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INDUCTION ROTOR ASSEMBLY WITH THIN FOILS

Abstract

An induction rotor assembly is provided. The induction rotor assembly includes a laminated stack, a plurality of foils, a plurality of conductor bars, a first end ring, and a second end ring. The laminated stack includes a body with an outer circumferential surface with a plurality of grooves extending from the first end to the second end. Each one of the plurality of foils is disposed within one of the grooves. Each of the foils is disposed between each of the conductor bars and each of the grooves. Each of the plurality of conductor bars includes a first conductor end and a second conductor end. The first end ring mates with a surface of each first conductor end. The second end ring mates with a surface of each second conductor end, and the plurality of conductor bars extends between the first end ring and the second end ring.

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Background/Summary

INTRODUCTION

[0001] The present disclosure relates to induction rotor assemblies and more particularly systems and methods of making cast induction rotor assemblies having conductive bars with thin foils.

[0002] An induction electric motor generally includes a stator and a rotor. The stator is generally stationary, while the rotor rotates and includes a series of conductor bars arranged in a circular pattern around a body of the rotor. When an electric current is applied to the stator, a magnetic field is created that interacts with the rotor and the conductor bars. This interaction causes the rotor to rotate, which in turn produces mechanical energy.

[0003] Many current traction motors, especially in electric vehicles, use bar winding to improve a fill factor of the stator. However, the bar winding can lead to a high skin effect or a tendency of an alternating electric current to become distributed within each conductor bar such that current density is largest near the conductor bar surface while decreasing exponentially with greater depths in each conductor bar. This high skin effect results in undesirable resistance, significantly increases loss, and limits motor power density, speed, and torque capability.

[0004] While current induction rotor assemblies achieve their intended purpose, there is a need for a system and method of making an induction rotor having conductor bars with improved electrical conductivity within the conductor.

SUMMARY

[0005] According to several aspects of the present disclosure, an induction rotor assembly is provided. The induction rotor assembly includes a laminated stack, a plurality of foils, a plurality of conductor bars, a first end ring, and a second end ring. The laminated stack includes a body having a first end and an opposing second end arranged along a longitudinal axis. The body has an outer circumferential surface extending from the first end to the second end along the longitudinal axis, and the outer circumferential surface has a plurality of grooves extending from the first end to the second end. Each one of the plurality of foils is disposed within one of the grooves. Each of the plurality of conductor bars is disposed within each of the grooves, and each one of the plurality of foils is disposed between each one of the plurality of conductor bars and each one of the grooves. Each of the plurality of conductor bars includes a first conductor end extending axially beyond the first end of the laminated stack and a second conductor end extending axially beyond the second end of the laminated stack. The first end ring mates with a surface of each first conductor end to interlock each of the plurality of conductor bars to the first end ring. The second end ring mates with a surface of each second conductor end to interlock each of the plurality of conductor bars to the second end ring, and the plurality of conductor bars extends between the first end ring and the second end ring.

[0006] In accordance with another aspect of the disclosure, the induction rotor assembly has a body including a plurality of laminated steel sheets.

[0007] In accordance with another aspect of the disclosure, the induction rotor assembly has a plurality of foils that is pure copper or copper graphene composite.

[0008] In accordance with another aspect of the disclosure, the induction rotor assembly has a plurality of foils that is less than or equal to 20% graphene by volume.

[0009] In accordance with another aspect of the disclosure, the induction rotor assembly has a plurality of foils including an adhesive on one side of each foil.

[0010] In accordance with another aspect of the disclosure, the induction rotor assembly has a plurality of foils with each foil between 20 and 30 micrometers thick.

[0011] In accordance with another aspect of the disclosure, the induction rotor assembly has a plurality of foils with each foil protruding from the grooves.

[0012] In accordance with another aspect of the disclosure, the induction rotor assembly has a plurality of foils with each foil including a coating at least partially having a rough surface.

