[0005] To be suitable for electric components, the fluids generally need to provide good lubricating performance, good electrical conductivity, and/or good cooling performance as well as being compatible with insulation coatings of any electrical wires or other componentry that the fluid may contact. Often, one or more of the desired properties needed for electric and hybrid-electric applications is compromised due to the collection of additives commonly used in such traditional lubricating fluids; thus, prior lubricating fluids may be unsuitable for electric or hybrid-electric vehicles for one or more reasons. For instance, some traditional lubricant packages may have low electrical conductivity but then have poor thermal conductivity (providing poor cooling performance), which would be undesired for electric or hybrid applications. Other traditional lubricant packages may have high thermal conductivity (providing good cooling capability) but then have poor electrical conductivity, which also would be undesired for the electric or hybrid applications. Yet other traditional lubricant compositions may attack or breakdown insulation provided on electrical wires or electrical components and, over time, degrade the performance of such electrical componentry as evidenced by a poor or degrading wire breakdown voltage after fluid aging. Thus, prior conventional driveline lubricating fluids do not necessarily provide desired performance for these unique applications in the context of electric or hybrid-electric drivelines.

BRIEF DESCRIPTION OF THE FIGURES

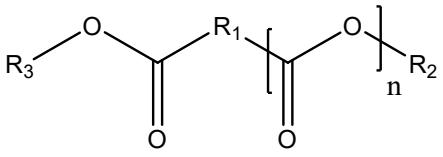
[0006] FIG. 1 is a plot of magnet wire breakdown voltage relative to metal content of a lubricating and cooling fluid and mol percent of ester groups in a base oil system of that lubricating fluid.

SUMMARY

[0007] The present disclosure relates to a driveline for an electric or hybrid-electric vehicle. In one approach or example, the driveline includes an electric motor including an insulated magnet wire having an insulation coating thereon with a thermal rating of about 190°C to about 210°C and a lubricating and cooling fluid in contact with the insulation coating of the insulated magnet wire of the electric motor. In some examples, the lubricating and cooling fluid includes a detergent system providing at least about 50 ppm metal to the fluid and a base oil system including a first base oil of lubricating

viscosity blended with an ester base oil. In approaches, the base oil system may also include at least about 20 weight percent of the ester base oil, and has a ratio of the metal provided by the detergent system to mol percent of ester groups in the base oil system of the lubricating and cooling fluid of about 70 or less.

[0008] In other approaches or examples of the driveline, the driveline may also include a number of optional examples in any combination. These optional approaches or examples of the driveline may include one or more of the following: wherein the insulation coating of the magnet wire includes one or more layers and wherein the layer in contact with the lubricating and cooling fluid includes a polyamide, a polyimide, a poly(amide/imide), combinations thereof, blends thereof, or copolymers thereof; and/or wherein the magnet wire has an AWG gauge of 14 to 30; and/or wherein the magnet wire is copper; and/or wherein the insulated magnet wire in contact with the lubricating and cooling fluid has a breakdown voltage of about 10,000 volts or higher; and/or wherein the ester base oil includes a branched diester; and/or wherein the branched diester is a reaction product of one or more dicarboxylic acids having an internal carbon chain length of 6 to 10 and one or more alcohols having a branched carbon chain length of 6 to 12 carbons; and/or wherein the ester base oil includes a monoester and/or a diester having the structure of Formula I:



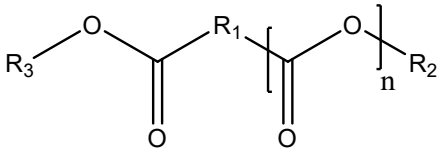
(Formula I)

wherein R_1 is a carbon chain having m-2 carbons with m being an integer from 6 to 10, R_2 and R_3 are the same or different and include C8 to C20 linear or branched alkyl chains, and n is an integer of 0 or 1; and/or wherein n is 1 and R_2 and R_3 are the same or different and include C8 to C10 branched alkyl chains; and/or wherein the ester base oil is selected from a dibasic ester based on bi(6-methylheptyl)adipate; a dibasic ester based on bis(8-methylnonyl) adipate; or a linear monoester having about 16 to about 18 carbons in an acid moiety thereof and about 20 linear carbons in an alcohol moiety thereof; or combinations thereof; and/or wherein the detergent system includes alkali or alkaline metal salts of phenates, sulfonates, calixarates, salixrates, salicylates, carboxylic acids, sulfurized derivatives thereof, or combinations thereof; and/or wherein the alkali or alkaline metal includes calcium, magnesium, potassium, sodium, lithium, barium, or mixtures thereof; and/or wherein the detergent system provides no more than 800 ppm of the metal; and/or wherein the first base

