1291030

PATENT SPECIFICATION (11) 1291030

DRAWINGS ATTACHED

(21) Application No. 12312/71 (22) Filed 30 April 1971

(31) Convention Application No. 7016289 (32) Filed 5 May 1970 in

(33) France (FR)

(45) Complete Specification published 27 Sept. 1972

(51) International Classification F02N 17/04

(52) Index at acceptance

F1B 1B9 2N14A 2N16A

F1G 18 5E2

(54) IMPROVEMENTS IN METHODS OF SUPERCHARGING A DIESEL ENGINE, IN SUPERCHARGED DIESEL ENGINES, AND IN SUPERCHARGING UNITS FOR DIESEL ENGINES

(71) We, ETAT FRANCAIS REPRESENTE PAR LE MINISTRE D'ETAT CHARGE DE LA DEFENSE NATIONALE DELEGATION MINISTERIELLE POUR L'ARMEMENT DIRECTION TECHNIQUE DES ARMEMENTS TERRESTRES ATELIER DE CONSTRUCTION D'ISSY-LES-MOULINEAUX, an organisation representing the French Government residing at Caserne Sully 92-Saint Cloud (Service AIN/B), France, 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 invention relates to supercharging methods for a diesel engine with a supercharging unit comprising a compressor, supplying fresh air in parallel to the engine and a combustion chamber, and a turbine supplied with combustion gas by the engine and said combustion chamber, the said turbine driving in rotation the said compressor, independent starter means being provided to bring the turbine-compressor assembly to self-maining operation independent of the engine.

The invention also relates to diesel engines supercharged by a supercharging unit comprising a compressor, supplying fresh air in parallel to the engine and to a combustion chamber, and a turbine supplied with combustion gas by the engine and the above-said combustion chamber, the above-said turbine driving in rotation the said compressor, independent starter means being provided to bring the turbine-compressor assembly to self-maintaining operation independent of the engine.

The invention relates also to supercharging units for diesel engines, comprising a compressor supplying fresh air to a combustion chamber, and to a turbine supplied with combustion gas by said combustion chamber, said turbine rotating the said compressor, independent starter means being provided to bring the turbine-compressor assembly to self-maintaining operation.

It has been appreciated that it would be advantageous, especially from the point of view of specific power/stroke volumn ratio and from the point of view or roubustness and simplicity, to provide supercharged diesel engines having a low compression ratio, less than 12, and which can reach values of 8 or even 6.

Now it is known that, all things being otherwise equal, the reduction of the compression ratio of a supercharged diesel engine caused the appearance, below a certain limiting compression ratio, which is situated around 12, of impossibilities of starting and difficulties of slow speed operation, by reason of the fact that the temperature of self-ignition of the fuel is no longer reached at the end of the compression stroke.

It is a specific object of the invention to improve the operation of supercharged diesel engines and to permit, for engines whose compression ratio is less than 12, starting without having to resort to any special starting method, and correct operation at slow speed.

The supercharging method according to the invention is characterized by the fact that, the engine having a compression ratio less than 12, the minimal rotary speed of its supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure enabling its starting and its operation at slow speed, this threshold value being all the higher, for a given supercharging unit, as the compression ratio of the engine is lower.

Preferably, the above-said threshold value is obtained by limiting the supply of fuel to the combustion chamber.

The diesel engine according to the invention is characterized by the fact that it has a compression ratio less than 12, by the fact that regulating means for the speed of its supercharging unit are provided and are

arranged so that the minimal rotary speed of this supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure enabling its starting and its operation at slow speed, this threshold value being all the higher, for a given supercharging unit, as the compression ratio of the engine is lower.

Preferably, the above-said regulating means are constituted by a supply device limiting the flow rate of fuel introduced into the combustion chamber.

The supercharging unit according to the invention is characterized by the fact that first connecting means are provided for the compressor to supply with fresh air, in parallel, the combustion chamber and the intake pipe of a diesel engine with a compression ratio less than 12, by the fact that second connecting means are provided so that the turbine can be supplied with the combustion gas by the combustion chamber and by the exhaust pipe of the above-said diesel engine, and by the fact that regulating means of the speed of the supercharging unit are provided and are arranged so that the minimal rotary speed of this supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure enabling its starting and its operation at slow speed, this threshold value being all the higher, for a given supercharging unit, as the compression ratio of the engine concerned is lower.