[0013] In accordance with another aspect of the disclosure, the induction rotor assembly has

multiple foil layers disposed between each groove and each conductor bar.
[0014] In accordance with another aspect of the disclosure, the induction rotor assembly has a plurality of conductor bars formed from at least one of copper or aluminum.
[0015] In accordance with another aspect of the disclosure, the induction rotor assembly includes a first end ring and a second end ring each cast in place over the first conductor end and the second conductor end, respectively, of each of the plurality of conductor bars.
[0016] In accordance with another aspect of the disclosure, the induction rotor assembly has a first end ring and a second end ring formed from aluminum.
[0017] According to several aspects of the present disclosure, a vehicle motor is provided. The vehicle motor includes a stator and an induction rotor assembly. The induction rotor assembly is configured to rotate due to a rotating magnetic field created by the stator. The induction rotor assembly includes a laminated stack, a plurality of foils, a plurality of conductor bars, a first end ring, and a second end ring. The laminated stack includes a body having a first end and an opposing second end arranged along a longitudinal axis. The body has an outer circumferential surface extending from the first end to the second end along the longitudinal axis, and the outer circumferential surface has a plurality of grooves extending from the first end to the second end. Each plurality of foils is disposed within one of the grooves. Each of the plurality of conductor bars is disposed within each of the grooves, and each one of the plurality of foils is disposed between each one of the plurality of conductor bars and each one of the grooves. Each of the plurality of conductor bars includes a first conductor end extending axially beyond the first end of the laminated stack and a second conductor end extending axially beyond the second end of the laminated stack. The first end ring mates with a surface of each first conductor end to interlock each of the plurality of conductor bars to the first end ring. The second end ring mates with a surface of each second conductor end to interlock each of the plurality of conductor bars to the second end ring, and the plurality of conductor bars extends between the first end ring and the second end ring.
[0018] In accordance with another aspect of the disclosure, the vehicle motor includes a plurality of foils of pure copper or copper-graphene composite.
[0019] In accordance with another aspect of the disclosure, the vehicle motor includes a plurality of foils, and each foil of the plurality of foils is between 20 and 30 micrometers thick.
[0020] In accordance with another aspect of the disclosure, the vehicle motor includes a plurality of conductor bars formed from at least one of copper or aluminum.
[0021] According to several aspects of the present disclosure, a method is provided. The method includes laminating a plurality of steel sheets to form a laminated stack having a first end and an opposing second end axially spaced along a longitudinal axis. A plurality of grooves are disposed on an outer circumferential surface of the laminated stack and extend from the first end to the second end. The method includes placing a plurality of foils in the plurality of grooves. The method includes forming a conductor bar in each of the grooves such that each one of the plurality of foils is disposed between each conductor bar and the laminated stack. A first conductor end extends axially beyond the first end of the laminated stack. The method also includes casting a first end ring in place around each first conductor end of each of the conductor bars and a second end ring in place around each second conductor end of each of the conductor bars to at least partially surround and electrically connect the first conductor end and the second conductor end of each of the plurality of conductor bars.
[0022] In accordance with another aspect of the disclosure, the method includes a plurality of foils including pure copper or copper-graphene composite.
[0023] In accordance with another aspect of the disclosure, the method includes placing preformed foils when placing the plurality of foils in the plurality of grooves.
[0024] In accordance with another aspect of the disclosure, the method includes placing the foils in situ when placing the plurality of foils in the plurality of grooves.

[0025] Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

[0027] FIG. **1** is a perspective view illustrating a vehicle having an electric motor with an induction rotor assembly, in accordance with the present disclosure.

[0028] FIG. **2** is a schematic exploded view illustrating the induction rotor assembly shown in FIG. **1**, where the induction rotor assembly includes a plurality of conductor bars, in accordance with the present disclosure.

[0029] FIG. **3** is a perspective view of a laminated stack of the induction rotor shown in FIG. **2**, with copper graphene foils disposed in grooves of the laminated stack, in accordance with the present disclosure.

[0030] FIG. **4** is a perspective view of the laminated stack of the induction rotor shown in FIGS. **2** and **3**, with a ring-shaped feature circumferentially extending around the laminated stack, in accordance with the present disclosure.

[0031] FIG. **5** is a flowchart illustrating a method of manufacturing the induction rotor assembly with graphene copper foils shown in FIG. **3**, in accordance with the present disclosure.

DETAILED DESCRIPTION

[0032] The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses.

