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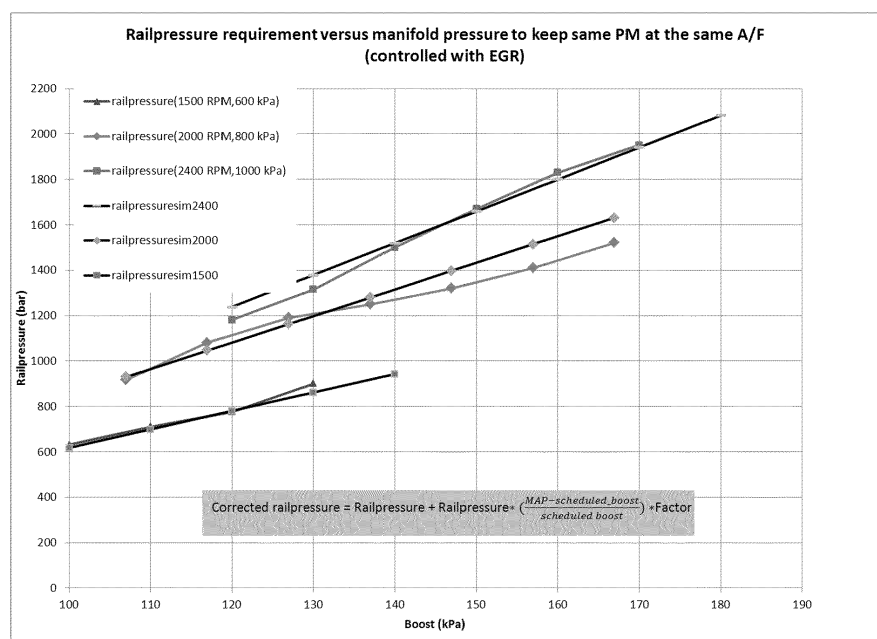
(54) **FUEL DELIVERY PRESSURE CONTROL**

(57) In an internal combustion engine, a method of controlling the pressure of a fuel accumulator volume which supplies fuel under pressure to one or more fuel injectors, comprising:

i) determining or measuring the actual pressure at the inlet manifold; and,

ii) determining an accumulator volume pressure based on the results of step i). The accumulator volume may be a common rail. The method may include determining the difference between the actual inlet/manifold pressure and a scheduled inlet /manifold pressure, and determining the accumulator volume based on this difference.

Figure 3a



Description

[0001] This disclosure relates to a method of controlling the pressure in fuel delivery systems and has particular but not exclusive application to controlling the pressure in common rail or fuel accumulator volumes.

[0002] A common rail is typically used to supply multiple fuel injectors for internal combustion engines. The common (fuel) rail pressure is typically controlled by an engine ECU and is controlled dependent on desired engine speed and load. For a given speed and load under steady state conditions, the boost pressure/ manifold inlet pressure is usually at the target boost/inlet pressure. In such circumstances it is fairly straight forward to determine an optimum rail pressure to achieve the desired performance in terms of limiting particulate matter (PM) and noise performance. If the rail pressure is too high, the engine noise will not be acceptable; if the rail pressure is too low the PM emissions will be too high.

[0003] During transient driving however, due to e.g. turbo lag, the boost pressure is often not at the target pressure for a given load speed point. When accelerating (decelerating) the boost pressure is typically below (above) the desired steady state boost pressure and hence the scheduled rail pressure will be too high (too low) for these conditions.

[0004] As a result, the noise will exceed limits during the early phase of acceleration transient. It is to be noted that the PM level is not optimum during the deceleration transient. To overcome the noise issue, the scheduled rail pressure is consequently made lower than optimum and hence once the steady state condition is reached, PM performance will be jeopardized in order to make the noise performance acceptable during transient condition.

[0005] It is an object of the invention to overcome these problems.

Statement of the Invention

[0006] In one aspect of the invention is provided, in an internal combustion engine, a method of controlling the pressure of a fuel accumulator volume which supplies fuel under pressure to one or more fuel injectors, comprising: i) determining or measuring the actual pressure at the inlet manifold; and, ii) determining an accumulator volume pressure based on the results of step i).

[0007] The fuel accumulator volume may be a common rail.

