the main circuit, it is preferred that engine speeds of at least about 2000 rpm. be used. For safety reasons, it is normally preferred not to exceed about 4000 rpm., more preferably about 3000 rpm., when practicing the method of this invention. Therefore, the preferred range of main circuit engine speeds is from about 1200 rpm. to about 4000 rpm., while the more preferred range is from about 2000 rpm. to about 3000 rpm.

While testing the engine at idle and main carburetion circuit speeds, the engine is operated under no load conditions. The no load condition means that the engine is essentially freerunning, i.e., not working against a load whether real or simulated. Therefore, the present invention is practiced without expensive and complex load-simulating equipment (e.g., chassis dynamometer). This "no-load" feature of the present invention provides a major advantage over prior art procedures. The present procedure is less expensive, quicker and requires less skill to practice than do the prior art procedures. The present invention permits the skilled technician or mechanic to devote the time and expertise that had been spent setting up and running loaded engine tests to more difficult maintenance problems. This "no-load" feature also allows more engines to be tested in a given period of time, thus extending the pollution control benefits of the present invention to more motorists. This in turn, increases the overall pollution control benefits of the invention.

In order to practice the present invention, it is not necessary to set any emission standards. It has been discovered that engine malfunctions which result in unnecessarily large amounts of harmful emissions can be diagnosed by comparing the carbon monoxide and/or hydrocarbon emissions data from idle and main carburetion circuit engine operation without regard to the absolute concentration of either contaminant. This discovery represents a major advance over the prior art procedures which relied entirely on arbitrarily set standards of exhaust gas carbon monoxide and hydrocarbon concentration. By correcting mechanical malfunctions indicated by practicing the present invention, one may reduce the exhaust gas concentration of carbon monoxide and hydrocarbons to the minimum possible, rather than merely below some arbitrarily set standard concentration. This enhances the pollution control benefits of the present invention in that diagnosis of mechanical malfunctions which may result in reductions in exhaust gas carbon monoxide and/or hydrocarbon concentration may be possible even though the initial concentrations of these pollutants are below a previously set acceptable level.

Among the engine malfunctions resulting in an overly rich air-fuel mixture to the engine which can be indicated by practicing the present invention are the following: (1) improper carburetor adjustment; (2) restricting carburetor air filter element (i.e., the air filter element is partially plugged, thereby impeding the flow of needed combustion air); (3) engine choke system not functioning properly; (4) malfunction positive crankcase ventilation system; and the like. Among the engine malfunctions resulting in improper fuel combustion which can be indicated by practicing the present invention are the following: (1) engine ignition system

malfunctions; (2) engine valve malfunctions; (3) worn or fouled spark plugs; (4) defective spark plug wire leads; (5) worn or defective piston rings; and the like. Once the method of the present invention has indicated the presence of an engine malfunction, further tests and procedures on individual components of the engine can be used to pinpoint and/or correct the malfunction.

For example, if the method of the present invention indicates that an engine has a malfunction resulting in an overly rich air-fuel mixture, the carburetor air-filter element can be tested by the method disclosed in ("Method" by Frederick L. Voelz, Docket No. 13-0014, patent application Ser. No. 82864 now Pat. No. 3,663,811) to determine if it is restricting the flow of combustion air, and/or the engine carburetor can be adjusted by the method disclosed in ("Method" by Frederick L. Voelz, Docket No. 13-0015) to minimize the amounts of carbon monoxide and hydrocarbons emitted from the engine. Similarly, if the method of the present invention indicates that the engine has a malfunction resulting in improper combustion of fuel, various tests of the ignition system and combustion chambers, for example, conventional inspection methods for spark plugs and spark plug leads, can serve to pinpoint the malfunctions.

Any internal combustion engine which can be run on both idle and main carburetion circuits may be tested by the method of the present invention. Among the types of engines included are 2 cycle engines, 4 cycle engines, rotary piston driven engines, turbine engines and the like. Engines which are normally operated in association with transportation means such as automobiles, trucks, etc., as well as those operated in association with non-transportation means may be tested in the practice of the present invention. Because of emission control system revisions, certain (e.g. Ford Motor Company products) 1969 and all subsequent motor vehicle engines are somewhat insensitive to that aspect of the present invention which indicates malfunctions resulting in an overly rich air-fuel mixture. Severe engine malfunctions which produce an overly-rich air-fuel mixture in these engines may be diagnosed by the method of the present invention. The aspect of the invention in which malfunctions resulting in improper fuel combustion can be diagnosed is unaffected by the above-noted design changes.