[0033] Referring to FIG. **1**, a vehicle **10** having a vehicle motor **12** or inverter is shown, according to the principles of the present disclosure. The vehicle motor **12** provides motive power to the vehicle **10** and receives electrical power from at least one battery (not shown). The vehicle motor **12** is illustrated with an exemplary vehicle **10**, and the vehicle **10** is an electric vehicle or hybrid vehicle having wheels **14** driven by the vehicle motor **12**. The vehicle motor **12** includes an induction electric motor. While the vehicle **10** is illustrated as a passenger road vehicle, it should be appreciated that the vehicle motor **12** may be used with various other types of vehicles. For example, the vehicle motor **12** may be used in nautical vehicles, for example boats, or aeronautical vehicles, for example drones or passenger airplanes. Moreover, the vehicle motor **12** may be used as a stationary power source separate and independent from a vehicle.

[0034] FIG. **1** depicts a cut away view of the vehicle motor **12** illustrating a stator **16** and an induction rotor assembly **18**. The stator **16** is a stationary portion of a rotary system within the vehicle motor **12** and is generally formed from steel. Electricity is provided to the stator **16** and is converted to a rotating magnetic field. The induction rotor assembly **18** rotates due to the rotating magnetic field and provides torque to the vehicle **10** for motive power.

[0035] FIG. **2** illustrates a schematic exploded perspective view of the induction rotor assembly **18**. The induction rotor assembly **18** includes a laminated stack **20**, a plurality of foils **22**, a plurality of conductor bars **24**, a first end ring **26**, and a second end ring **28**.

[0036] The laminated stack **20** includes a body **30** having a first end **32** and an opposing second end **34** to define a longitudinal axis A. The body **30** is formed from a plurality of laminated steel sheets stacked in an axial direction. The body **30** may be steel or steel alloy. The body **30** has an outer circumferential surface **36** extending from the first end **32** to the second end **34** coaxial with the longitudinal axis A.

[0037] As shown in FIG. **2**, the outer circumferential surface **36** has a plurality of longitudinal walls **38** defining a plurality of open longitudinal grooves **40** formed therethrough from the first end **32** to the second end **34**. The longitudinal grooves **40** may be slightly skewed relative to longitudinal axis A along a length LL of the laminated stack **20**. Additionally, the longitudinal grooves **40** may be parallel to longitudinal axis A.

[0038] FIG. **3** illustrates a plurality of foils **22** disposed in the plurality of grooves **40** of the laminated stack **20**. The plurality of foils **22** is formed of a copper-graphene composite and may include up to 20% volume graphene, for example. The copper-graphene composite provides an improved mechanical and electrical performance within the induction rotor assembly **18**. Additionally, using foils **22** including copper or a copper graphene composite improves current flow since copper has 64% higher electrical conductivity than aluminum, which increased the efficiency of utilizing the skin effect at higher frequencies. Moreover, using copper graphene foils **22** adjacent to the grooves **40** may eliminate welding and inner laminar shorting occurring during casting of the induction rotor assembly **18** by aluminum molten material between laminations in the induction rotor assembly **18** without copper graphene foil **22** in the grooves **40**.

[0039] Each of the plurality of foils **22** is formed or folded into each of the grooves **40** so that the foils **22** contact and conform with the surface geometry of each groove **40**. In some instances, an adhesive may be disposed on at least one side of the foils **22** (e.g., on a side adjacent to the laminated stack **20** and a surface of the grooves **40**. In an example, each of the plurality of foils **22** may be between 20 and 30 micrometers (μm) thick and 60 millimeters in length (e.g., an axial length of the grooves **40**). Further, at least one side of each foil **22** (e.g., a side configured to contact liquid aluminum and/or the conductor bars **24** may include a rough or serrated surface, which facilitates improved bonding between the foils **22** and the conductor bars **24**. The rough or serrated surface may remove melt surface oxide for better mold filling. In some instances, the rough or serrated surface may be formed using a coating on the foil **22**, where the coating causes the rough surface. An amount of roughness of the rough or serrated surface may be determined at least partially based on aluminum melt surface tension. In an example, the coating on the foil **22** includes a copper silver (Cu—Ag) or copper nickel (Cu—Ni)-based coating, and cold-spray or physical vapor deposition (PVD) methods may be used to apply the coating. When the coating includes copper silver (Cu—Ag), the copper silver (Cu—Ag) can be between 25 and 35 weight percentage (wt. %). Additionally, at least some of the longitudinal walls **38** may include surface roughness, which is replicated on the foils **22** prior to the casting process.