The above-said regulating means can be constituted by a supply device limiting the flow rate of the fuel introduced into the combustion chamber.

The above-said regulating means can comprise an actuating member which can modify the threshold value according to the compression ratio of the engine concerned.

The invention, apart from the features which have been considered, consists of certain other features which will be more explicity discussed below.

The invention will, in any case, be better understood with the aid of the supplementary description which follows as well as of the accompanying drawings, which description and drawings relate to preferred embodiments of the invention and do not have of course any limiting character. In these drawings:—

Figure 2 is a diagrammatic view of a supercharged diesel engine, with one compression stage, constructed according to the invention and constituting a first embodiment;

Figure 2 is a diagrammatic view of a supercharged diesel engine, with one compression stage, constructed according to the invention and constituting a second embodiment thereof;

Figure 3 is a diagrammatic view of a supercharged diesel engine, with one compression stage, constructed according to the invention and constituting a third embodiment thereof;

Figure 4 shows a supercharging unit according to the invention, with one compression stage, and constructed in a manner analogous to the embodiment of the diesel engine shown in Figure 1;

Figure 5 shows a supercharging unit according to the invention, with one compression stage, and constructed according to the invention in a manner analogous to the embodiment of the diesel engine shown in Figure 2;

Figure 6 shows a supercharging unit according to the invention, with one compression stage, and constructed in a manner similar to that of the embodiment of the diesel engine shown in Figure 3; and

Figures 7 and 8 show two variations of a supercharged diesel engine with two compression stages and constructed according to the invention in a manner similar to the embodiment of the supercharged diesel engine with one compression stage which is illustrated in Figure 2.

As shown in Figures 1 to 3, the diesel engine 1 is supercharged by a supercharging unit, with one compression stage, which comprises,

a compressor 2, supplying fresh air in parallel to the engine 1 and a combustoin chamber 3,

and a turbine 4 supplied with combustion gas by the engine 1 and the above-said combustion chamber 3.

The turbine 4 rotates the compressor 2 through a connecting shaft 5.

Independent starting means 6, which can be constituted by an electric motor, are provided to bring the turbine 2-compressor 4 assembly into self-maintaining operation independent of the engine.

This engine has a compression ratio less than 12, and regulating means for the speed of the supercharging unit are provided and are arranged so that the minimal rotary speed of this supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine 1, conditions of temperature and of pressure enabling its starting and its operation at slow speed.

This threshold value is all the higher, for a given supercharging unit, as the compression ratio of the engine is low.

Regulating means are constituted by a supply device 7 limiting the flow rate of fuel introduced into the combustion chamber 3, and such a supply device can be constituted by an electro-pump delivering a flow rate of fuel proportional to its supply voltage.

In the embodiment illustrated in Figure 1, the combustion chamber 3 receives only fresh air coming from the compressor 2.

In the ci
the combus
hand, fresh
2, and, on
combustion
pipe 1b of
In the ei
the combus
constituted
pressor 2 a
tion gases
of the engi
By way
the diesel
8 and that
the superch
of 0.75, th
charging u
a compress
which will
the compr
Now, in
the minim
is 80°C
perature o
pression st
To obt
ambient te
equal to 0
temperatur
to 1.3 or
pressure r
It is this
threshold
supercharg
There w
to Figures
one compr
This su
a compr
combustion
and a tu
gas by th
30.
The turl
through a
Indepen
for exampl
bring the
to self-ma
First co
order that
fresh air,
chamber 3
engine (no
less than
Second
so that the
combustion
and by th
diesel engin
Regulatir
supercharg
arranged so
this superc

In the embodiment illustrated in Figure 2, the combustion chamber 3 receives, on one hand, fresh air coming from the compressor 2, and, on the other hand, all or part of the combustion gases coming from the exhaust pipe 1b of the engine 1.

In the embodiment illustrated in Figure 3, the combustion chamber 3 receives a mixture constituted by fresh air coming from the compressor 2 and by all or part of the combustion gases coming from the exhaust pipe 1b of the engine 1.

By way of example, if it is assumed that the diesel engine has a compression ratio of 8 and that the turbine and the compressor of the supercharging unit have an isentropic yield of 0.75, there will be obtained for this supercharging unit a self maintaining operation for a compression ratio in the compression of 1.3, which will produce a rise in temperature in the compressor of about 30°C.

Now, in an engine of compression ratio 8, the minimal temperature in the intake pipe is 80°C to obtain the auto-ignition temperature of the fuel at the end of the compression stroke.