[0008] The method may include determining the difference between the actual inlet/manifold pressure and a scheduled inlet /manifold pressure, and determining the pressure in the accumulator volume based on this difference.

[0009] The method preferably comprises determining a rail pressure requirement assuming steady state conditions, and applying a correction factor thereto, wherein said correction factor is dependent on the difference between the actual inlet /manifold pressure and the scheduled manifold pressure.

[0010] The rail pressure requirement may be based on the equation:

$$\text{Corrected rail pressure} = \text{SchRP} + \text{SchRP} * \left(\frac{\text{MAP} - \text{scheduled boost}}{\text{scheduled boost}} \right) * F$$

where SchRP is the scheduled Rail Pressure based on speed and load assuming steady state; MAP : the actual inlet/manifold pressure;

Scheduled boost is the desired/scheduled boost pressure based on engine speed and load;

F is a calibration factor.

[0011] The calibration factor may be variable and dependent on speed and/or load.

[0012] The engine may be a turbocharged engine.

[0013] By making a correction of the rail pressure demand based on inlet/manifold pressure deviation from the steady state desired manifold pressure level, an optimum PM and noise performance can be obtained under all conditions. The actual inlet/manifold pressure may be measured by a pressure sensor or may be estimated from other parameters.

Brief Description of Drawings

[0014] The invention will now be described by way of example and with reference to the following figures of which:

Figure 1 shows the effect of inlet manifold (or boost) pressure of particulate matter emissions;

Figure 2 shows the rail pressure (correction) required to compensate for the manifold pressure in order to keep the same PM emissions; and,

Figure 3a and 3b illustrate rail pressure correction compensating for manifold pressure effects.

[0015] Figure 1 shows the effect of manifold pressure on particulate matter emissions. The figure shows plots at different engine speeds at the same rail pressure and same air/fuel ratio. The pressure denoted in the legend as (600,800,1000kPa relates to the load of the engine in this case expressed in IMEP (Indicated Mean Effective Pressure in kPa). The load may alternatively be injected fuel quantity or whatever load variable commonly used). The air fuel ratio

may be controlled by exhaust gas recirculation.

[0016] Figure 2 shows the rail pressure required to compensate for the manifold pressure in order to keep the same PM emissions. It shows the rail pressure requirement versus manifold pressure to keep the same PM at the same A/F (controlled by EGR).

[0017] According to one aspect of the invention, the rail pressure is controlled dependent on the actual boost/inlet manifold pressure.

[0018] In a particular example, the rail pressure is computed based on requirements such as torque and speed, and then corrected dependent on the actual inlet/boost pressure. In a preferred aspect, the correction is applied which is dependent on the difference between the actual inlet/boost pressure and that scheduled/desired (e.g. that determined by the ECU), the latter of which may be considered as the current inlet manifold pressure under steady state conditions. By making a correction of the rail pressure demand based on the manifold pressure deviation from the steady state desired manifold pressure level, an optimum PM and noise performance can be obtained under all conditions.

[0019] In a particular example, the following equation is used to correct rail pressure:

$$\text{Corrected rail pressure} = \text{SchRP} + \text{SchRP} * \left(\frac{\text{MAP} - \text{scheduled_boost}}{\text{scheduled_boost}} \right) * F$$

SchRP: This is the rail pressure that comes from the scheduling table versus speed and load; it is that determined by conventional methodology by the ECU;

MAP: the actual manifold pressure (measured directly or estimated);

Scheduled boost: This is the desired boost/inlet pressure looked-up in the boost target table versus speed and load;

F is a factor; i.e. a calibration value.

[0020] The calibration value may be a single value.

[0021] In advanced examples, if more precision is needed, this factor may be variable i.e. optimized to provide more accuracy and dependent on engine speed and load. The factor in this case may be determined from a look-up table relating the factor to speed and load. With this factor the slope of the rail pressure change versus manifold pressure change can be adjusted.

[0022] The factor(s) used in the methodology can be determined by calibration and may be stored in the ECU. The factor may be dependent on various engine parameters and on boost pressure itself and may be stored as a look up table. In an example a sensor to measure actual pressure is used to determine actual inlet pressure.