[0040] As shown in FIG. **3**, and in some instances, the plurality of foils **22** may protrude from the grooves **40** in one or both directions (e.g., parallel to longitudinal axis A). When the plurality of foils **22** protrudes from the grooves **40**, the foils **22** can facilitate better bonding to other components during subsequent casting. In an example, the protruding foils **22** may extend from the grooves **40** in a direction proximate an ingate. The protruding foils **22** may extend from the grooves aligned with the longitudinal axis A and may be bent (e.g., 90°) at an edge **42** of the groove so that a protruding portion **44** contacts the body **30** and is perpendicular to the grooves **40** and longitudinal axis A. In some instances, the protruding portion **44** may be welded to protruding portions **44** of the other foils **22** disposed in other grooves **40**. During high pressure die casting of the induction rotor assembly **18**, bending the protruding portion **44** (near an ingate side) can keep the foils **22** from being displaced during the casting process.

[0041] Referring to FIG. **4**, a ring-shaped feature **46** is shown affixed to an outer circumferential surface **36** of the laminated stack **20**. The ring-shaped fixture **46** extends around at least a portion of the outer circumferential surface **36** and may be in the form of a cylinder and/or ring. The ring-shaped feature **46** is configured to hold the foils **22** in the grooves **40** after placement of the foils **22** and during casting of the conductor bars **24**. The ring-shaped fixture **46** may be removed after casting of the conductor bars **24**. The ring-shaped fixture **46** may include a material (e.g., steel) with a melting temperature greater than that of a material of the conductor bars **24** (e.g., aluminum).

[0042] Referring again to FIG. **2**, each of the plurality of conductor bars **24** is disposed within each of the longitudinal grooves **40**. Each of the plurality of foils **22** is disposed between each one of the plurality of conductor bars **24** and each one of the plurality of grooves **40**. For convenience, FIG. **2** illustrates one conductor bar **24** removed to show one longitudinal groove **38** defined by the longitudinal walls **38**. The conductor bars **24** carry induced current in the induction rotor assembly **18**, which interacts with the magnetic field produced by the stator **16** and produces torque. Each of the plurality of conductor bars **24** has a first conductor end **41**. The first conductor end **41** extends axially beyond the first end **32** of the laminated stack **20**. Each of the plurality of conductor bars **24** also has a second conductor end **42**. The second conductor end **42** extends axially beyond the second end **34** of the laminated stack **20**. Each of the conductor bars **24** has a conductor length L.sub.C extending parallel to the longitudinal axis A. The conductor bars **24** may be manufactured from aluminum or copper.
[0043] As illustrated in FIG. **2**, the first end ring **26** abuts and is fixed to each of the first conductor ends **41** of each of the plurality of conductor bars **24** at the first end **32** of the laminated stack **20**. The second end ring **28** abuts and is fixed to each of the second conductor ends **42** of each of the plurality of conductor bars **24** at the second end **34** of the laminated stack **20**. The first end ring **26** at least partially surrounds and electrically couples the first end **32** to the conductor bars **24**. The second end ring **28** at least partially surrounds and electrically couples the second end **34** to the conductor bars **24**. The first end ring **26** and the second end ring **28** are preferably cast in place from aluminum or a cast aluminum alloy. However, it should be appreciated that the first end ring **26** and the second end ring **28** may be cast in place from other conductive materials.
[0044] Referring now to FIG. **5**, a flowchart illustrating a method **100** for manufacturing an induction rotor assembly **18** having graphene-copper foils is presented, in accordance with the present disclosure.
[0045] The method starts at block **102**. Block **102** depicts laminating a plurality of steel sheets to define the laminated stack **20**. The laminated stack **20** includes the first end **32** and the second end **34**. The second end **34** is axially spaced from the first end **32** along the longitudinal axis A. The steel sheets are laminated together so that slots in each of the steel sheets cooperate to define the grooves **40** extending along the longitudinal axis A. The grooves **40** are angularly spaced about and equidistant from the longitudinal axis A. The method then moves to block **104**.
[0046] Block **104** depicts placing a plurality of foils **22** in the plurality of grooves **40**. The plurality of foils **22** can be formed and placed into the grooves **40** using a variety of methods. In examples, the foils **22** may be formed using 3D additive manufacturing, metal printing, a spray coating, and may include other highly conductive materials. Additionally, the foils **22** may include a high conductive layer surface finish using the previously listed forming methods for better bonding to the conductor bars **24**.
[0047] In an example, the foils **22** may be preformed and bent, folded, or otherwise shaped in conformity with a geometry of each groove **40**. The preformed foils **22** are then placed into the grooves **40**. Placing the foils **22**, in this example, includes using an automated process (e.g., a robotic arm) to place and/or shape the foils **22**. In some instances, placing the plurality of foils **22** may include placing multiple foils **22** into each groove **40**. Additionally, placing the plurality of foils **22** may include pre-heating the foils **22** and/or the laminated stack **20** (e.g., to 150-350° C.) prior to being positioned within each groove **40** to assist with metallurgical bonding between the foils **22** and the conductor bars **24**. Placing the plurality of foils **22** may include forming an intermetallic phase at an interface between each foil **22** and the conductor bars **24**. The intermetallic phase may be disposed on an entire surface of the foils **22** or dispersed on the surface of the foils **22**.
[0048] In another example, placing the foils **22** includes placing and shaping the foils **22** in situ. Placing and shaping the foils **22** in situ can include placing the foils **22** within each groove **40** and then shaping each foil **22** to conform to the geometry of each individual groove **40**. For example,

