US 20240372421A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2024/0372421 A1

(43) Pub. Date: Nov. 7, 2024

Kuppa et al.

(54) E-MACHINE SYSTEM WITH STATOR CORE HAVING COOLING FLOW PASSAGES

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(21) Appl. No.: **18/335,190**

(22) Filed: **Jun. 15, 2023**

(30) **Foreign Application Priority Data**

May 4, 2023 (IN) 202311031714

Publication Classification

(51) **Int. Cl.**

H02K 1/20 (2006.01)

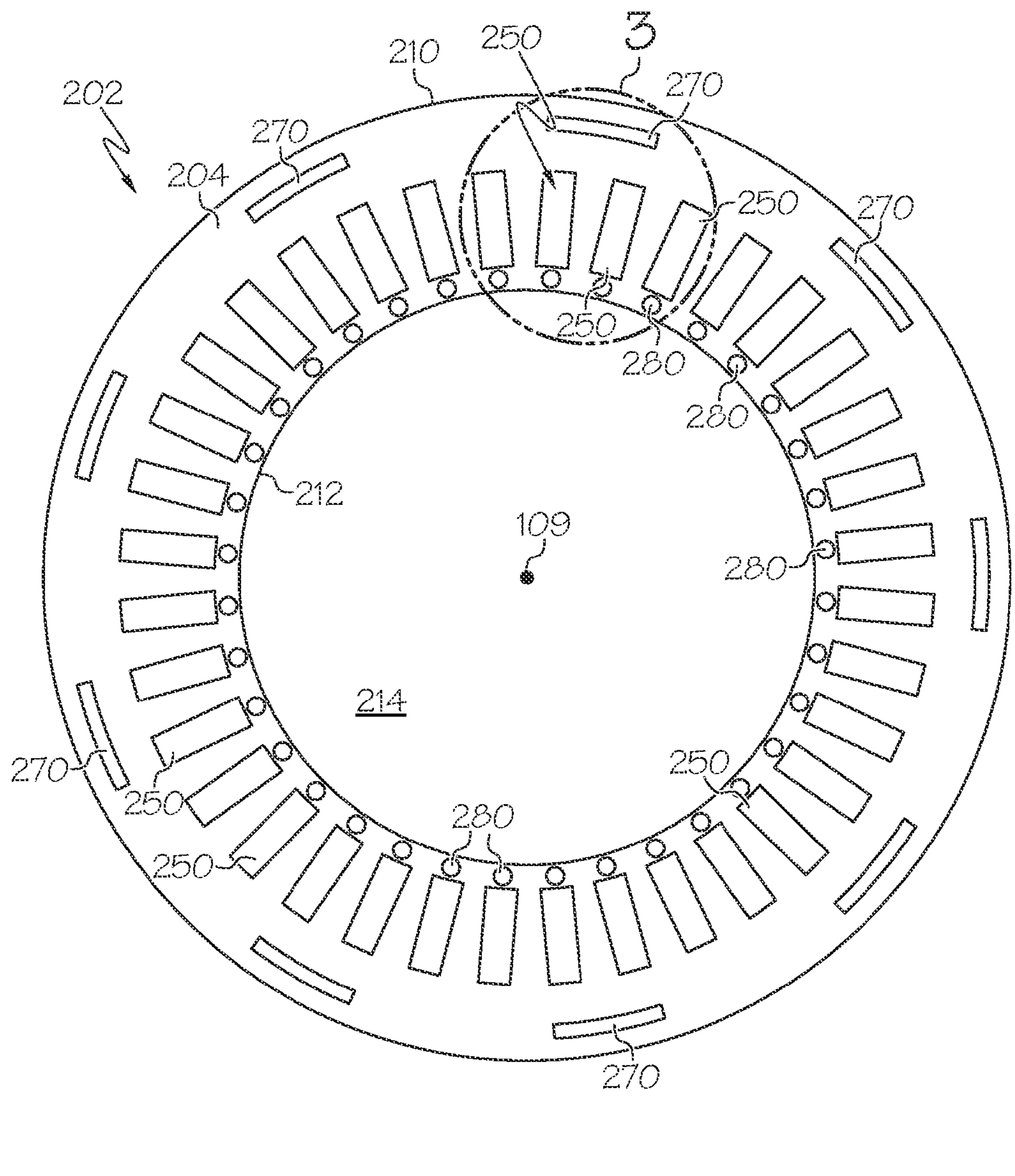
H02K 9/19 (2006.01)