oil of the base oil system is a mineral or synthetic base oil; and/or wherein the first base oil of the base oil system is a polyalphaolefin.

[0009] In another approach or example of this disclosure, the driveline for a hybrid or hybrid-electric vehicle includes an electric motor with an insulated magnet wire having an insulation coating thereon and wherein the insulation coating include a polyamide, a polyimide, a poly(amide/imide), a combination thereof, blends thereof, or copolymers thereof combined with a lubricating and cooling fluid in contact with the coating of the insulated magnet wire of the electric motor. In examples, the lubricating and cooling fluid may include a detergent system providing at least about 50 ppm metal to the fluid and a base oil system including a first base oil of lubricating viscosity blended with an ester base oil and wherein the base oil system includes at least about 20 weight percent of the ester base oil.

[0010] In other approaches or examples of the driveline described in the previous paragraph, the driveline may also include a number of optional examples in any combination. These optional approaches or examples of the driveline may include one or more of the following: a ratio of the metal provided by the detergent system to the mol percent of ester groups in the base oil system of about 70 or less; and/or wherein the insulation coating of the magnet wire has a thermal rating of about 190°C to about 200°C; and/or wherein the insulated magnet wire in contact with the lubricating and cooling fluid has a breakdown voltage of about 10,000 volts or higher; and/or wherein the ester base oil includes a branched diester; and/or wherein the branched diester is a reaction product of one or more dicarboxylic acids having an internal carbon chain length of 6 to 10 and one or more alcohols having a branched carbon chain length of 6 to 12 carbons; and/or wherein the ester base oil includes a monoester and/or a diester having the structure of Formula I:



(Formula I)

wherein R_1 is a carbon chain having m-2 carbons with m being an integer from 6 to 10, R_2 and R_3 are the same or different and include C8 to C20 linear or branched alkyl chains, and n is an integer of 0 or 1; and/or wherein n is 1 and R_2 and R_3 are the same or different and include C8 to C10 branched alkyl chains; and/or wherein the ester base oil is selected from a dibasic ester based on bi(6-methylheptyl)adipate; a dibasic ester based on bis(8-methylnonyl) adipate; or a linear monoester having about 16 to about 18 carbons in an acid moiety thereof and about 20 linear carbons in an alcohol moiety thereof; or combinations thereof; and/or

wherein the detergent system includes alkali or alkaline metal salts of phenates, sulfonates, calixarates, salixrates, salicylates, carboxylic acids, sulfurized derivatives thereof, or combinations thereof; and/or wherein the alkali or alkaline metal includes calcium, magnesium, potassium, sodium, lithium, barium, or mixtures thereof; and/or wherein the detergent system provides no more than 800 ppm of the metal.

[0010a] In one aspect, the present disclosure refers to a driveline for an electric or hybrid-electric vehicle, the driveline comprising:

an electric motor including an insulated magnet wire having an insulation coating thereon with a thermal rating of 190°C. to 210°C., wherein the insulation coating of the magnet wire includes one or more layers and wherein the layer in contact with the lubricating and cooling fluid includes a polyamide, a polyimide, a poly(amide/imide), combinations thereof, blends thereof, or copolymers thereof;

a lubricating and cooling fluid in contact with the insulation coating of the insulated magnet wire of the electric motor;

wherein the lubricating and cooling fluid includes a detergent system providing at least 50 ppm metal to the fluid and a base oil system including a first base oil of lubricating viscosity blended with an ester base oil, wherein the base oil system includes at least 20 weight percent of the ester base oil, and a ratio of the metal provided by the detergent system to mol percent of ester groups in the base oil system of the lubricating and cooling fluid of 70 or less; and

wherein the insulated magnet wire in contact with the lubricating and cooling fluid has a breakdown voltage of 10,000 volts or higher.

