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(54) IMPROVEMENTS RELATING TO THE OPERATION OF INTERNAL COMBUSTION ENGINES DRIVING VEHICLES

(71) We, ROBERT BOSCH GMBH, a German Company, of Postfach 50, 7 Stuttgart 1, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

The present invention relates to methods of and apparatus for regulating the operating behaviour of an internal combustion engine driving a vehicle in a predetermined range of operation.

Regulation of the engine operating behaviour is effected by varying the ratio of the components of the operating mixture of an internal combustion engine relative to one another. It has been proposed to regulate engine operating behaviour in conformity with the difference between the magnitude of variations in the cyclic fluctuations of the average pressure in the combustion chamber and a desired value.

According to this latter proposal the desired value is only varied in dependence upon the speed of the internal combustion engine and/or other operating parameters of the internal combustion engine.

The present invention provides a method of regulating the operating behaviour of an internal combustion engine driving a vehicle in a predetermined range of operation in which the ratio of the components of the operating mixture fed to the internal combustion engine relative to one another is varied in dependence upon the difference between the magnitude of at least indirectly detected variations in the cyclic fluctuations of the average pressure in the engine combustion chamber or chambers and a variable desired value derived from operating parameters of the internal combustion engine and operating parameters of a motor vehicle driven by the internal combustion engine or solely from operating parameters of the motor vehicle driven by the internal combustion engine.

The invention includes apparatus for regulating the operating behaviour of an internal combustion engine driving a vehicle in a predetermined range of operation comprising means for at least indirectly detecting variations in the cyclic fluctuations of the average pressure in the engine combustion chamber or chambers, means for deriving a variable desired value from operating parameters of the internal combustion engine and operating parameters of the motor vehicle driven by the internal combustion engine or solely from operating parameters of the motor vehicle, and means for varying the ratio of the components of the operating mixture fed to the internal combustion engine relative to one another in dependence upon the difference between the magnitude of said at least indirectly detected variations in the cyclic pressure fluctuations and said variable desired value.

Thus the behaviour of a gearbox connected on the output side of the internal combustion engine is also taken into account in conjunction with the motor vehicle driven by the internal combustion engine. According to the type of vehicle and gearbox, the uneven running signal is damped to a greater or lesser extent in conformity with the fluctuations in the average pressure in the combustion chamber at the output of the internal combustion engine, so that, when the gearbox has different gear-shift positions, for example in the case of a step-speed change gearbox, differing desired values have to be taken into account irrespective of the speed of the internal combustion engine in order that a uniform utilizable signal for the regulation can be obtained from the comparison with the smooth running signal. Therefore, the desired value can be adapted to the control quantity which is obtained with uniform approximation to the running limit in the total operating range of the internal combustion engine and which corresponds to the variations in the cyclic fluctuations of the average pressure in the combustion chamber and optimum regulation is rendered possible.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic illustration of a first embodiment of vehicle engine and transmission system in which desired engine operating value is switchable in dependence upon

the selected gear ratio,

Figure 2 is a similar illustration of a second embodiment in which control quantities for forming the desired engine operating value are obtained at the output of the internal combustion engine and the gear box connected to the output thereof, and

Figure 3 is a similar illustration of a third embodiment in which the control quantities are taken exclusively from beyond the output of a gearbox connected to the output of the internal combustion engine.

Figure 1 shows, diagrammatically, a system by means of which the method, in accordance with the invention, for regulating the operating behaviour of an internal combustion engine can be performed. The engine is an internal combustion engine 1 which is operated in a conventional manner by means of a fuel metering device 2 for producing an operating mixture. The device 2 can be any optional device such as a carburettor or fuel injection system, in which the individual components of the operating mixture can be influenced electro-mechanically. Furthermore, a gearbox 4 is provided which is coupled to the crankshaft of the internal combustion engine by the usual clutch (not shown) and whose output shaft 5 is operatively connected to the vehicle drive wheels 7 in a conventional manner, for example by way of an interposed Cardan shaft and a differential. The vehicle and the details of the Cardan shaft, the differential, etc. have not been shown. In the present instance, the connection between the internal combustion engine and the gearbox has been indicated by a shaft portion 8 which is to be regarded as the drive shaft of the gearbox and also as a portion of crankshaft of the internal combustion engine. The clutch can be in the form of a mechanical clutch or, alternatively, in the form of an hydraulic clutch. The gearbox is a mechanical speed change gearbox of conventional construction.