In the method of the present invention, the engine is run at normal operating temperatures to insure consistent results. In order to achieve normal operating temperatures, the engine may be run for a sufficiently long time so that the engine choke system, if any, is completely open and does not itself restrict the flow of combustion air. In any case, normal engine operating temperatures vary depending on the type of engine, air-fuel ratio, thermostating, etc. Generally, normal operating temperatures for internal combustion engines are from about 170° to about 240°F. (engine block temperature.)

The carbon monoxide and hydrocarbon contents of the exhaust gases may be analyzed in any conventional manner known to the art. Included among these conventional analytical methods are gas chromatography, mass spectrometry and infra-red spectrometry. Because of the speed and accuracy of analysis, it is preferred to utilize infra-red spectrometry in the practice of the present invention. In particular, the use of non-dispersive infra-red (NDIR) analyzers is preferred in

the practice of this invention. These infra-red analyzers operate on the known principle that carbon monoxide gas and hydrocarbon gas absorb infra-red energy having specific wave lengths. When infra-red energy is sent through a stream of engine exhaust gas, a certain amount of energy is absorbed by the carbon monoxide (or hydrocarbons) in the gas stream. The amount of absorbed energy has a direct relationship to the volume concentration of carbon monoxide (or hydrocarbons) in the exhaust gas. By comparing, normally using electronic means, the amount of infra-red energy of the specific wave length absorbed by carbon monoxide (or hydrocarbons) remaining with the original amount of infra-red energy of this wave length, it is possible to determine the amount of carbon monoxide (or hydrocarbons) in the exhaust gas. This type of infra-red analyzer can be packaged as a relatively portable and inexpensive instrument. The analyzer mobility and low cost are additional reasons for preferring infra-red spectrometry for analyzing the carbon monoxide and hydrocarbon concentrations of engine exhaust gases.

When testing internal combustion engines that are associated with automobile and other motor vehicles, it is preferred to sample the engine exhaust gases for analysis from the tail pipe effluent, i.e., the exhaust system effluent. Although it is not critical to the present invention which engine operational mode is run first, if the exhaust gases for analysis are sampled from the exhaust system effluent, it is preferred to run the engine in mode (B) (main carburetion circuit operation) prior to mode (A) (idle circuit operation). This procedure is preferred since operating the engine on the main carburetion circuit clears the engine exhaust system and helps to insure representative sampling of the exhaust gases when the engine is operated at idle. If operational mode (A) is run prior to operational mode (B), it is preferred that the engine be operated at an elevated speed (e.g. about 2000 rpm.) for about 30 seconds to clear the engine exhaust system prior to operating the engine in mode (A).

Since the engine exhaust system (i.e., muffler, tail pipe, etc.) is subject to great wear, the possibility of gas leaks exists. Therefore, in order to insure the accuracy and reproducibility of the tail pipe effluent carbon monoxide and hydrocarbon analyses, it is preferred that if the tail pipe effluent is used as the source for exhaust gas samples, the engine exhaust system be tested for gas leaks at some point during the practice of this invention. The point at which the leak testing takes place is not critical to the present invention, although, for convenience and time saving reasons, it is preferred that the leak testing occur at or prior to the time of the first carbon monoxide and hydrocarbon analyses.

The exhaust system leak testing can be accomplished in any conventional manner, for example, visual inspection of the exhaust system. However, the preferred method of leak testing is to analyze the tail pipe effluent for oxygen concentration. It is well known that the exhaust gases from a conventional four cycle internal combustion engine (the standard automobile engine) operated on the idle carburetion circuit contain between about 1% to about 4% by volume of oxygen. Any significant deviation, for example, at least about 3% by volume from the upper limit of the above oxygen concentration range found in the tail pipe effluent indicates a leak in the engine exhaust system. Exhaust from engines which are equipped with air injection emission

control devices normally contain between about 7% to about 20% by volume of oxygen, and therefore, may be deemed insensitive to the "oxygen analysis" method for testing for air leaks. The oxygen concentration can be obtained by any conventional analytical method, such as amperometric methods, magnetic susceptibility methods, gas chromatography and mass spectrometry. The preferred methods of oxygen analysis are the amperometric methods.

The following examples illustrate more clearly the method of the present invention. However, these illustrations are not to be interpreted as specific limitations on this invention.

