need for engine oil additive components and/or combinations that are effective to reduce or eliminate LSPI in boosted internal combustion engines.

SUMMARY AND TERMS

[0006] The present disclosure relates to a lubricating oil composition and method of operating a boosted internal combustion engine. The lubricating oil composition includes greater than 50 wt.% of a base oil of lubricating viscosity, one or more calcium-containing overbased detergents having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896, and one or more magnesium-containing detergents. The one or more calcium-containing overbased detergents provide 900 ppm by weight to less than 2400 ppm by weight of calcium to the lubricating oil composition, and the one or more magnesium-containing detergents provide 50 ppm by weight to 1000 ppm by weight of magnesium to the lubricating oil composition, both based on a total weight of the lubricating oil composition. The lubricating oil composition may be effective to reduce low speed pre-ignition events in the boosted internal combustion engine lubricated with the lubricating oil composition.

[0006a] In one aspect of the present disclosure, there is provided an engine oil composition comprising:

greater than 50 wt.% of a base oil of lubricating viscosity;

an overbased calcium sulfonate detergent having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896, and

one or more magnesium-containing detergents, and

one of:

(a) an overbased calcium phenate or calcium salicylate detergent having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896, and

(b) at least one low-based calcium-containing detergent having a total base number of up to 175 mg KOH/g, measured by the method of ASTM D-2896 in an amount the provides at least 50 ppm by weight of calcium to the lubricating oil composition, based on a total weight of the engine oil composition,

wherein the engine oil composition includes an amount of the overbased calcium-containing detergent that provides 900 ppm by weight to less than 1800 ppm by weight of calcium to the engine oil composition, and an amount of the magnesium-containing detergent

that provides 50 ppm by weight to 1000 ppm by weight of magnesium to the engine oil composition, both amounts being based on a total weight of the engine oil composition; and the total calcium in the engine oil composition is up to 1800 ppm, based on a total weight of the engine oil composition, and

the engine oil composition passes the TEOST-33 test (thermal-oxidation engine oil simulation test) by having a weight gain of 30 mg or less and meets the ILSAC GF-5 performance requirements.

[0006b] In another aspect of the present disclosure, there is provided a method for operating a boosted internal combustion engine comprising:

lubricating a boosted internal combustion engine with an engine oil composition comprising

greater than 50 wt.% of a base oil of lubricating viscosity;

an overbased calcium sulfonate detergent having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896

an amount of one or more magnesium-containing detergents sufficient to provide 50 ppm by weight to 1000 ppm by weight of magnesium to the engine oil composition, based on a total weight of the engine oil composition, and

one of:

(a) an overbased calcium phenate or calcium salicylate detergent having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896, and

(b) at least one low-based calcium-containing detergent having a total base number of up to 175 mg KOH/g, measured by the method of ASTM D-2896 in an amount the provides at least 50 ppm by weight of calcium to the engine oil composition, based on a total weight of the engine oil composition,

wherein the engine oil composition includes an amount of the overbased calcium-containing detergents that provides 900 ppm by weight to less than 1800 ppm by weight of calcium to the engine oil composition, based on a total weight of the engine oil composition and the total calcium in the engine oil composition is up to 1800 ppm, based on a total weight of the engine oil composition, and

operating the engine lubricated with the engine oil composition.

[0007] In another embodiment, the disclosure provides a method for reducing low speed pre-ignition events in a boosted internal combustion engine. The method includes a step of lubricating the boosted internal combustion engine with a lubricating oil composition including greater than 50 wt.% of a base oil of lubricating viscosity, one or more calcium-containing overbased detergents having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896, and one or more magnesium-containing detergents. The one or more calcium-containing overbased detergents provide 900 ppm by weight to less than 2400 ppm by weight of calcium to the lubricating oil composition, and the one or more magnesium-containing detergents provide 50 ppm by weight to 1000 ppm by weight of magnesium to the lubricating oil composition, both based on a total weight of the lubricating oil composition. The boosted internal combustion engine is operated and lubricated with the lubricating oil composition whereby the low speed pre-ignition events in the engine lubricated with the lubricating oil composition may be reduced.