To obtain this value of 80°C for an ambient temperature which will be assumed equal to 0°C, it is hence necessary that the temperature ratio in the compression be equal to 1.3 or with an isentropic yield of 0.75, a pressure ratio equal to 2 in the compressor. It is this pressure ratio which fixes the threshold value of the rotary speed of the supercharging unit.

There will now be described, with reference to Figures 4 to 6, a supercharging unit with one compression stage, for a diesel engine.

This supercharging unit comprises,

a compressor 20 supplying fresh air to a combustion chamber 30,

and a turbine 40 supplied with combustion gas by the above-said combustion chamber 30.

The turbine 40 rotates the compressor 20 through a connecting shaft 50.

Independent starter means 60, such as for example an electric motor, are provided to bring the turbine 40-compressor 20 assembly to self-maintaining operation.

First connecting means 21 are provided in order that the compressor 20 may supply fresh air, in parallel to the combustion chamber 30 and the intake pipe of a diesel engine (not shown) with a compression ratio less than 12.

Second connecting means 41 are provided so that the turbine 40 can be supplied with combustion gas by the combustion chamber 30 and by the exhaust pipe of the above-said diesel engine.

Regulating means for the speed of the supercharging unit are provided and are arranged so that the minimal rotary speed of this supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure enabling its starting and its operation at slow speed.

This threshold value is all the higher, for a given supercharging unit, as the compression ratio of the corresponding engine is low.

These regulating means can be constituted by a supply device 70 limiting the flow rate of fuel introduced into the combustion chamber 30, such a supply device being constitutable by an electro pump delivering a flow rate of fuel proportional to its supply voltage.

These regulating means can comprise an actuating member which can modify the threshold value according to the compression ratio of the engine concerned.

In the embodiment illustrated in Figure 4, the combustion chamber 30 receives only when the supercharging unit cooperates with the engine, fresh air coming from the compressor 20.

In the embodiment illustrated in Figure 5, the combustion chamber 30 receives, when the supercharging unit cooperates with the engine, on one hand, fresh air coming from the compressor 20, and, on the other hand, all or part of the combustion gases coming from the exhaust pipe of the said engine.

In the embodiment illustrated in Figure 6, the combustion chamber 30 receives, when the supercharging unit cooperates with the engine, a mixture constituted by fresh air coming from the compressor 20, and by all or part of the combustion gases coming from the exhaust pipe of the above-said engine.

In the foregoing, it has been assumed that the supercharged diesel engine according to the invention included a supercharging unit with one compression stage, but such a diesel engine can include a supercharging unit with two or more compression stages.

A supercharged diesel engine comprising a supercharging unit with two compression stages is illustrated in Figures 7 and 8, this diesel engine being assumed constructed in a manner similar to that of the embodiment illustrated in Figure 2, the same reference numerals denoting the same members in Figures 7 and 8 and in Figure 2, but modified by the index 1 when it relates to elements of the high pressure stage.

This diesel engine hence comprises a supercharging unit with a low pressure stage, compressor 2-turbine 4, and a high pressure stage, compressor 2_1-turbine 4_1.

In the variation illustrated in Figure 7, it is the high pressure compressor 2_1 which supplies the combustion chamber 3, whilst in the variation illustrated in Figure 8 it is the low pressure compressor 2 which supplies the combustion chamber 3.

Of course, there can be envisaged other

supercharging arrangements with two or several compression stages and the invention can be applied also thereto.

It is the same for supercharging units which could have also two or several compression stages arranged in different ways, the invention being then applicable to such supercharging units.

Finally, the method of supercharging a diesel engine according to the invention is applied to a diesel engine with a supercharging unit with two or several compression stages arranged according to various systems.

Finally, the invention enables the exploitation of supercharged diesel engines of which the compression ratio is less than 12, these diesel engines being capable of being started without resorting to any special starting process and capable of operating correctly at slow speed.

Moreover, the invention enables the obtaining, for such diesel engines of a satisfactory overall yield (yield taking into account amounts of fuel injected into the diesel engine and into the combustion chamber).