[0010b] In one aspect, the present disclosure refers to a driveline for a hybrid or hybrid-electric vehicle, the driveline comprising:

an electric motor including an insulated magnet wire having an insulation coating thereon, wherein the insulation coating include a polyamide, a polyimide, a poly(amide/imide), a combination thereof, blends thereof, or copolymers thereof, wherein the insulation coating of the magnet wire has a thermal rating of 190° C. to 200° C.;

a lubricating and cooling fluid in contact with the coating of the insulated magnet wire of the electric motor;

wherein the lubricating and cooling fluid includes a detergent system providing at least 50 ppm metal to the fluid and a base oil system including a first base oil of lubricating viscosity blended with an ester base oil, wherein the base oil system includes at least 20 weight percent of the ester base oil,

wherein the ester base oil is selected from a dibasic ester based on bi(6-methylheptyl)adipate; a dibasic ester based on bis(8-methylnonyl)adipate; or a linear monoester having 16 to 18 carbons in an acid moiety thereof and 20 linear carbons in an alcohol moiety thereof; or combinations thereof and

wherein a ratio of the metal provided by the detergent system to the mol percent of ester groups in the base oil system of 70 or less; and

wherein the insulated magnet wire in contact with the lubricating and cooling fluid has a breakdown voltage of 10,000 volts or higher.

[0010c] In one aspect, the present disclosure refers to a system including a lubricating fluid and an insulated magnet wire, the system comprising:

a lubricating fluid including (i) a detergent system providing at least 50 ppm metal to the fluid; (ii) a base oil system including a first base oil of lubricating viscosity blended with an ester base oil, wherein the base oil system includes at least 20 weight percent of the ester base oil and providing ester groups to the base oil system; and (iii) a ratio of the metal provided by the detergent system to mol percent of ester groups in the base oil system of the lubricating fluid of 70 or less;

an insulated magnet wire having an insulation coating thereon with a thermal rating of 190° C. to 210° C., wherein the insulation coating of the magnet wire includes one or more layers and wherein an outermost layer of the insulation coating has a composition including a polyamide, a polyimide, a poly(amide/imide), combinations thereof, blends thereof, or copolymers thereof; and

wherein the lubricating fluid contacts the outermost layer of the insulated magnet wire.

[0011] In yet further approaches or examples of this disclosure, methods of lubricating a driveline and electric motor are provided. In examples, the methods include lubricating the driveline and/or or electric motor with any example of the lubricating and cooling fluids described herein wherein the insulated magnet wire of the electric motor is in contact with the lubricating an cooling fluid. In one aspect, the present disclosure refers to a method of lubricating an electric motor of a hybrid or hybrid-electric vehicle, the method comprising:

lubricating an electric motor with a lubricating fluid;

wherein the electric motor includes at least one insulated magnet wire having an insulation coating thereon, wherein the insulation coating includes one or more layers and wherein an outermost layer includes a polyamide, a polyimide, a poly(amide/imide), a

combination thereof, blends thereof, or copolymers thereof, and wherein the insulation coating of the magnet wire has a thermal rating of 190° C. to 200° C.;

wherein the lubricating fluid includes (i) a detergent system providing at least 50 ppm metal to the fluid; (ii) a base oil system including a first base oil of lubricating viscosity blended with an ester base oil, wherein the base oil system includes at least 20 weight percent of the ester base oil and providing ester groups to the base oil system; and (iii) a ratio of the metal provided by the detergent system to mol percent of ester groups in the base oil system of the lubricating fluid of 70 or less; and

wherein the lubricating fluid contacts the outmost layer of the insulated magnet wire.

[0012] In yet other approaches or examples, the use of any example of the lubricating and cooling fluids herein is described for lubricating any example of the drivelines of a hybrid or hybrid-electric vehicle described herein. In approaches, the use includes contacting at least the insulated magnet wire of the electric motor with any example of the lubricating and cooling fluids herein for achieving the improved breakdown voltage as described above.