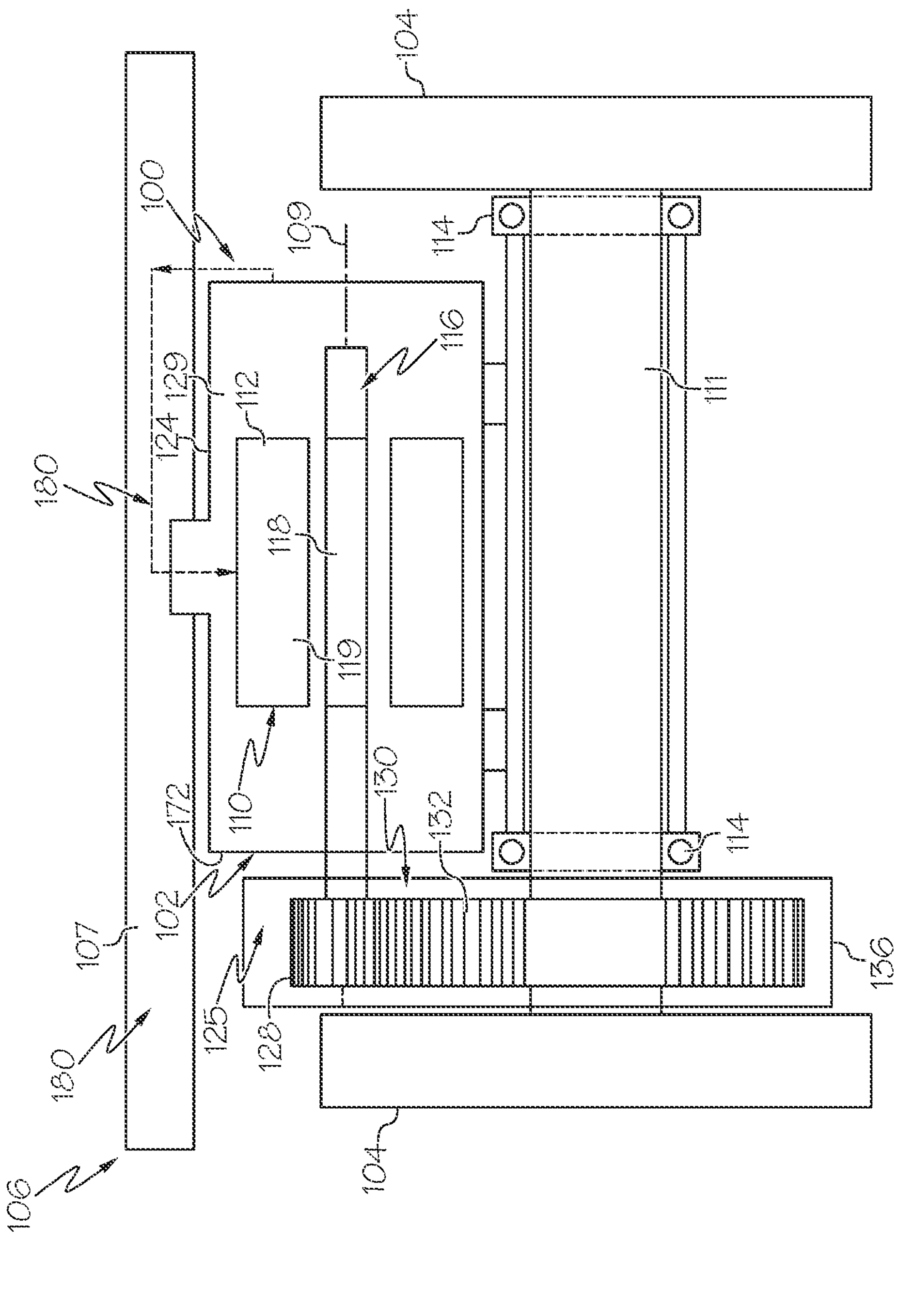
(52) **U.S. Cl.**

CPC ***H02K 1/20*** (2013.01); ***H02K 9/19*** (2013.01)

(57) **ABSTRACT**

A stator core includes a first end and a second end separated along an axis. The stator core includes an inner radial surface and an outer radial surface. Also, the stator core includes an outer coolant groove defined on the outer radial surface of the stator core. The outer coolant groove extends about the axis. Additionally, the stator core includes a yoke flow channel extending through the stator core along the axis. The yoke flow channel is in fluid communication with the outer coolant groove. Furthermore, the outer coolant groove configured to receive coolant of the fluid coolant system and provide the coolant to the yoke flow channel, which provides the coolant to at least one of the first end and the second end.




104
100
109
114
116
129
112
124
111
180
118
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172
130
132
114
102
107
125
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128
180
104
106