By way of example, a rotating mark 9 is provided on the crankshaft 8 and, together with a detector 10, acts as a tacho-generator to produce a signal corresponding to the speed of the internal combustion engine. The detector 10 is connected to a smooth running regulator 12 which produces an adjusting signal for a control device of the fuel metering device 2. According to the construction of the smooth running regulator 12, the latter receives signals from the detector 10 in synchronism with the engine speed or, alternatively, a continuous signal if the tacho-generator is of different construction. In both cases, the variation in the cyclic fluctuations of the average pressure in the combustion chamber is detected at the crankshaft of the internal combustion engine for the respective known types of smooth running regulation, and is processed in the regulator 12 to form an adjusting signal.

Since, in conformity with the variations in the cyclic fluctuations of the average pressure in the combustion chamber or in the uneven running, the control quantity thus determined exhibits a differing bandwidth of the absolute value of the fluctuations according to the speed of the internal combustion engine with the same mode of operation approximating to the running limit, it is also known to compare the variable quantity corresponding to uneven running with a desired value varying with the engine speed in order to obtain a similar kind of adjusting signal at the output of the smooth running regulator 12. Thus, an adjusting quantity corresponding to the difference between the control quantity and the desired value is formed in the smooth running regulator. It is known that an adjusting signal of uniform magnitude over the entire range of speed of the internal combustion engine is obtainable with the same approximation to the running limit when the desired value varies proportionally to T^3, T being the duration of one revolution of the crankshaft. Furthermore, it is known that the desired value can be influenced in dependence upon other operating parameters of the internal combustion engine. This is illustrated in the drawings in that the speed control quantity and further control quantities, such as control quantities corresponding to the absolute pressure in the intake pipe or the temperature of the internal combustion engine, are fed to a switching device 14 in order to form the desired value.

However, the uneven running control signal derivable from the crankshaft is also dependent upon the masses which are connected to the output of the internal combustion engine and which can have, for example, a damping effect on the rotational behaviour of the internal combustion engine. The gearbox connected to the output of an internal combustion engine for operating a motor vehicle is particularly noticeable in this respect. The control quantity taken from the crankshaft is dependent upon the gears according to the construction of the vehicle and the gearbox. When the gear-dependence is not taken into account in the desired value, this dependence is such that the operating mixture of the internal combustion engine can be rendered lean to only a slight extent in the low gears and to a maximum extent only in the highest gear.

Therefore, in accordance with the invention, in the embodiment of Figure 1 the gear selector lever 16 is connected to a switch 17 which, according to the position of the gear selector lever, taps from a voltage divider 18 a voltage value characterising this position of the gear lever and feeds it to the switching device 14 for the purpose of influencing the desired value.

The control quantity produced by the even running regulator 12 is now fed to the fuel metering device in which the operating mixture to be introduced into the combustion chambers of the internal combustion engine is influenced. By way of example, this can be effected by controlling the quantity of air, the quantity of fuel

and, if required, by varying the quantity of exhaust gas feedback.

The embodiment of Figure 2 is of substantially the same construction as the embodiment of Figure 1. The description of Figure 1 is referred to with respect to the same parts and their function. However, in contrast to the embodiment of Figure 1, the gearbox 4 of Figure 2 may be a step speed change gearbox or an automatic gearbox. A further difference is that the correcting, gear-ratio-dependent parameter is ascertained in a different way. For this purpose, a detector 20 is associated with the output shaft 5 of the gearbox and detects the speed of the output shaft 5 and feeds it to a divider 21. Furthermore, the divider 21 receives the speed signal from the detector 10 and divides it by the speed signal of the detector 20 and feeds the resultant control quantity as a gear-ratio-dependent parameter to the switching device 14 for the purpose of forming the desired value. As in the embodiment of Figure 1, this switching device receives the speed signal from the detector 10 and, as required, can also process further parameters to form the final desired value.

In another case, the signal from a tachometer shaft, particularly from an electrical travelling velocity sensor, can be processed instead of the speed signal from the detector 20.