the foils **22** may be folded into each groove **40** and then pushed and conformed with the profile of the groove **40** using thin needles. The foils **22** may have a thickness between 20 and 30 micrometers (μm).

[0049] In some instances, placing the foils **22** can include placing a ring-shaped feature **46** around a circumference of the laminated stack **20** prior to a casting of the conductor bars **24**. The ring-shaped feature **46** functions to hold the foils **22** in place as the casting material (e.g., aluminum) flows through the grooves **40**. The ring-shaped feature **46** is generally removed with minor machining subsequent to casting the conductor bars **24**.

[0050] Additionally, placing the foils **22** in each of the grooves **40** may include bending a protruding portion **44** of the foils **22**. In this instance, bending the protruding portion **44** includes bending the protruding portion **44** over an edge of the groove **40** so that the bent protruding portion **44** substantially contacts and is flush with an axial surface **48** of the laminated stack **20**. The bent protruding portion **44** can be bent using an automated process (e.g., a robotic arm). Additionally, the bent protruding portion **44** can be welded to adjacent bent protruding portions **44** of adjacent foils **22**. The method **100** then moves to block **106**.

[0051] Block **106** depicts forming a conductor bar **24** in each of the plurality of grooves **40**. Each one of the conductor bars **24** is formed on the foils **22** in each groove **40**, and the foils **22** are disposed between each conductor bar **24** and the laminated stack **20**. The conductor bars **24** are formed to include a conductor length L.sub.C longer than the laminated stack length LL so that the first conductor end **41** and the second conductor end **42** extend outward beyond the first end **32** and the second end **34** of the laminated stack **20**, respectively. In some instances, the conductor bars **24** are pre-formed and placed into each groove **40**. In other instances, the conductor bars **24** are cast in situ in each groove **40**. The conductor bars **24** are formed and/or positioned so that the first conductor end **41** and the second conductor end **42** of each of the plurality of conductor bars **24** extend axially outward beyond the first end **32** and the second end **34** of the laminated stack **20**, respectively. The method **100** then moves to block **108**.

[0052] Block **108** depicts casting the first end ring **26** in place around the first conductor end **41** and casting the second end ring **28** in place around the second conductor end **42**. Casting the first end ring **26** and the second end ring **28** in place can include placing the laminated stack **20**, having the plurality of conductor bars **24** positioned therein, into a form. The form defines the first end ring **26** and/or the second end ring **28** and can be any suitable shape and size for casting the first end ring **26** and/or the second end ring **28**. The first end ring **26** is cast in place around the first conductor end **41** on each of the conductor bars **24**. The first end ring **26** is cast to at least partially surround and electrically connect the first conductor end **41** of each of the plurality of conductor bars **24** with the first end ring **26**. Additionally, the second end ring **28** is cast in place around the second conductor end **42** on each of the conductor bars **24**. The second end ring **28** is cast to at least partially surround and electrically connect the second conductor end **42** of each of the plurality of conductor bars **24** with the second end ring **28**.