FIG. 1

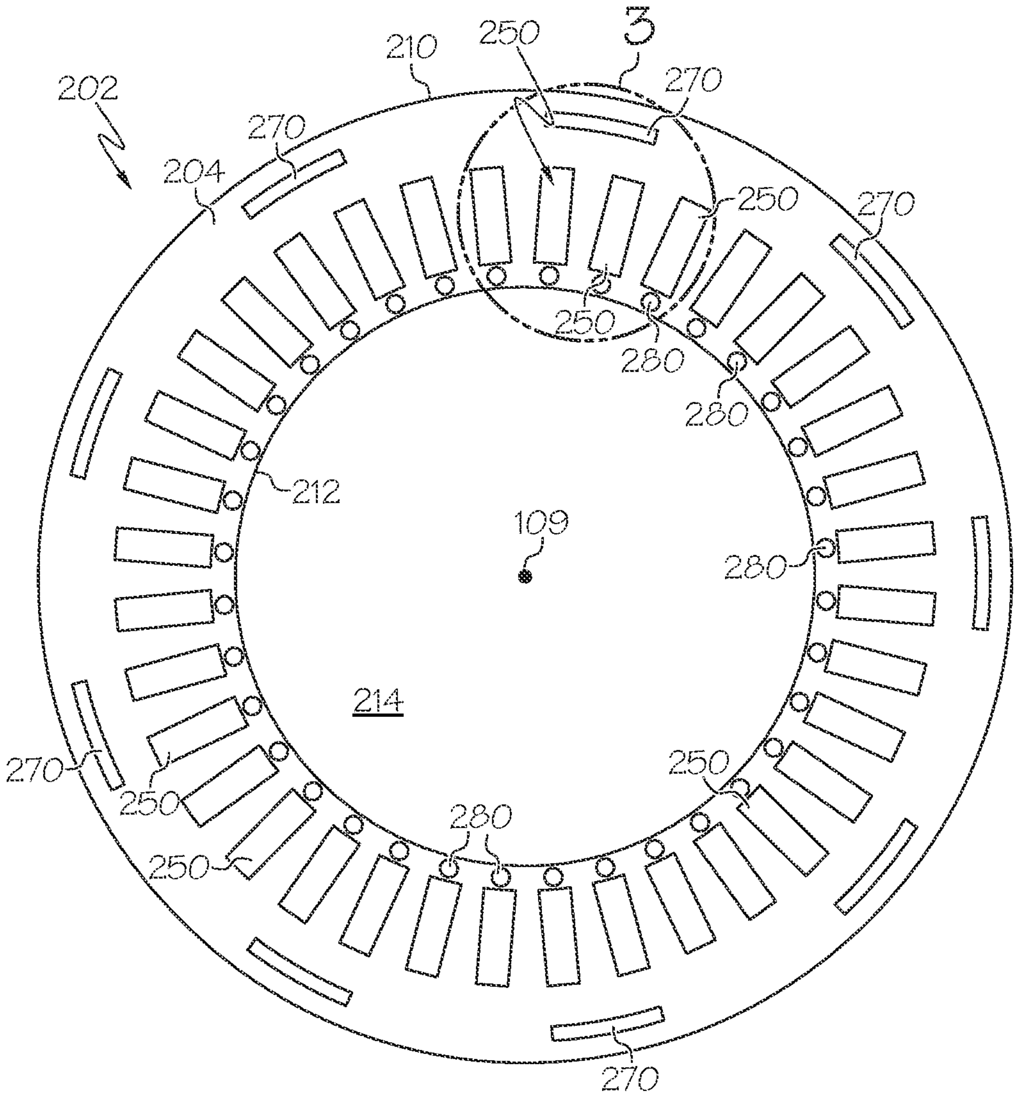
202
210
250
3
270
204
270
250
270
250
280
280
212
109
280
214
270
250
250
250
280
270

FIG. 2

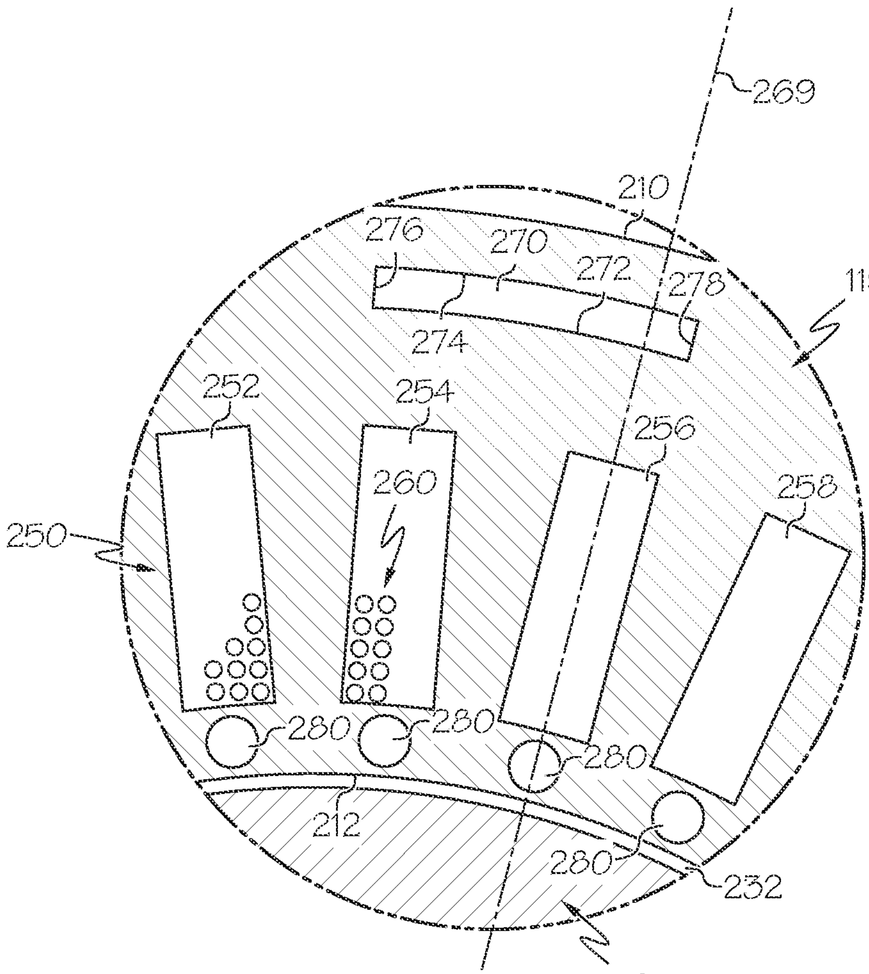
269
210
276
270
272
278
119
274
252
254
256
258
260
250
280
280
280
280
212
232
118