[0008] In any of the foregoing embodiments, the one or more overbased calcium-containing detergents comprise a compound selected from an overbased calcium sulfonate detergent, an overbased calcium phenate detergent, an overbased calcium salicylate detergent and mixtures thereof. In some embodiments, the overbased detergent is a mixture of two or more overbased calcium containing detergents. In each of the foregoing embodiments, the

What is claimed is:

1. An engine oil composition comprising:

greater than 50 wt.% of a base oil of lubricating viscosity;

an overbased calcium sulfonate detergent having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896, and

one or more magnesium-containing detergents, and

one of:

(a) an overbased calcium phenate or calcium salicylate detergent having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896, and

(b) at least one low-based calcium-containing detergent having a total base number of up to 175 mg KOH/g, measured by the method of ASTM D-2896 in an amount the provides at least 50 ppm by weight of calcium to the lubricating oil composition, based on a total weight of the engine oil composition,

wherein the engine oil composition includes an amount of the overbased calcium-containing detergent that provides 900 ppm by weight to less than 1800 ppm by weight of calcium to the engine oil composition, and an amount of the magnesium-containing detergent that provides 50 ppm by weight to 1000 ppm by weight of magnesium to the engine oil composition, both amounts being based on a total weight of the engine oil composition; and the total calcium in the engine oil composition is up to 1800 ppm, based on a total weight of the engine oil composition, and

the engine oil composition passes the TEOST-33 test (thermal-oxidation engine oil simulation test) by having a weight gain of 30 mg or less and meets the ILSAC GF-5 performance requirements.

2. The engine oil composition of claim 1, comprising an overbased calcium phenate detergent or an overbased calcium salicylate detergent.

3. The engine oil composition of claim 1, wherein the reduction of low-speed preignition (LSPI) events is a 50% or greater reduction and the LSPI events are LSPI counts during 25,000 engine cycles, wherein the engine is operated at 2000 revolutions per minute with brake mean effective pressure of 18,000 kPa.

4. The engine oil composition of claim 1, wherein the one or more magnesium-containing detergents are overbased magnesium-containing detergents having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896 and the one or more overbased magnesium-containing detergents are selected from an overbased magnesium sulfonate detergent, an overbased magnesium phenate detergent, an overbased magnesium salicylate detergent and mixtures thereof.

5. The engine oil composition of claim 1, wherein the amount of the magnesium-containing detergent is sufficient to provide from 100 ppm by weight to 800 ppm

by weight of magnesium to the engine oil composition, based on the total weight of the engine oil composition.

6. The engine oil composition of claim 1, wherein the one or more overbased calcium-containing detergents provides from 1050 to 1650 ppm by weight calcium to the engine oil composition based on a total weight of the engine oil composition.

7. The engine oil composition of claim 1, wherein the engine oil composition has a ratio of a total mmol metal in the engine oil composition to a total base number of the engine oil composition ranging from greater than 4.5 to 10.0.

8. The engine oil composition of claim 1, wherein the total base number of the engine oil composition is at least 7.5 mg KOH/g.

9. The engine oil composition of claim 1, comprising (b) the at least one low-based/neutral calcium-containing detergent.

10. The engine oil composition of claim 9, wherein the at least one low-based/neutral calcium-containing detergent comprises a compound selected from a low based calcium sulfonate detergent, a low based calcium phenate detergent, a low based calcium salicylate detergent and mixtures thereof.

11. The engine oil composition of claim 1, wherein the total calcium in the engine oil composition ranges from 1000 ppm to 1800 ppm.

12. The engine oil composition of claim 1, wherein the total calcium in the engine oil composition ranges from 1050 ppm to 1650 ppm.

13. The engine oil composition of claim 1, further comprising one or more components selected from the group consisting of friction modifiers, antiwear agents, dispersants, antioxidants, and viscosity index improvers.

14. The engine oil composition of claim 1, wherein the greater than 50% of base oil is selected from the group consisting of Group II, Group III, Group IV, Group V base oils, and a combination of two or more of the foregoing, and wherein the greater than 50 wt.% of base oil is other than diluent oils that arise from provision of additive components or viscosity index improvers in the composition.