EXAMPLE 1

A 1964 Pontiac automobile powered by a standard 4 cycle, internal combustion engine was selected for testing. During the test, the engine was run at no load conditions and at normal operating temperatures so that the engine choke system did not restrict the flow of combustion air. It was determined that the engine exhaust system was in tact and that, therefore, reliable specimens of exhaust gas could be obtained by sampling the tail pipe effluent. The engine speed was brought to and maintained at 2500 rpm. (main carburetion circuit operation) through the use of a portable tachometer. While maintaining the speed of the engine at 2500 rpm., the exhaust gases (tail pipe effluent) from the engine were analyzed for carbon monoxide and hydrocarbon concentrations by means of a portable non-dispersive infra-red analyzer. The carbon monoxide concentration was determined to be 3.75% by volume of the total exhaust gases, and the hydrocarbon concentration was determined to be 380 ppm.

The engine speed was then reduced to idle, about 440 rpm., and the exhaust gases were again analyzed for carbon monoxide and hydrocarbon concentration. At this point, the exhaust gases contained 1.3% by volume carbon monoxide and 440 ppm. hydrocarbon.

These analytical data indicated that the engine was receiving an overly-rich air-fuel mixture. It was determined, using the method of ("Method" by Frederick L. Voelz, Docket No. 13-0014, patent application Ser. No. 82864 now patent no. 3,663,811), that the carburetor air filter element was restricting the flow of combustion air to the engine. The used carburetor air filter element was replaced by a non-restricting element. This maintenance procedure resulted in an exhaust gas carbon monoxide concentration reduction of 20% at 2500 rpm. and about 4% at the idle carburetion circuit operation.

EXAMPLE 2

A 1968 Chevrolet automobile equipped with a standard 4 cycle, internal combustion engine was tested in a manner similar to that of Example 1. The carbon monoxide concentration of the exhaust gases at 2500 rpm. was determined to be 1.0% by volume while the concentration at idle carburetion circuit operation was 0.4% by volume. Exhaust gas hydrocarbon concentration at 2500 rpm. was 80 ppm. and at idle was 180 ppm. These data indicated that the engine was receiving an overly rich air-fuel mixture.

Various engine components were tested including the positive crankcase ventilation system. The positive crankcase ventilation system was pressure tested and determined to be operating at less vacuum than desir-

able. Therefore, the positive crankcase ventilation valve was replaced. This maintenance procedure resulted in an exhaust gas carbon monoxide concentration reduction of 30% at 2500 rpm. and 50% at idle circuit operation.

EXAMPLE 3

A 1968 Dodge automobile equipped with a standard 4 cycle, internal combustion engine was selected for testing. The engine was tested in a manner similar to that of Example 1. The engine exhaust gas carbon monoxide concentration at 2500 rpm. was 1.0% by volume, while the carbon monoxide concentration at idle was 5.5% by volume. The exhaust gas hydrocarbon concentration was 1200 ppm. at 2500 rpm. and 350 ppm. at idle. These data indicated that the engine had a malfunction resulting in improper fuel combustion.

The engine ignition system was inspected and it was found that the spark plugs were worn and fouled. Replacement of these spark plugs resulted in a reduction in exhaust gas hydrocarbon concentration of 79% at 2500 rpm. and about 6% at idle.

EXAMPLE 4

A 1966 Ford automobile equipped with a standard 4 cycle, internal combustion engine was selected for testing. The procedure followed was similar to that of Example 1. The exhaust gas carbon monoxide concentration at 2500 rpm. was 0.95% by volume and at idle as 1.7% by volume. The exhaust gas hydrocarbon concentration was 1500 ppm. at 2500 rpm. and 700 ppm. at idle. These results indicated an engine malfunction resulting in improper fuel combustion. The ignition system was inspected and it was found that the distributor rotor and cap were worn and needed replacement. The replacement of these components resulted in an exhaust gas hydrocarbon concentration reduction of 90% at 2500 rpm. and 20% at idle.

EXAMPLE 5

A 1966 Plymouth automobile equipped with a standard 4 cycle, internal combustion engine was tested in a manner similar to that of Example 1. The concentration of carbon monoxide in the engine exhaust gases was considered to be normal at both engine speeds, while the exhaust gas hydrocarbon concentration at 2500 rpm. was 820 ppm. and at idle was 320 ppm. These results indicated a malfunction resulting in improper fuel combustion. The ignition system was inspected and it was determined that a single spark plug was cracked and, therefore, needed replacement. Replacing this single spark plug resulted in a reduction in hydrocarbon concentration at 2500 rpm. of 88% and at idle of 44%.