FIG. 3

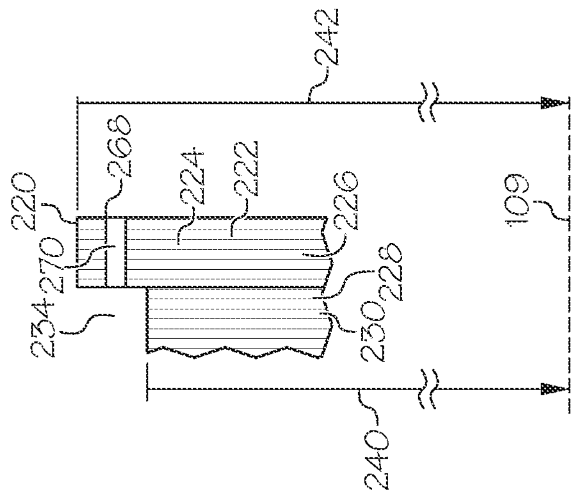
242
220
268
224
222
226
270
234
228
230
109
240

FIG. 4B

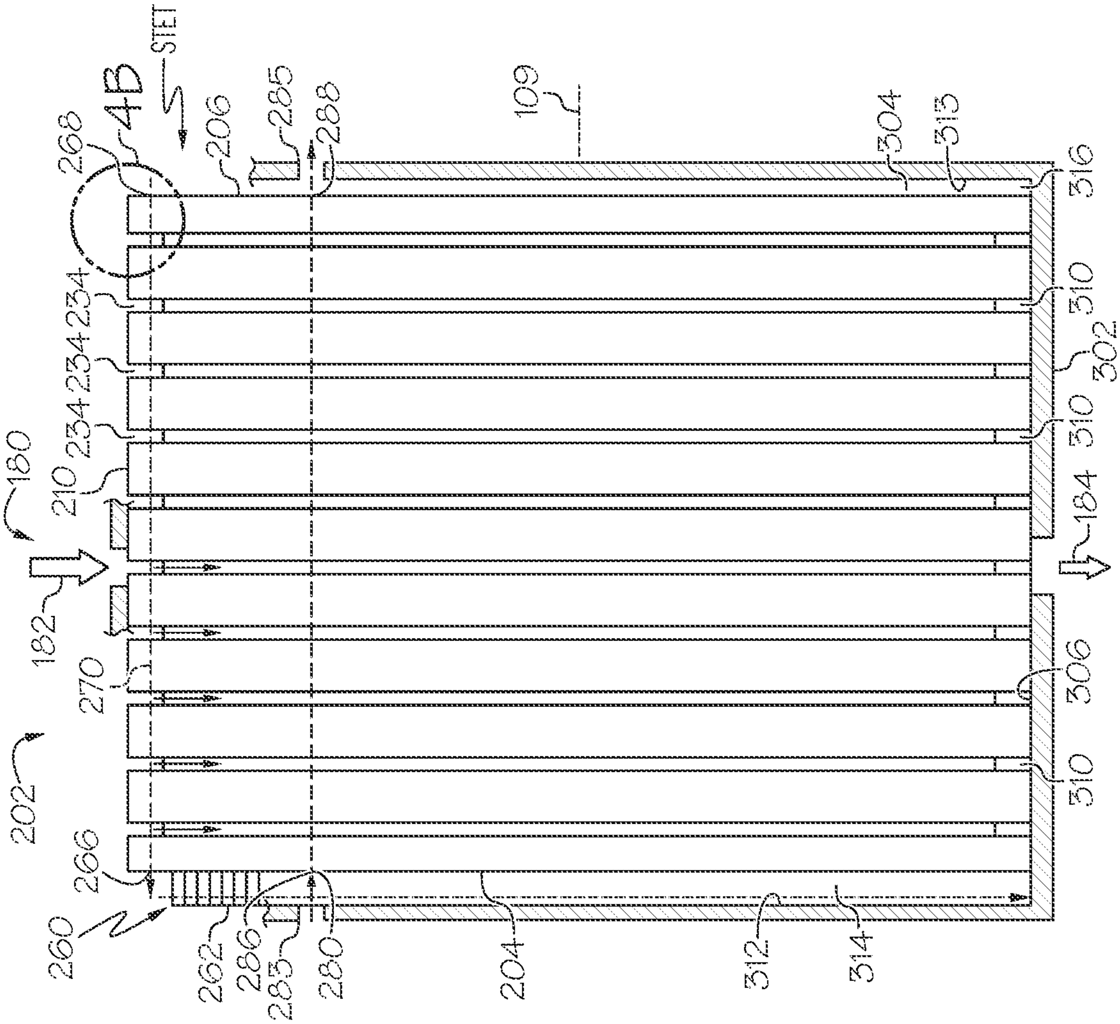
STET
4B
268
206
285
288
109
304
313
316
234
234
234
234
310
310
302
180
210
182
184
270
306
202
310
266
260
262
286
283
280
204
312
314