15. The engine oil composition of claim 1, wherein the engine oil composition is effective to reduce low speed pre-ignition events in a boosted internal combustion engine lubricated with the engine oil composition relative to a number of low speed pre-ignition events in the same engine lubricated with reference lubricating oil R-1,

wherein R-1 is formulated from 80.7 wt.% of a Group III base oil, 12.1 wt.% of passenger car motor oil additive package and 7.2 wt.% of a 35 SSI ethylene/propylene copolymer viscosity index improver, and R-1 also showed the following properties and partial elemental analysis:

10.9	Kinematic Viscosity at 100°C, (mm^2/sec)
3.3	TBS, APPARENT_VISCOSITY, cPa
2438	calcium (ppmw)
< 10	magnesium (ppmw)
80	molybdenum (ppmw)
772	phosphorus (ppmw)
855	zinc (ppmw)
9.0	Total Base Number ASTM D-2896 (mg KOH/g)
165	Viscosity Index

wherein the low speed pre-ignition events are low speed pre-ignition counts during 25,000 engine cycles, wherein the engine is operated at 2000 revolutions per minute with brake mean effective pressure of 18,000 kPa.

16. A method for operating a boosted internal combustion engine comprising:

lubricating a boosted internal combustion engine with an engine oil composition comprising

greater than 50 wt.% of a base oil of lubricating viscosity;

an overbased calcium sulfonate detergent having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896

an amount of one or more magnesium-containing detergents sufficient to provide 50 ppm by weight to 1000 ppm by weight of magnesium to the engine oil composition, based on a total weight of the engine oil composition, and

one of:

(a) an overbased calcium phenate or calcium salicylate detergent having a total base number of greater than 225 mg KOH/g, measured by the method of ASTM D-2896, and

(b) at least one low-based calcium-containing detergent having a total base number of up to 175 mg KOH/g, measured by the method of ASTM D-2896 in an amount the provides at least 50 ppm by weight of calcium to the engine oil composition, based on a total weight of the engine oil composition,

wherein the engine oil composition includes an amount of the overbased calcium-containing detergents that provides 900 ppm by weight to less than 1800 ppm by weight of calcium to the engine oil composition, based on a total weight of the engine oil composition and the total calcium in the engine oil composition is up to 1800 ppm, based on a total weight of the engine oil composition, and

operating the engine lubricated with the engine oil composition.

17. The method of claim 16, wherein the engine oil composition passes a TEOST 33 bench oxidation test (thermal-oxidation engine oil simulation test) by having a weight gain of 30 mg or less and low speed pre-ignition events in the boosted internal combustion engine lubricated with the engine oil composition are reduced relative to a number of low speed pre-ignition events in the same engine lubricated with reference lubricating oil R-1,

wherein R-1 is formulated from 80.7 wt.% of a Group III base oil, 12.1 wt.% of passenger car motor oil additive package and 7.2 wt.% of a 35 SSI ethylene/propylene copolymer viscosity index improver, and R-1 also showed the following properties and partial elemental analysis:

10.9	Kinematic Viscosity at 100°C, (mm^2/sec)
3.3	TBS, APPARENT_VISCOSITY, cPa
2438	calcium (ppmw)
< 10	magnesium (ppmw)
80	molybdenum (ppmw)
772	phosphorus (ppmw)
855	zinc (ppmw)
9.0	Total Base Number ASTM D-2896 (mg KOH/g)
165	Viscosity Index

wherein the low speed pre-ignition events are low speed pre-ignition counts during 25,000 engine cycles, wherein the engine is operated at 2000 revolutions per minute with brake mean effective pressure of 18,000 kPa.

18. The method of claim 17, wherein low-speed pre-ignition (LSPI) events are based on LSPI counts during 25,000 engine cycles, wherein the engine is operated at 2000 revolutions per minute (RPM) with brake mean effective pressure (BMEP) of 18,000 kPa.

19. The method of claim 16, wherein the amount of the magnesium-containing detergent is sufficient to provide from 100 ppm by weight to 800 ppm by weight of magnesium to the engine oil composition, based on the total weight of the engine oil composition.

20. The method of claim 16, wherein the total calcium in the engine oil composition ranges from 1000 ppm to 1800 ppm.

21. The method of claim 17, wherein the lubricating step lubricates a combustion chamber or cylinder walls of a spark-ignited direct injection engine or port fuel injected internal combustion engine provided with a turbocharger or a supercharger.

22. The method of claim 18, further comprising a step of measuring low speed pre-ignition events of the internal combustion engine lubricated with the engine oil.