Claims

1. A method of reducing low-speed pre-ignition (LSPI) events in a direct-injection spark-ignition internal combustion engine comprising lubricating the crankcase of the engine with a lubricating oil composition, the lubricating oil composition comprising:
a calcium detergent providing the lubricating oil composition with a calcium content of from 0.15 to 0.5 wt.%, based on the weight of the lubricating oil composition, a boron-containing additive, and a molybdenum-containing additive, said lubricating oil composition having: a molybdenum content of 150 ppm to 1500 ppm by weight, based on the weight of the lubricating oil composition, a boron content of 150 ppm to 1500 ppm by weight, based on the weight of the lubricating oil composition;
a magnesium content of no more than 0.03 wt.%, based on the weight of the lubricating oil composition,
a phosphorus content of 0.01 to 0.12 wt.%, based on the weight of the lubricating oil composition, and
a sulfated ash content of from 0.2 to 2.0 mass%, based on the weight of the lubricating oil composition

2. A method according to claim 1, wherein, in operation, the engine generates a brake mean effective pressure level of greater than 1,500 kPa, optionally greater than 2,000 kPa, at engine speeds of from 1,000 to 2,500 rotations per minute (rpm), optionally from 1,000 to 2,000 rpm.

3. A method according to claim 1 or claim 2, wherein the lubricating oil composition has a molybdenum content of from 150 ppm to 1500 ppm, for example of from 300 to 1500 ppm, such as from 350 to 1000 ppm, by weight, based on the weight of the lubricating oil composition.

4. A method according to claim 1, 2 or 3, wherein the lubricating oil composition has a boron content of from 150 to 1500 ppm, for example of from 200 to 1000 ppm, by weight, based on the weight of the lubricating oil composition.

5. A method according to any one of the preceding claims, wherein the lubricating oil composition comprises a calcium detergent providing the lubricating oil composition with a calcium content of from 0.08 to 0.5 wt.%, for example of from 0.15 to 0.4 wt.%, based on the weight of the lubricating oil composition.

6. A method according to any one of the preceding claims, wherein the lubricating oil composition has a magnesium content of no more than 0.12 wt.%.

7. A method according to claim 6, wherein the lubricating oil composition has a magnesium content of 0.0 wt.% , based on the weight of the lubricating oil composition.

8. A method according to any preceding claim, wherein the boron-containing additive is one or more of: a borated dispersant, a borated dispersant viscosity index improver, an alkali metal or an alkaline earth metal borate, a borated overbased metal detergent, a borated epoxide, a borate ester, a sulfurised borate ester, or a borate amide; optionally wherein the boron-containing additive is one or more of a borated dispersant, a borate ester or a borated overbased metal detergent.

9. A method according to any preceding claim, wherein the molybdenum-containing additive is an oil-soluble or oil-dispersible organo-molybdenum compound, optionally wherein the molybdenum-containing additive is one or more of a molybdenum dithiocarbamate, a molybdenum dithiophosphate, a molybdenum dithiophosphinate, a molybdenum xanthate, a molybdenum thioxanthate, or a molybdenum sulfide.

10. Use of a combination of a boron-containing additive and a molybdenum-containing additive in a lubricating oil composition to reduce LSPI events, when the composition lubricates the crankcase of a direct injection-spark ignition internal combustion engine, wherein, the molybdenum-containing additive provides the lubricating oil composition with a molybdenum content

of at least 150 ppm by weight, based on the weight of the lubricating oil composition, and the boron-containing additive provides the lubricating oil composition with a boron content of at least 150 ppm by weight, based on the weight of the lubricating oil composition.

11. A use according to claim 10, wherein, in operation, the engine generates a break mean effective pressure level of greater than 1,500 kPa, optionally greater than 2,000 kPa, at engine speeds of from 1,000 to 2,500 rotations per minute (rpm), optionally from 1,000 to 2,000 rpm.

12. A use according to claim 10 or claim 11, wherein the molybdenum-containing additive provides the lubricating oil composition with a molybdenum content of from 150 ppm to 1500 ppm, for example of from 300 to 1500 ppm, such as from 350 to 1000 ppm, by weight, based on the weight of the lubricating oil composition

13. A use according to any one of claims 10 to 12, wherein the boron-containing additive provides a boron content of from 150 to 1500 ppm, for example of from 200 to 1000 ppm, by weight, based on the weight of the lubricating oil composition.

14. A use according to any one of claims 10 to 13, wherein the lubricating oil composition comprises a calcium detergent providing the lubricating oil composition with a calcium content of from 0.08 to 0.5 wt.%, for example of from 0.15 to 0.4 wt.%, based on the weight of the lubricating oil composition.

15. A use according to any one of claims 10 to 14, wherein the lubricating oil composition has a magnesium content of no more than 0.12 wt.%.

16. A use according to claim 15, wherein the lubricating oil composition has a magnesium content of 0.0 wt.%, based on the weight of the lubricating oil composition.

17. A use according to any one of claims 10 to 16, wherein the boron-containing additive is one or more of: a borated dispersant, a borated dispersant VI

improver, an alkali metal or a mixed alkali metal or an alkaline earth metal borate, a borated overbased metal detergent, a borated epoxide, a borate ester, a sulfurised borate ester, or a borate amide; optionally wherein the boron-containing additive is one or more of a borated dispersant, a borate ester or a borated overbased metal detergent.

18. A use according to any one of claims 10-17, wherein the molybdenum-containing additive is an oil-soluble or oil-dispersible organo-molybdenum compound, optionally wherein the molybdenum-containing additive is one or more of a molybdenum dithiocarbamate, a molybdenum dithiophosphate, a molybdenum dithiophosphinate, a molybdenum xanthate, a molybdenum thioxanthate, or a molybdenum sulfide.

19. A use according to any one of claims 10 to 18, wherein the lubricating oil composition has a phosphorus content of no more than 0.12 wt.%, preferably not more than 0.08 wt.% and more preferably no more than 0.06 wt%, based on the weight of the lubricating oil composition.