FIG. 4A

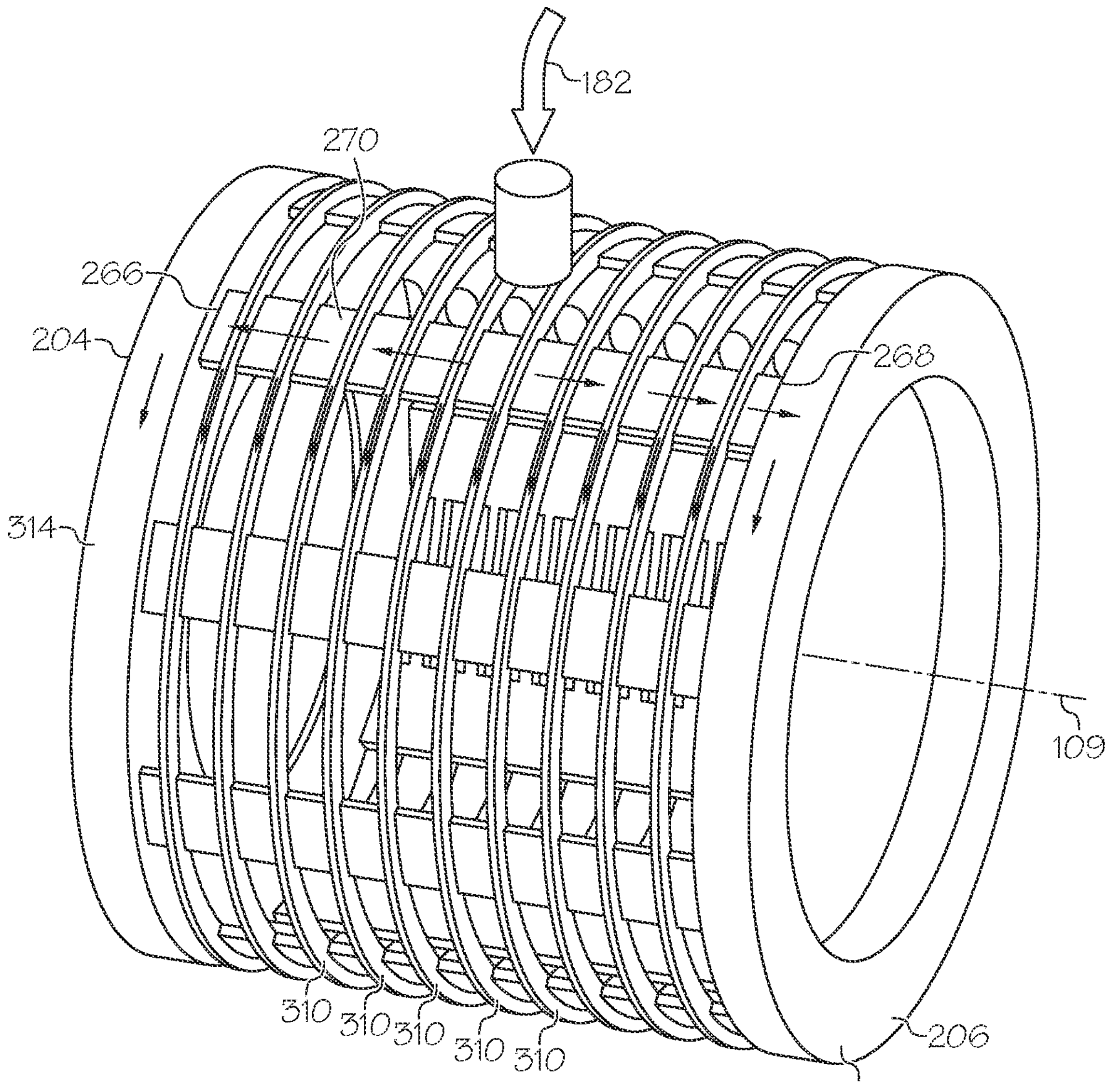

FIG. 5

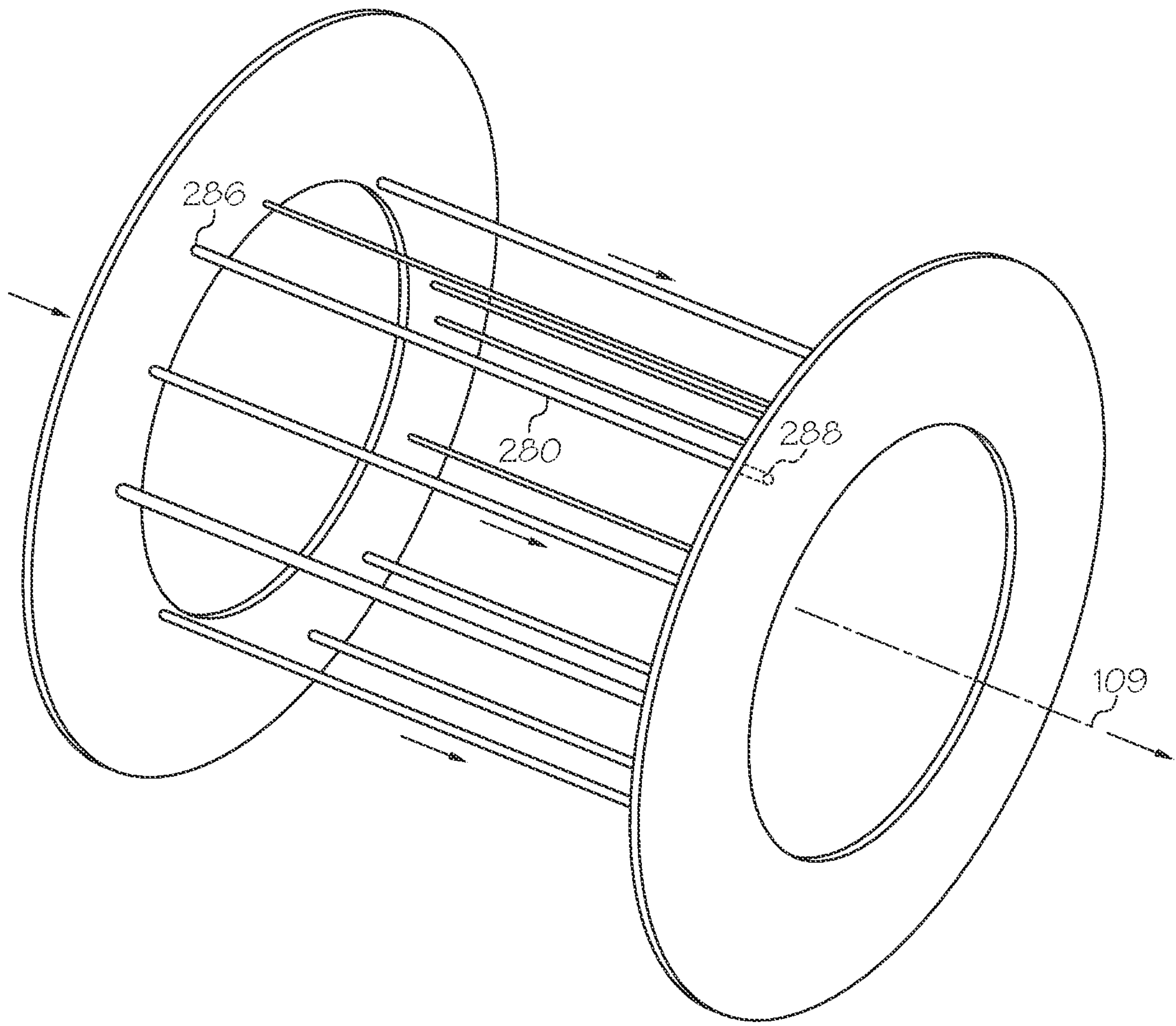

FIG. 6

E-MACHINE SYSTEM WITH STATOR CORE HAVING COOLING FLOW PASSAGES

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Indian Provisional Patent Application No. 202311031714, filed May 4, 2023, the entire content of which is incorporated by reference herein.

TECHNICAL FIELD

[0002] The present disclosure relates, generally, to an e-machine system such as an electric motor system, electric generator system, and the like, and the present disclosure relates, more particularly, to an e-machine system with a stator core having cooling flow passages.

BACKGROUND

[0003] E-machines, such as electric motors, electric generators, and combination motor/generators, are provided for a variety of uses. For example, electric traction motors are proposed for electric vehicles, locomotives, and the like.

[0004] Some e-machine systems may generate heat during operation, may operate in high-temperature environments, etc. Thus, e-machine systems are proposed that include cooling features. However, providing such cooling features remains challenging. There may be detrimental increases in costs, part count, device complexity, size, bulkiness, and/or weight if these cooling features are included.

[0005] Thus, there remains a need for an e-machine system that provides effective cooling. There remains a need for these e-machine systems, wherein the cooling features are provided in a relatively compact, low-weight package. There is also a need for such an e-machine system that also provides high manufacturing efficiency for reduced costs and manufacturing time.