DETAILED DESCRIPTION

[0013] The present disclosure describes systems including magnet wires with lubricating and cooling fluids suitable for electric and/or hybrid-electric vehicle applications, and in particular, drivelines and/or transmissions thereof where the lubricating and cooling fluids contact the electric and/or hybrid-electric motors and components thereof such as the insulated magnet wires. The fluids herein exhibit not only good lubricating properties, but also good electrical properties and are compatible with insulation coating layers of the magnet wires found in the electric motors of such vehicle applications.

[0014] In some aspects, the present disclosure includes a system with a driveline for an electric or hybrid-electric vehicle where the driveline includes at least an electric motor with one or more insulated magnet wires. Each magnet wire has an insulation coating thereon with a thermal rating of about 190°C to about 210°C. As understood by a person of skill in the art, thermal ratings or thermal class of wire is based upon ASTM D2307. This test is set forth in NEMA MW 1000, a standards publication from the National Electrical Manufacturers Association. In approaches, the insulation coating of the magnet wire may include one or more layers and wherein at least the outer layer in contact with the lubricating

CLAIMS

What is claimed is:

1. A driveline for an electric or hybrid-electric vehicle, the driveline comprising:

an electric motor including an insulated magnet wire having an insulation coating thereon with a thermal rating of 190°C. to 210°C., wherein the insulation coating of the magnet wire includes one or more layers and wherein the layer in contact with the lubricating and cooling fluid includes a polyamide, a polyimide, a poly(amide/imide), combinations thereof, blends thereof, or copolymers thereof;

a lubricating and cooling fluid in contact with the insulation coating of the insulated magnet wire of the electric motor;

wherein the lubricating and cooling fluid includes a detergent system providing at least 50 ppm metal to the fluid and a base oil system including a first base oil of lubricating viscosity blended with an ester base oil, wherein the base oil system includes at least 20 weight percent of the ester base oil, and a ratio of the metal provided by the detergent system to mol percent of ester groups in the base oil system of the lubricating and cooling fluid of 70 or less; and

wherein the insulated magnet wire in contact with the lubricating and cooling fluid has a breakdown voltage of 10,000 volts or higher.

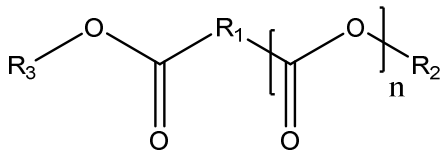
2. The driveline for a hybrid or hybrid-electric vehicle of claim 1, wherein the magnet wire has an AWG gauge of 14 to 30.

3. The driveline for a hybrid or hybrid-electric vehicle of claim 2, wherein the magnet wire is copper.

4. The driveline for a hybrid or hybrid-electric vehicle of claim 1, wherein the ester base oil includes a branched diester.

5. The driveline for a hybrid or hybrid-electric vehicle of claim 4, wherein the branched diester is a reaction product of one or more dicarboxylic acids having an internal carbon chain length of 6 to 10 and one or more alcohols having a branched carbon chain length of 6 to 12 carbons.

6. The driveline for a hybrid or hybrid-electric vehicle of claim 1, wherein the ester base oil includes a monoester and/or a diester having the structure of Formula I:



(Formula I)

wherein R_1 is a carbon chain having m-2 carbons with m being an integer from 6 to 10, R_2 and R_3 are the same or different and include C8 to C20 linear or branched alkyl chains, and n is an integer of 0 or 1.

7. The driveline for a hybrid or hybrid-electric vehicle of claim 6, wherein n is 1 and R_2 and R_3 are the same or different and include C8 to C10 branched alkyl chains.

8. The driveline for a hybrid or hybrid-electric vehicle of claim 1, wherein the ester base oil is selected from a dibasic ester based on bi(6-methylheptyl)adipate; a dibasic ester based on bis(8-methylnonyl)adipate; or a linear monoester having 16 to 18 carbons in an acid moiety thereof and 20 linear carbons in an alcohol moiety thereof; or combinations thereof.

9. The driveline for a hybrid or hybrid-electric vehicle of claim 1, wherein the detergent system includes alkali or alkaline metal salts of phenates, sulfonates, calixarates, salixrates, salicylates, carboxylic acids, sulfurized derivatives thereof, or combinations thereof.