Figure 3 shows, diagrammatically, a third possibility of taking into account the speed-dependence of the uneven running signal. In this method, as in the method described above, an internal combustion engine 1 is provided with a gearbox 4 which is connected to the output thereof and which again can be a manual speed change gearbox or an automatic gearbox. The output shaft 5 of the speed change gearbox is operatively connected to the drive wheels 7. Furthermore, a smooth running regulator 12 is again provided and produces an adjusting signal for influencing the operating mixture of the internal combustion engine.

In a further method, the control quantity for the smooth running regulator 12 is also formed by the detector 20 on the output shaft 5 of the gearbox, though the signal may be a synchronized or a continuous signal according to the design of the regulator. The control quantity of the detector 20 is fed to the switching device 14 for the purpose of forming the desired value, which switching device can also evaluate other operating parameters of the internal combustion engine in addition to the speed signal. Alternatively, a detector 23 mounted directly on the drive wheels of the motor vehicle may be used instead of the detector 20, and, for example, can be used at the same time as a tacho-generator for an anti-wheel-locking device for the vehicle brakes.

In this development, the control quantity is taken from the output side of the gearbox in accordance with the variations in the cyclic fluctuations of the average pressure in the combustion chamber, and gear dependence thus at the same time being taken into account during the formation of the control quantity. The desired value now formed only has to take into account the speed dependence of this control quantity.

In this development, in order to prevent the regulation from being influenced by a gear-shift operation of the gearbox, it is advantageous to switch off the regulation, or to maintain it at a fixed value during the gear-shift operation. When using the detector 23, it is likewise advantageous to take this measure on the wheels of the motor vehicle when braking the motor vehicle.

WHAT WE CLAIM IS:—

1. A method of regulating the operating behaviour of an internal combustion engine driving a vehicle in a predetermined range of operation in which the ratio of the components of the operating mixture fed to the internal combustion engine relative to one another is varied in dependence upon the difference between the magnitude of at least indirectly detected variations in the cyclic fluctuations of the average pressure in the engine combustion chamber or chambers and a variable desired value derived from operating parameters of the internal combustion engine and operating parameters of a motor vehicle driven by the internal combustion engine, or solely from operating parameters of the motor vehicle driven by the internal combustion engine.

2. A method as claimed in claim 1, in which an engine operating parameter from which the desired value is in part derived is a value substantially proportional to the third power of the duration of a revolution, and in which a vehicle operating parameter from which the derived value is in part derived is the gear ratio of a change speed gear connected to the output of the internal combustion engine.

3. A method as claimed in claim 2, in which a control quantity variable in accordance with the position of the gear selector lever serves for detecting the gear ratio of the change speed gearbox.

4. A method as claimed in claim 1, in which one of the engine operating parameters from which the desired value is in part derived as a value substantially proportional to the third power of the duration of a revolution, and in which the vehicle operating parameter from which the desired value is in part derived is the output speed of a gearbox connected to the output of the internal combustion engine, or a control quantity corresponding to the rotational speed of the driven vehicle wheels, the control signal corresponding to the speed of the internal combustion engine and in part determining said desired value, being divided by the value of the said output speed of control quantity.

5. A method as claimed in claim 4, in which the output speed of the gearbox is detected by means of a travel velocity sensor.

6. A method as claimed in claim 1, in which, in order to detect the operating parameter of the motor vehicle driven by the internal combustion engine, the variations in the cyclic fluctuations of the average pressure in the combustion chamber or chambers are detected by detecting variations in the angular velocity of the output shaft of the gearbox, and in which the output speed of the gearbox, acting as a control quantity, is detected as one of the vehicle operating parameters for the purpose of forming the desired value.

7. A method as claimed in claim 6, in which the regulation is switched off during a gear-shift operation.

8. A method as claimed in claim 6, in which the control quantity of a rotational sensor on the wheels of the motor vehicle acts as a control quantity corresponding to the variations in the cyclic fluctuations of the average pressure in the engine combustion chamber or chambers.

9. A method as claimed in claim 8 in which the rotational sensor forms part of an anti-wheel-lock device.

10. A method as claimed in claim 8 or 9 in which the regulation may be switched off or fixed at a fixed value during the gear-shift operation and a braking operation.