WHAT WE CLAIM IS:—

1. Method of supercharging a diesel engine having a supercharging unit comprising a compressor, supplying the engine and a combustion chamber in parallel with fresh air, and a turbine supplied with combustion gas by the engine and said combustion chamber, said turbine rotating said compressor, independent starter means being provided to bring the turbine-compressor assembly to self-maintaining operation independent of the engine, the engine having a compression ratio less than 12, the minimal rotary speed of its supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure enabling its starting and its operation at slow speed, this threshold value being all the higher, for a given supercharging unit, as the compression ratio of the engine is low.

2. Supercharging method according to claim 1, wherein said threshold value is obtained by limiting the supply of fuel of the combustion chamber.

3. Supercharging method according to claim 1 or 2, wherein the supercharging unit has several compression stages.

4. Diesel engine supercharged by a supercharging unit comprising a compressor, supplying in parallel the engine and a combustion chamber with fresh air, and a turbine supplied with combustion gas by the engine and said combustion chamber, said turbine rotating said compressor, independent starter means being provided to bring the turbine-compressor assembly to self-maintaining operation independent of the engine, wherein the engine has a compression ratio less than 12, and regulating means for the speed of its supercharging unit are provided and are arranged so that the minimal rotary speed of this supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure permitting its starting and its slow speed operation, this threshold value being all the higher, for a given supercharging unit, as the compression ratio of the engine is low.

5. Supercharged diesel engine according to claim 4, wherein said regulating means are constituted by a supply device limiting the flow rate of fuel introduced into the combustion chamber.

6. Supercharged diesel engine according to claim 4 or 5, wherein the combustion chamber receives only fresh air coming from the compressor.

7. Supercharged diesel engine according to claim 4 or 5, wherein the combustion chamber receives, on one hand, fresh air coming from the compressor, and, on the other hand, all or part of the combustion gas coming from the exhaust pipe of the engine.

8. Supercharged diesel engine according to claim 4 or 5, wherein the combustion chamber receives a mixture constituted by fresh air coming from the compressor and by all or part of the combustion gas coming from the exhaust pipe of the engine.

9. Supercharged diesel engine according to any one of claims 4 to 8, wherein the supercharging unit has several compression stages.

10. Supercharging unit for a diesel engine comprising a compressor supplying fresh air to a combustion chamber, and a turbine supplied with combustion gas by said combustion chamber, said turbine rotating said compressor, independent starter means being provided to bring the turbine-compressor assembly to self-maintaining operation, wherein first connecting means are provided for the compressor to supply fresh air in parallel to the combustion chamber and the intake pipe of a diesel engine with a compression ratio less than 12, second connecting means being provided for the turbine to be supplied with combustion gas by the combustion chamber and by the exhaust pipe of said diesel engine, and speed regulating means for the supercharging unit being provided and arranged so that the minimal rotary speed of this supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure permitting its starting and its slow speed operation, this threshold value being all the higher, for a given supercharging unit, as the compression ratio of the engine concerned is low.

11. Supercharging unit for a diesel engine according to claim 10, wherein said regulating means are constituted by a supply device

limiting the fl
the combustio

12. Superch
according to cl
means compri
can modify th
the compressi
cerned.

13. Superch
according to a
wherein the co
air coming fr
the supercharg
engine.

14. Superch
according to a
wherein the
when the supe
the engine, o
from the comp
all or part of
from the exha

15. Superch
according to a
wherein the
when the supe
the engine, a

Printed f
Publishe

supercharging arrangements with two or several compression stages and the invention can be applied also thereto.

It is the same for supercharging units which could have also two or several compression stages arranged in different ways, the invention being then applicable to such supercharging units.

Finally, the method of supercharging a diesel engine according to the invention is applied to a diesel engine with a supercharging unit with two or several compression stages arranged according to various systems.

Finally, the invention enables the exploitation of supercharged diesel engines of which the compression ratio is less than 12, these diesel engines being capable of being started without resorting to any special starting process and capable of operating correctly at slow speed.

Moreover, the invention enables the obtaining, for such diesel engines of a satisfactory overall yield (yield taking into account amounts of fuel injected into the diesel engine and into the combustion chamber).

WHAT WE CLAIM IS:—

1. Method of supercharging a diesel engine having a supercharging unit comprising a compressor, supplying the engine and a combustion chamber in parallel with fresh air, and a turbine supplied with combustion gas by the engine and said combustion chamber, said turbine rotating said compressor, independent starter means being provided to bring the turbine-compressor assembly to self-maintaining operation independent of the engine, the engine having a compression ratio less than 12, the minimal rotary speed of its supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure enabling its starting and its operation at slow speed, this threshold value being all the higher, for a given supercharging unit, as the compression ratio of the engine is low.