10. The driveline for a hybrid or hybrid-electric vehicle of claim 9, wherein the alkali or alkaline metal includes calcium, magnesium, potassium, sodium, lithium, barium, or mixtures thereof.

11. The driveline for a hybrid or hybrid-electric vehicle of claim 1, wherein the detergent system provides no more than 800 ppm of the metal.

12. The driveline for a hybrid or hybrid-electric vehicle of claim 1, wherein the first base oil of the base oil system is a mineral or synthetic base oil.

13. The driveline for a hybrid or hybrid-electric vehicle of claim 1, wherein the first base oil of the base oil system is a polyalphaolefin.

14. A driveline for a hybrid or hybrid-electric vehicle, the driveline comprising:

an electric motor including an insulated magnet wire having an insulation coating thereon, wherein the insulation coating include a polyamide, a polyimide, a poly(amide/imide), a combination thereof, blends thereof, or copolymers thereof, wherein the insulation coating of the magnet wire has a thermal rating of 190° C. to 200° C.;

a lubricating and cooling fluid in contact with the coating of the insulated magnet wire of the electric motor;

wherein the lubricating and cooling fluid includes a detergent system providing at least 50 ppm metal to the fluid and a base oil system including a first base oil of lubricating viscosity blended with an ester base oil, wherein the base oil system includes at least 20 weight percent of the ester base oil,

wherein the ester base oil is selected from a dibasic ester based on bi(6-methylheptyl)adipate; a dibasic ester based on bis(8-methylnonyl)adipate; or a linear monoester having 16 to 18 carbons in an acid moiety thereof and 20 linear carbons in an alcohol moiety thereof; or combinations thereof and

wherein a ratio of the metal provided by the detergent system to the mol percent of ester groups in the base oil system of 70 or less; and

wherein the insulated magnet wire in contact with the lubricating and cooling fluid has a breakdown voltage of 10,000 volts or higher.

15. The driveline for a hybrid or hybrid-electric vehicle of claim 14, wherein the ester base oil is a dibasic ester based on bi(6-methylheptyl)adipate or a dibasic ester based on bis(8-methylnonyl)adipate.

16. The driveline for a hybrid or hybrid-electric vehicle of claim 14, wherein the detergent system includes alkali or alkaline metal salts of phenates, sulfonates, calixarates, salixrates, salicylates, carboxylic acids, sulfurized derivatives thereof, or combinations thereof.

17. The driveline for a hybrid or hybrid-electric vehicle of claim 16, wherein the alkali or alkaline metal includes calcium, magnesium, potassium, sodium, lithium, barium, or mixtures thereof.

18. The driveline for a hybrid or hybrid-electric vehicle of claim 14, wherein the detergent system provides no more than 800 ppm of the metal.

19. A system including a lubricating fluid and an insulated magnet wire, the system comprising:

a lubricating fluid including (i) a detergent system providing at least 50 ppm metal to the fluid; (ii) a base oil system including a first base oil of lubricating viscosity blended with an ester base oil, wherein the base oil system includes at least 20 weight percent of the ester base oil and providing ester groups to the base oil system; and (iii) a ratio of the metal provided by the detergent system to mol percent of ester groups in the base oil system of the lubricating fluid of 70 or less;

an insulated magnet wire having an insulation coating thereon with a thermal rating of 190° C. to 210° C., wherein the insulation coating of the magnet wire includes one or more layers and wherein an outermost layer of the insulation coating has a composition including a polyamide, a polyimide, a poly(amide/imide), combinations thereof, blends thereof, or copolymers thereof; and

wherein the lubricating fluid contacts the outermost layer of the insulated magnet wire.

20. The system of claim 19, wherein the insulated magnet wire in contact with the lubricating fluid has a breakdown voltage of 10,000 volts or higher.

21. The system claim 19, wherein the insulated magnet wire includes a wire having an AWG gauge of 14 to 30.

22. The system of claim 21, wherein the magnet wire is copper.

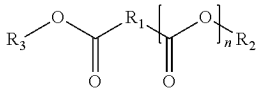
23. The system of claim 19, wherein an outer surface of the insulated magnet wire contacts the lubricating fluid.