11. Apparatus for regulating the operating behaviour of an internal combustion engine driving a vehicle in a predetermined range of operation comprising means for at least indirectly detecting variations in the cyclic fluctuations of the average pressure in the engine combustion chamber or chambers, means for deriving a variable desired value from operating parameters of the internal combustion engine and operating parameters of the motor vehicle driven by the internal combustion engine or solely from operating parameters of the motor vehicle, and means for varying the ratio of the components of the operating mixture fed to the internal combustion engine relative to one another in dependence upon the difference between the magnitude of said at least indirectly detected variations in the cyclic pressure fluctuations and said variable desired value.

12. Apparatus as claimed in claim 11, in which an engine operating parameter from which the desired value is in part derived is the engine speed, the desired value being substantially proportional to the third power of the duration of a revolution, and in which a vehicle operating parameter from which the desired value is in part derived is the gear ratio of a change speed gear connected to the output of the internal combustion engine.

13. Apparatus as claimed in claim 11, in which one of the engine operating parameters from which the desired value is in part derived is the speed of the internal combustion engine, the desired value being substantially proportional to the third power of duration of a revolution, and in which the vehicle operating parameter from which the desired value is in part derived is the output speed of a gearbox connected to the output of the internal combustion engine, or a control quantity corresponding to the rotational speed of the driven vehicle wheels, the control signal corresponding to the speed of the internal combustion engine and in part determining said desired value being derived by the value of the said output speed or control quantity.

14. Apparatus as claimed in claim 11, in which, in order to detect the operating parameter of the motor vehicle driven by the internal combustion engine, the variations in the cyclic fluctuations of the average pressure in the combustion chamber or chambers are detected by detecting variations in the angular velocity of the output shaft of the gearbox, and in which the output speed of the gearbox, acting as a control quantity, is detected as one of the vehicle operating parameters for the purpose of forming the desired value.

15. A method of regulating the operating behaviour of an internal combustion engine driving a vehicle, substantially as herein described with reference to Figure 1 of the accompanying drawings.

16. A method of regulating the operating behaviour of an internal combustion engine driving a vehicle, substantially as herein described with reference to Figure 2 of the accompanying drawings.

17. A method of regulating the operating behaviour of an internal combustion engine driving a vehicle, substantially as herein described with reference to Figure 3 of the accompanying drawings.

18. Apparatus for regulating the operating behaviour of an internal combustion engine driving a vehicle, constructed and adapted to operate substantially as herein described with reference to and as illustrated in Figure 1 of the accompanying drawings.

19. Apparatus for regulating the operating behaviour of an internal combustion engine driving a vehicle, constructed and adapted to operate substantially as herein described with reference to and illustrated in Figure 2 of the accompanying drawings.

20. Apparatus for regulating the operating behaviour of an internal combustion engine driving a vehicle, constructed and adapted to operate substantially as herein described with reference to and as illustrated in Figure 3 of the accompanying drawings.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig.2

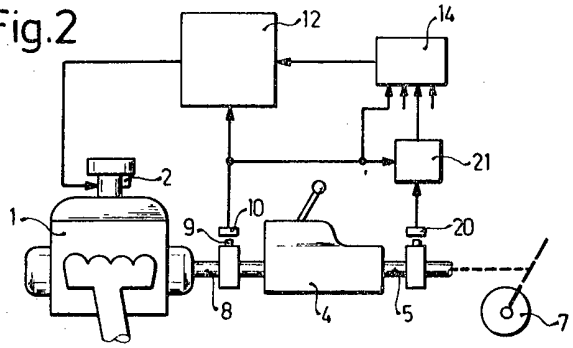

Fig.1

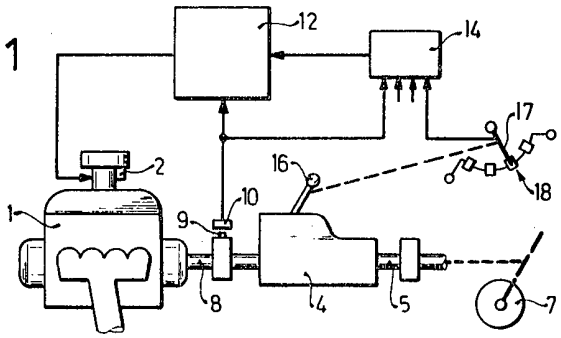

Fig.3