[0053] Casting the first end ring **26** and the second end ring **28** includes injecting molten material into the form and around the first conductor end **41** and the second conductor end **42** of each conductor bar **24**. The first end ring **26** and the second end ring **28** is preferably cast from aluminum or an aluminum alloy. It will be appreciated that the first end ring **26** and the second end ring **28** may be cast using some other conductive material. Casting the first end ring **26** and/or the second end ring **28** includes flowing the molten material in and around the first conductor end **41** and the second conductor end **42** of each conductor bar **24** upon solidification. Casting processes that may be used to cast the first end ring **26** and the second end ring **28** include a high pressure die casting process, a low pressure die casting process, a sand-casting process, or a squeeze casting process.

[0054] Casting the first end ring **26** and the second end ring **28** may further include compressing the molten material as the molten material solidifies. Compressing the molten material as the

molten material solidifies during the casting process reduces porosity on the finished cast in place product and improves mechanical properties of the finished product.
[0055] Additionally, casting the first end ring **26** and the second end ring **28** may further include vibrating each of the conductor bars **24** at an ultrasonic frequency for a pre-defined period of time during solidification of the molten material of the cast in place first end ring **26** and/or the second end ring **28**. Preferably, the ultrasonic frequency is 20 kHz or greater. The conductor bars **24** may be vibrated for a time less than 20 seconds. Vibrating the conductor bars **24** during solidification of the molten material during the casting process can break up aluminum oxides disposed on the outer surface of the first conductor end **41** and/or the second conductor end **42** of the conductor bars **24**. Vibrating the conductor bars **24** also improves wetting between the molten material and the conductor bars **24**. Method **100** then ends.
[0056] The present disclosure has many advantages and benefits over prior art induction rotor assemblies. For example, using copper and/or copper graphene foils **22** between the laminated stack **20** and the conductor bars **24** improves current flow near an outer surface of the conductor bars **24** since copper has a 64% higher electrical conductivity than aluminum, which increases the skin effect at higher frequencies. Additionally, using copper graphene composite foils **22** adjacent to the grooves **40** eliminates welding and inner laminar shorting occurring during casting of the induction rotor assembly **18** by the aluminum molten material, which occurs between lamination layers of the laminated stack **20** without the foils **22**. Moreover, the induction rotor assembly **18** is more efficient with higher rotor resistance during startup and higher starting torque and with lower resistance during normal operation so that machine efficiency can be higher due to a lower rotor loss. Thus, the induction rotor assembly **18** disclosed herein increases rotor resistance during startup due to the skin effect (e.g., higher rotor current frequency) and reduces the resistance during normal operation (e.g., rotor current frequency is very low) due to higher conductivity of the copper graphene foils **22**, which improves overall efficiency of the induction rotor assembly **18** and vehicle motor **12**.
[0057] This description is merely illustrative in nature and is in no way intended to limit the disclosure, its application, or uses. The broad teachings of the disclosure can be implemented in a variety of forms. Therefore, while this disclosure includes particular examples, the true scope of the disclosure should not be so limited since other modifications will become apparent upon a study of the drawings, the specification, and the following claims.

Claims

1. An induction rotor assembly, comprising: a laminated stack including a body having a first end and an opposing second end arranged along a longitudinal axis, wherein the body has an outer circumferential surface extending from the first end to the second end along the longitudinal axis, wherein the outer circumferential surface has a plurality of grooves extending from the first end to the second end; a plurality of foils, wherein each one of the plurality of foils is disposed within one of the grooves; a plurality of conductor bars, wherein each of the plurality of conductor bars is disposed within each of the grooves, wherein each one of the plurality of foils is disposed between each one of the plurality of conductor bars and each one of the grooves, and wherein each of the plurality of conductor bars includes a first conductor end extending axially beyond the first end of the laminated stack and a second conductor end extending axially beyond the second end of the laminated stack; a first end ring mating with a surface of each first conductor end to interlock each of the plurality of conductor bars to the first end ring; and a second end ring mating with a surface of each second conductor end to interlock each of the plurality of conductor bars to the second end ring, and wherein the plurality of conductor bars extend between the first end ring and the second end ring.
2. The induction rotor assembly of claim 1, wherein the body includes a plurality of laminated steel