BRIEF SUMMARY

[0006] This summary is provided to describe select concepts in a simplified form that are further described in the Detailed Description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0007] In one embodiment, a stator core is disclosed that is configured for an e-machine of an e-machine system. The stator core is configured to fluidly connect to a fluid coolant system of the e-machine system. The stator core includes a first end and a second end that is separated from the first end along an axis. The stator core includes an inner radial surface facing radially toward the axis and extending along the axis between the first end and the second end. The stator core further includes an outer radial surface facing radially away from the axis and extending along the axis between the first end and the second end. Also, the stator core includes an outer coolant groove defined on the outer radial surface of the stator core. The outer coolant groove extends about the axis. Additionally, the stator core includes a yoke flow channel extending through the stator core along the axis. The yoke flow channel is in fluid communication with the outer coolant groove. Furthermore, the outer coolant groove configured to receive coolant of the fluid coolant system and provide the coolant to the yoke flow channel, which provides the coolant to at least one of the first end and the second end.

[0008] In another embodiment, an e-machine system is disclosed that includes an e-machine with a stator member. The e-machine system includes a stator core of the stator member. Also, the e-machine system includes a fluid coolant system that is operatively connected to the stator core. The stator core includes a first end and a second end that is separated from the first end along an axis. The stator core also includes an inner radial surface facing radially toward the axis and extending along the axis between the first end and the second end and an outer radial surface facing radially away from the axis and extending along the axis between the first end and the second end. Moreover, the stator core includes an outer coolant groove defined on the outer radial surface of the stator core, the outer coolant groove extending about the axis. Furthermore, the stator core includes a yoke flow channel extending through the stator core along the axis, the yoke flow channel in fluid communication with the outer coolant groove. The outer coolant groove is configured to receive coolant of the fluid coolant system and provide the coolant to the yoke flow channel, which provides the coolant to at least one of the first end and the second end.

[0009] In a further embodiment, a stator core configured for an e-machine of an e-machine system is disclosed. The stator core is configured to fluidly connect to a fluid coolant system of the e-machine system. The stator core includes a first end and a second end that is separated from the first end along an axis. Also, the stator core includes an inner radial surface facing radially toward the axis and extending along the axis between the first end and the second end and an outer radial surface facing radially away from the axis and extending along the axis between the first end and the second end. Moreover, the stator core includes an outer coolant groove defined on the outer radial surface of the stator core, the outer coolant groove extending about the axis. Furthermore, the stator core includes a yoke flow channel extending through the stator core along the axis, the yoke flow channel in fluid communication with the outer coolant groove. The outer coolant groove is configured to receive coolant of the fluid coolant system and provide the coolant to the yoke flow channel, which provides the coolant to at least one of the first end and the second end. Additionally, the stator core includes a tooth flow channel extending through the stator core along the axis, the tooth flow channel configured to receive coolant of the fluid coolant system. Furthermore, the stator core includes a winding opening extending through the stator core along the axis, the winding opening configured to receive stator windings of the e-machine therein. The winding opening is disposed radially between the yoke flow channel and the tooth flow channel. The inner radial surface is smooth and continuous about the axis, and the outer radial surface has a cross section taken normal to the axis, the cross section being smooth and continuous.

[0010] Furthermore, other desirable features and characteristics of the present disclosure will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and the preceding background.

BRIEF DESCRIPTION OF DRAWINGS

[0011] The present disclosure will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and wherein:

[0012] FIG. **1** is a schematic illustration of an e-machine system according to example embodiments of the present disclosure;

[0013] FIG. **2** is an end view of a stator core of the e-machine system according to example embodiments of the present disclosure;

[0014] FIG. **3** is a detail end view of the stator core of FIG. **2**;

[0015] FIG. **4**A is a side view of the stator core of FIG. **2**;

[0016] FIG. **4**B is a detail side view of the stator core of FIG. **4**A;

[0017] FIG. **5** is a perspective view illustrating fluid flow through passages of the stator core of FIGS. **2-4**B according to example embodiments; and

[0018] FIG. **6** is a perspective view illustrating fluid flow through additional passages of the stator core of FIGS. **2-4**B according to example embodiments.

DETAILED DESCRIPTION

[0019] The following detailed description is merely exemplary in nature and is not intended to limit the present disclosure or the application and uses of the present disclosure. As used herein, the word "exemplary" means "serving as an example, instance, or illustration." Thus, any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. All of the embodiments described herein are exemplary embodiments provided to enable persons skilled in the art to make or use the present disclosure and not to limit the scope of the present disclosure, which is defined by the claims. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary, or the following detailed description.

[0020] Broadly, example embodiments disclosed herein include a stator arrangement of an e-machine that is in fluid communication within a fluid coolant system. The stator arrangement includes a stator core that may include a number of features fluidly connected within the fluid coolant system. The stator core may include one or more grooves, channels, tubes, openings, apertures, recesses, and/or other passages configured to receive a fluid coolant. These features may be arranged, shaped, positioned, etc. to direct flow of the coolant. Also, features may be fluidly connected to direct flow of the coolant about the stator core in a predetermined manner. These features of the stator core may also distribute the coolant about, within, over, and/or through the stator core for routing the coolant for effective cooling.