[0023] The advantage of this method is that the steady state PM/noise performance can be optimized without having to make a compromise for the real live transient conditions. If throttling is introduced during some circumstances, and thus the manifold pressure is changed accordingly or when the engine is operated at low ambient pressure where the manifold pressure is likely to be different for the same speed load point, the rail pressure is automatically kept close to its optimum. Thus the overall performance will be improved.

[0024] If this compensation is not desired in applications or for older calibrations for the same engine, the factor can be calibrated to "0" and no impact will be seen by the introduction of the methodology.

[0025] Figure 3a and 3b illustrate rail pressure correction compensating for manifold pressure effects, and show plots at various engine speeds and pressure (what pressure) of the rail pressure applied to the common rail against boost pressure, with and without using the correction factor, using a single value and an optimized value for the factor respectively.

[0026] The plots compare and thus show how the rail pressure is somewhat changed as a result of the methodology.

[0027] It is with turbochargers and with their typical "not instantaneous" boost response that lag is most obvious in comparison with superchargers, for instance, that have much faster boost response and some superchargers even have "instantaneous" boost response, the here described problem can almost be neglected. However aspects are not limited to turbocharger applications. In general, anything that leads to a non-instantaneous following of the manifold pressure to the desired load of the engine (like big volumes in the air path; intercooler volume, manifold volume, tubing benefits from this rail-pressure correction methodologies. . In general, it is the turbocharger, that is responsible for the biggest "lag" in the whole air system. In applications without boost devices (normally aspirated engines) the manifold pressure is either always constant (= equal to ambient pressure) if it is a diesel without throttle valve or it changes with the movement of the throttle valve if there is a throttle and in the latter case it is only the manifold volume that is responsible for some slight transient "lag" between throttle movement and manifold pressure due to the manifold filling effects.

Claims

1. In an internal combustion engine, a method of controlling the pressure of a fuel accumulator volume which supplies fuel under pressure to one or more fuel injectors, comprising:

- i) determining or measuring the actual pressure at the inlet manifold; and,
ii) determining an accumulator volume pressure based on the results of step i).

2. A method as claimed in claim 1 wherein said fuel accumulator volume is a common rail.

3. A method as claimed in claims 1 or 2 including determining the difference between the actual inlet/manifold pressure and a scheduled inlet /manifold pressure, and determining the accumulator volume based on this difference.

4. A method as claimed in claims 1 to 3 comprising determining a rail pressure requirement assuming steady state conditions, and applying a correction factor thereto, wherein said correction factor is dependent on the difference between the actual inlet /manifold pressure and the scheduled manifold pressure.

5. A method as claimed in claim 4 wherein said rail pressure requirement is determined based on the equation:

$$\text{Corrected rail pressure} = \text{SchRP} + \text{SchRP} * \left(\frac{\text{MAP} - \text{scheduled_boost}}{\text{scheduled_boost}} \right) * F$$

where SchRP is the scheduled Rail Pressure based on speed and load assuming steady state; MAP: the actual inlet/manifold pressure;

Scheduled boost is the desired/scheduled boost pressure based on engine speed and load;

F is a calibration factor.