In each of the preceeding examples, correction of the malfunction indicated by practicing the present invention resulted in a substantial reduction in the amount of carbon monoxide or hydrocarbons emitted to the atmosphere. Because of the concern over air pollution, this benefit of the present invention is increasingly important and, from the point-of-view of the public at large, may be the primary advantage of the present invention.

These examples illustrate that the present invention provides an inexpensive, highly portable and quick method for determining: (1) whether the internal combustion engine being tested does in fact have a mal-

function which results in unnecessarily large emissions of carbon monoxide and/or hydrocarbons; and (2) what the general nature of the malfunction is. Without this invention and in the absence of elaborate equipment, such as a chassis dynamometer, it would be necessary to take time to test each individual engine component separately and, even then, the possibility would still exist that each component would be functioning properly. This wasting of valuable maintenance time and skill can be avoided by practicing the present invention.

Example 2 is of particular significance, for this example indicates clearly that the method of the present invention is able to diagnose the presence of malfunctions which result in unnecessarily high concentrations of carbon monoxide and/or hydrocarbons without regard for the absolute concentration of these components. The initial levels of carbon monoxide determined (i.e., 1.0% by volume at 2500 rpm. and 0.4% by volume at idle) are substantially below arbitrarily set acceptable emission standards which have been used in the past. This fact, notwithstanding, the method of the present invention pointed to a malfunction which upon being corrected resulted in a substantial reduction in the amount of carbon monoxide emitted to the atmosphere.

In summary, the preceeding examples illustrate that the method of the present invention is quick, uncomplicated and does not require a great deal of mechanical skill or experience to practice. The fact that during the practice of the invention, the engine is operated at no load conditions and portable infra-red analyzers and tachometers can be used, makes this method extremely valuable for inexpensive testing of large numbers of internal combustion engines. The portable, infra-red analyzers and other equipment, such as oxygen analyzers, which may be necessary, can be loaded onto a truck or van which is sent from place to place testing engines. This mobility feature is an additional outstanding benefit of the present invention.

While this invention has been described with respect to various specific examples and embodiments, it is to be understood that the invention is not limited thereto and that it can be variously practiced within the scope of the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method for diagnosing malfunctions of internal combustion engines which result in exhaust gases having unnecessarily high concentrations of carbon monoxide and hydrocarbons comprising:

1. analyzing for the carbon monoxide and hydrocar-

bon concentrations of the exhaust gases from said engine, said gases being sampled while said engine is being operated in modes (A) and (B), said engine operational modes being at essentially constant no load conditions at normal operating temperatures and (A) on the idle carburetion circuit and (B) on the main carburetion circuit, the engine being operated in modes (A) and (B) in any chronological sequence; and

2. comparing said carbon monoxide and hydrocarbon concentrations, wherein engine malfunctions resulting in an overly-rich air-fuel mixture to said engine are indicated when the carbon monoxide concentration obtained from operational mode (B) exceeds that from operational mode (A) and engine malfunctions resulting in improper fuel combustion are indicated when the hydrocarbon concentration obtained from operational mode (B) exceeds that from operational mode (A); and

3. correcting at least one of said indicated engine malfunctions and thereby reducing at least one of said carbon monoxide and hydrocarbon concentrations in said engine exhaust gases.

2. The method of claim 1, wherein said engine operated on the main carburetion circuit is operated at a speed of at least about 1200 rpm.

3. The method of claim 2, wherein said carbon monoxide and hydrocarbon concentrations are obtained by means of infra-red spectrometry.

4. The method of claim 1, wherein said engine operated on the main carburetion circuit is operated at a speed from about 1,200 rpm. to about 4,000 rpm.

5. The method of claim 4, wherein said carbon monoxide and hydrocarbon concentrations are obtained by means of infra-red spectrometry.

6. The method of claim 5, wherein said engine is operated in association with a motor vehicle and the exhaust gases for analysis are sampled from the exhaust system effluent.

7. The method of claim 1, wherein said engine operated on the main carburetion circuit is operated at a speed from about 2,000 rpm. to about 3,000 rpm.

8. The method of claim 7, wherein said carbon monoxide and hydrocarbon concentrations are obtained by means of infra-red spectrometry.

9. The method of claim 8, wherein said engine is operated in association with a motor vehicle and the exhaust gases for analysis are sampled from the exhaust system effluent.

10. The method of claim 1, wherein said carbon monoxide and hydrocarbon concentrations are obtained by means of infra-red spectrometry.

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