24. The system of claim 19, wherein the ester base oil includes a branched diester.

25. The system of claim 24, wherein the branched diester is a reaction product of one or more dicarboxylic acids having an internal carbon chain length of 6 to 10 and one or more alcohols having a branched carbon chain length of 6 to 12 carbons.

26. The system of claim 19, wherein the ester base oil includes a monoester and/or a diester having the structure of Formula I:

(Formula I)



wherein R_1 is a carbon chain having m−2 carbons with m being an integer from 6 to 10, R_2 and R_3 are the same or different and include C8 to C20 linear or branched alkyl chains, and n is an integer of 0 or 1.

27. The system of claim 26, wherein n is 1 and R_2 and R_3 are the same or different and include C8 to C10 branched alkyl chains.

28. The system of claim 19, wherein the ester base oil is selected from a dibasic ester based on bi (6-methylheptyl) adipate; a dibasic ester based on bis(8-methylnonyl) adipate; or a linear monoester having 16 to 18 carbons in an acid moiety thereof and 20 linear carbons in an alcohol moiety thereof; or combinations thereof.

29. The system of claim 19, wherein the detergent system includes alkali or alkaline metal salts of phenates, sulfonates, calixarates, salixrates, salicylates, carboxylic acids, sulfurized derivatives thereof, or combinations thereof.

30. The system of claim 29, wherein the alkali or alkaline metal includes calcium, magnesium, potassium, sodium, lithium, barium, or mixtures thereof.

31. The system of claim 19, wherein the detergent system provides no more than 800 ppm of the metal.

32. The system vehicle of claim 19, wherein the first base oil of the base oil system is a mineral or synthetic base oil.

33. The system of claim 19, wherein the first base oil of the base oil system is a polyalphaolefin.

34. A method of lubricating an electric motor of a hybrid or hybrid-electric vehicle, the method comprising:

lubricating an electric motor with a lubricating fluid;

wherein the electric motor includes at least one insulated magnet wire having an insulation coating thereon, wherein the insulation coating includes one or more layers and wherein an outermost layer includes a polyamide, a polyimide, a poly(amide/imide), a combination thereof, blends thereof, or copolymers thereof, and wherein the insulation coating of the magnet wire has a thermal rating of 190° C. to 200° C.;

wherein the lubricating fluid includes (i) a detergent system providing at least 50 ppm metal to the fluid; (ii) a base oil system including a first base oil of lubricating viscosity blended with an ester base oil, wherein the base oil system includes at least 20 weight percent of the ester base oil and providing ester groups to the base oil system; and (iii) a ratio of the metal provided by the detergent system to mol percent of ester groups in the base oil system of the lubricating fluid of 70 or less; and

wherein the lubricating fluid contacts the outmost layer of the insulated magnet wire.

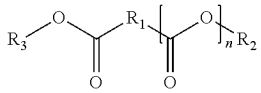
35. The method of claim 34, wherein the insulated magnet wire in contact with the lubricating fluid has a breakdown voltage of 10,000 volts or higher.

36. The method of claim 34, wherein the ester base oil includes a branched diester.

37. The method of claim 36, wherein the branched diester is a reaction product of one or more dicarboxylic acids having an internal carbon chain length of 6 to 10 and one or more alcohols having a branched carbon chain length of 6 to 12 carbons.

38. The method of claim 34, wherein the ester base oil includes a monoester and/or a diester having the structure of Formula I:

(Formula I)



wherein R_1 is a carbon chain having m−2 carbons with m being an integer from 6 to 10, R_2 and R_3 are the same or different and include C8 to C20 linear or branched alkyl chains, and n is an integer of 0 or 1.

39. The method of claim 38, wherein n is 1 and R_2 and R_3 are the same or different and include C8 to C10 branched alkyl chains.

40. The method of claim 34, wherein the ester base oil is selected from a dibasic ester based on bi(6-methylheptyl)adipate; a dibasic ester based on bis(8-methylnonyl)adipate; or a linear monoester having 16 to 18 carbons in an acid moiety thereof and 20 linear carbons in an alcohol moiety thereof.

41. The method of claim 34, wherein the detergent system provides no more than 800 ppm of the metal.