6. A method as claimed in claim 5 wherein said calibration factor is variable and dependent on speed and/or load.

7. A method as claimed in claim 1 to 6 wherein said engine is a turbocharged engine.

Figure 1

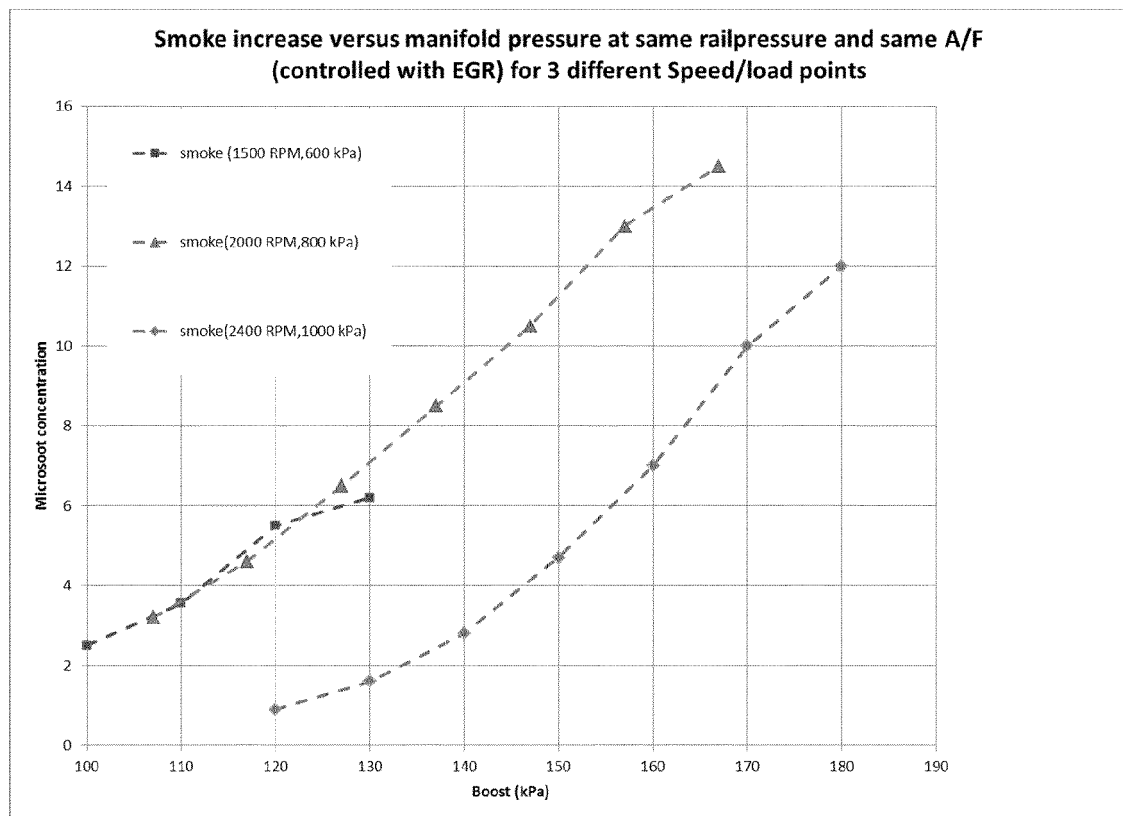


Figure 2

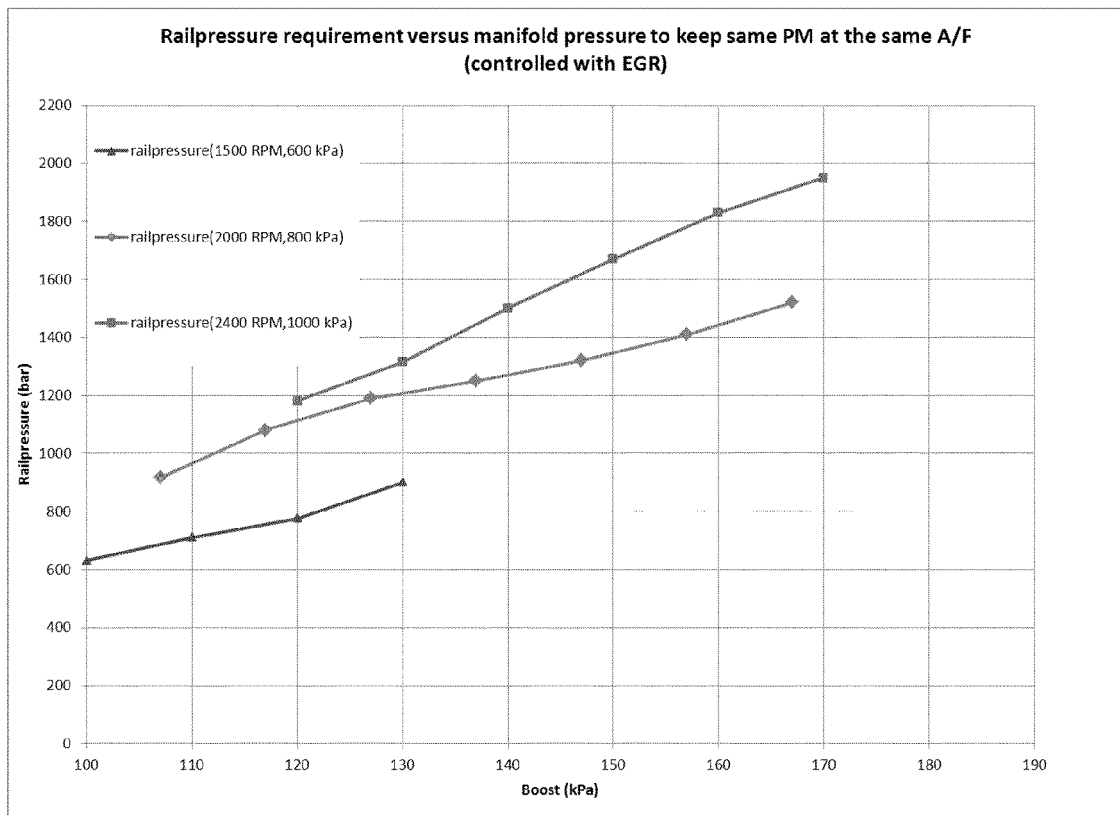


Figure 3a

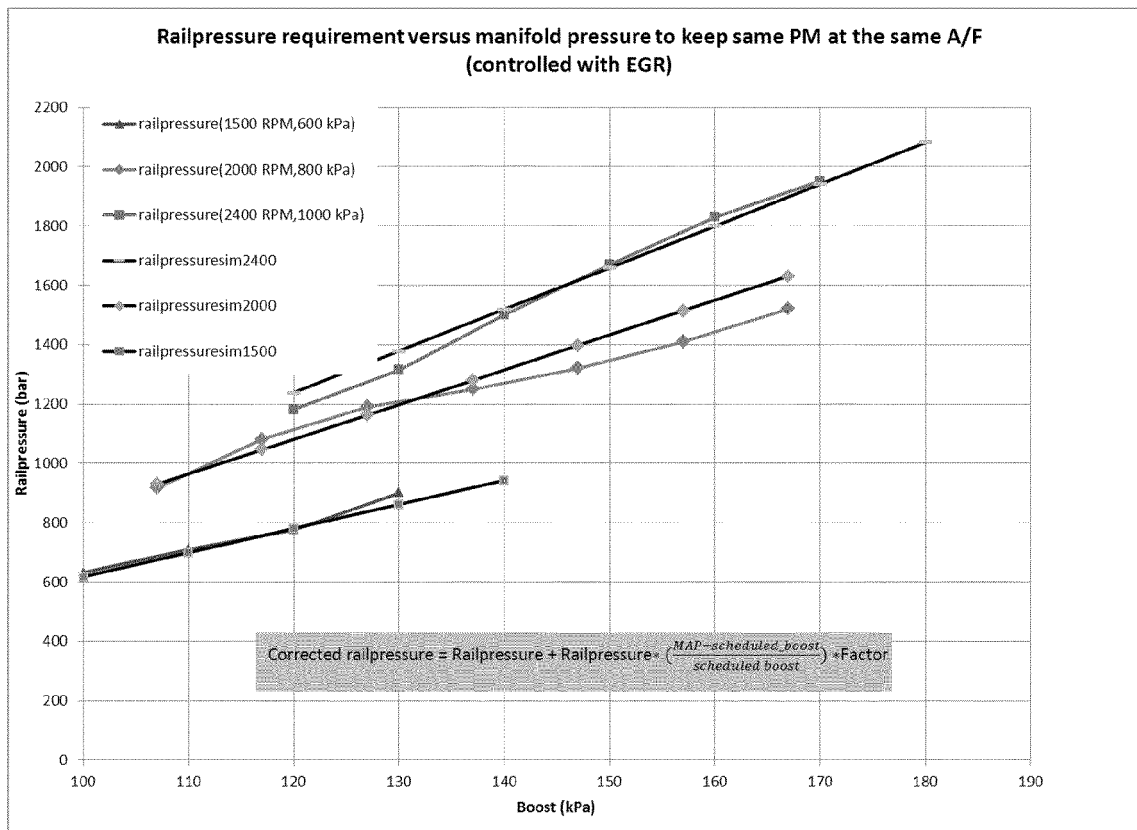


Figure 3b