sheets.
3. The induction rotor assembly of claim 1, wherein the plurality of foils is pure copper or copper graphene composite.
4. The induction rotor assembly of claim 3, wherein the plurality of foils is less than or equal to 20% graphene by volume.
5. The induction rotor assembly of claim 1, wherein the plurality of foils includes an adhesive on one side of each foil.
6. The induction rotor assembly of claim 1, wherein each foil of the plurality of foils is between 20 and 30 micrometers thick.
7. The induction rotor assembly of claim 1, wherein each foil of the plurality of foils protrudes from the grooves.
8. The induction rotor assembly of claim 1, wherein each foil of the plurality of foils includes a coating at least partially having a rough surface.
9. The induction rotor assembly of claim 1, wherein multiple foil layers are disposed between each groove and each conductor bar.
10. The induction rotor assembly of claim 1, wherein the plurality of conductor bars is formed from at least one of copper or aluminum.
11. The induction rotor assembly of claim 1, wherein the first end ring and the second end ring are each cast in place over the first conductor end and a second conductor end, respectively, of each of the plurality of conductor bars.
12. The induction rotor assembly of claim 4, wherein the first end ring and the second end ring include and are formed from aluminum.
13. A vehicle motor, comprising: a stator; and an induction rotor assembly configured to rotate due to a rotating magnetic field created by the stator, wherein the induction rotor assembly includes a laminated stack including a body having a first end and an opposing second end arranged along a longitudinal axis, the body having an outer circumferential surface extending from the first end to the second end along the longitudinal axis, the outer circumferential surface having a plurality of grooves extending from the first end to the second end; a plurality of foils, wherein each one of the plurality of foils is disposed within one of the grooves; a plurality of conductor bars, wherein each of the plurality of conductor bars is disposed within each of the grooves, wherein each one of the plurality of foils is disposed between each one of the plurality of conductor bars and each one of the grooves, and wherein each of the plurality of conductor bars includes a first conductor end extending axially beyond the first end of the laminated stack and a second conductor end extending axially beyond the second end of the laminated stack; a first end ring mating with a surface of each first conductor end to interlock each of the plurality of conductor bars to the first end ring; and a second end ring mating with a surface of each second conductor end to interlock each of the plurality of conductor bars to the second end ring, and wherein the plurality of conductor bars extends between the first end ring and the second end ring.
14. The vehicle motor of claim 13, wherein the plurality of foils is pure copper or copper-graphene composite.
15. The vehicle motor of claim 13, wherein each foil of the plurality of foils is between 20 and 30 micrometers thick.
16. The vehicle motor of claim 13, wherein the plurality of conductor bars is formed from at least one of copper or aluminum.
17. A method of manufacturing an induction rotor assembly, comprising: laminating a plurality of steel sheets to form a laminated stack having a first end and an opposing second end axially spaced along a longitudinal axis, wherein a plurality of grooves are disposed on an outer circumferential surface of the laminated stack and extend from the first end to the second end; placing a plurality of foils in the plurality of grooves; forming a conductor bar in each of the grooves such that each one of the plurality of foils is disposed between each conductor bar and the laminated stack, wherein a

first conductor end extends axially beyond the first end of the laminated stack; and casting a first end ring in place around each first conductor end of each of the conductor bars and a second end ring in place around each second conductor end of each of the conductor bars to at least partially surround and electrically connect the first conductor end and the second conductor end of each of the plurality of conductor bars.

18. The method of claim 17, wherein the plurality of foils includes pure copper or copper-graphene composite.

19. The method of claim 17, wherein placing the plurality of foils in the plurality of grooves includes placing preformed foils.

20. The method of claim 17, wherein placing the plurality of foils in the plurality of grooves includes placing the foils in situ.