2. Supercharging method according to claim 1, wherein said threshold value is obtained by limiting the supply of fuel of the combustion chamber.

3. Supercharging method according to claim 1 or 2, wherein the supercharging unit has several compression stages.

4. Diesel engine supercharged by a supercharging unit comprising a compressor, supplying in parallel the engine and a combustion chamber with fresh air, and a turbine supplied with combustion gas by the engine and said combustion chamber, said turbine rotating said compressor, independent starter means being provided to bring the turbine-compressor assembly to self-maintaining operation independent of the engine, wherein the engine has a compression ratio less than 12, and regulating means for the speed of its supercharging unit are provided and are arranged so that the minimal rotary speed of this supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure permitting its starting and its slow speed operation, this threshold value being all the higher, for a given supercharging unit, as the compression ratio of the engine is low.

5. Supercharged diesel engine according to claim 4, wherein said regulating means are constituted by a supply device limiting the flow rate of fuel introduced into the combustion chamber.

6. Supercharged diesel engine according to claim 4 or 5, wherein the combustion chamber receives only fresh air coming from the compressor.

7. Supercharged diesel engine according to claim 4 or 5, wherein the combustion chamber receives, on one hand, fresh air coming from the compressor, and, on the other hand, all or part of the combustion gas coming from the exhaust pipe of the engine.

8. Supercharged diesel engine according to claim 4 or 5, wherein the combustion chamber receives a mixture constituted by fresh air coming from the compressor and by all or part of the combustion gas coming from the exhaust pipe of the engine.

9. Supercharged diesel engine according to any one of claims 4 to 8, wherein the supercharging unit has several compression stages.

10. Supercharging unit for a diesel engine comprising a compressor supplying fresh air to a combustion chamber, and a turbine supplied with combustion gas by said combustion chamber, said turbine rotating said compressor, independent starter means being provided to bring the turbine-compressor assembly to self-maintaining operation, wherein first connecting means are provided for the compressor to supply fresh air in parallel to the combustion chamber and the intake pipe of a diesel engine with a compression ratio less than 12, second connecting means being provided for the turbine to be supplied with combustion gas by the combustion chamber and by the exhaust pipe of said diesel engine, and speed regulating means for the supercharging unit being provided and arranged so that the minimal rotary speed of this supercharging unit is limited to a threshold value sufficient to create, in the intake pipe of the engine, conditions of temperature and of pressure permitting its starting and its slow speed operation, this threshold value being all the higher, for a given supercharging unit, as the compression ratio of the engine concerned is low.

11. Supercharging unit for a diesel engine according to claim 10, wherein said regulating means are constituted by a supply device

* C L M S *

limiting the flow rate of fuel introduced into the combustion chamber.

12. Supercharging unit for a diesel engine according to claim 10, wherein said regulating means comprise an actuating member which can modify the threshold value according to the compression ratio of the engine concerned.

13. Supercharging unit for a diesel engine according to any one of claims 10, 11 or 12, wherein the combustion chamber receives fresh air coming from the compressor, only when the supercharging unit cooperates with the engine.

14. Supercharging unit for a diesel engine according to any one of claims 10, 11 or 12, wherein the combustion chamber receives, when the supercharging unit cooperates with the engine, on one hand, fresh air coming from the compressor, and, one the other hand, all or part of the combustion gases coming from the exhaust pipe of said engine.

15. Supercharging unit for a diesel engine according to any one of claims 10, 11 or 12, wherein the combustion chamber receives, when the supercharging unit cooperates with the engine, a mixture constituted by fresh air coming from the compressor and by all or part of the combustion gases coming from the exhaust pipe of said engine.

16. Supercharging unit for a diesel engine according to any one of claims 11 to 15, wherein it comprises several compression stages.

17. Method of supercharging a diesel engine with a supercharging unit, substantially as hereinbefore described with reference to the accompanying drawings.

18. Supercharging unit for a diesel engine, substantially as hereinbefore described, with reference to the accompanying drawings.

19. Supercharged diesel engine substantially as hereinbefore described with reference to the accompanying drawings.

FORRESTER, KETLEY & CO.,
Chartered Patent Agents,
Jessel Chambers, 88—90 Chancery Lane,
London WC2 A1HB.
and
Rutland House, Edmund Street,
Birmingham 3.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1972.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