[0021] The stator core may include one or more outer coolant grooves defined on an outer radial surface of the stator core. The outer coolant groove(s) may extend about the axis of rotation of the motor (i.e., the axis of the stator core). The stator core may further include one or more yoke flow channels extending through the stator core along the axis. The yoke flow channel(s) may be in fluid communication with the outer coolant groove(s). Additionally, the stator core may include one or more tooth flow channels extending through the stator core along the axis. The stator core may also include one or more winding openings extending through the stator core along the axis, and the winding opening(s) may be configured to receive stator windings therein. The winding opening(s) may be disposed radially between the yoke flow channel(s) and the tooth flow channel(s).

[0022] The fluid coolant system may provide flow of a coolant that flows through a plurality of circumferentially-extending outer coolant grooves and axially along the yoke flow channels to the ends of the motor. In some embodiments, flow may be distributed amongst a plurality of the outer coolant grooves and a plurality of yoke flow channels due to fluid connections therebetween. Also, in some embodiments, flow through the yoke flow channels may be directed in both axial directions toward the ends of the stator core. Additionally, coolant may be provided to the tooth flow channels, and the coolant may flow generally in an axial direction through the stator core. In some embodiments, the coolant may flow in one direction from one end to the opposite end through the tooth flow channels. The coolant system may provide effective cooling for the motor. Also, the stator core may be manufactured efficiently.

[0023] Additionally, in some embodiments, an inner radial surface of the stator core (i.e., the surface opposing the rotor member of the e-machine) may be smooth and continuous about the axis. This may provide improved performance because the gap between the stator core and the rotor member may be substantially constant about the circumference of the stator/rotor interface.

[0024] FIG. **1** is a schematic view of an e-machine system **100** according to example embodiments of the present disclosure. The e-machine system **100** may have a variety of configurations. In some embodiments, the e-machine system **100** may be configured as a traction drive system **102** that is included, for example, on a vehicle **106**. Thus, the traction drive system **102** may be configured for driving one or more wheels **104** of the vehicle **106**. More specifically, the wheels **104** may be included at opposite ends of an axle **111**, and a chassis **107** may be supported on the wheels **104** by a suspension system (not shown). The vehicle **106** may be an electric car, truck, van, motorcycle, boat, or other vehicle. However, it will be appreciated that the e-machine system **100** may be configured otherwise without departing from the scope of the present disclosure.

[0025] Generally, the e-machine system **100** may include a housing **125**. The housing **125** may include an e-machine housing **124** with a cavity **129** therein. The e-machine system **100** may also include an e-machine **110** that is received in the cavity **129** and housed within the e-machine housing **124**.

[0026] The e-machine **110** may be an electric motor **112** in some embodiments. However, it will be appreciated that the e-machine **110** may be configured as an electric generator. Furthermore, the e-machine **110** may be operable in some modes as a motor and in additional modes as a generator. The e-machine **110** may include a rotor member **118** and a stator member **119** that are housed within the cavity **129** of the e-machine housing **124**.

[0027] The rotor member **118** may be supported on a shaft **116**, and the shaft **116** may be supported for rotation about an axis **109** (i.e., rotation axis **109**) within the e-machine housing **124**. The stator member **119** of the e-machine **110** may be fixed within the e-machine housing **124** and may surround the rotor member **118** and the shaft **116**. In embodiments in which the e-machine **110** is an electric motor **112**, the shaft **116** may be referred to as an output shaft **116** of the electric motor **112**. In some embodiments, a gear connection member **128** (e.g., a gear, a spline on the shaft **116**, or other part with gear teeth features) may be operably supported on the shaft **116**.

[0028] Also, the e-machine system **100** may include a transmission **130**. The transmission **130** may generally include a geartrain **132** that is housed within a gearbox housing **136** of the housing **125**. The gearbox housing **136** may be attached (e.g., fixed) to a side wall **172** of the e-machine housing **124**.

[0029] The geartrain **132** may be of any suitable type. The geartrain **132** may operatively connect the e-machine **110** and the axle **111** and may transmit power therebetween. The e-machine **110** may be coupled to the wheels **104** via the transmission **130**. The geartrain **132** may be attached to the gear connection member **128** and to the axle **111**. The gearbox housing **136** and the e-machine housing **124** may be moveably supported on the axle **111** by one or more bearings **114** (e.g., a bearing sleeve, suspension tube, etc.) such that the axle **111** may rotate relative thereto.

[0030] During operation, the electric motor **112** may rotatably drive the shaft **116** and the gear connection member **128** supported thereon. This rotational power may transfer to the geartrain **132**, which may transmit the power to the axle **111** to rotate the wheels **104** and propel the vehicle **106**.

[0031] Furthermore, the e-machine system **100** may include a fluid coolant system **180**. The fluid coolant system **180** may be configured for circulating a fluid, such as a fluid coolant. The fluid may be a liquid, a coolant oil, etc.

[0032] The fluid coolant system **180** may be coupled to the stator member **119** as will be discussed. Accordingly, the fluid coolant system **180** and the stator member **119** may include features that provide cooling to the stator member **119**. This may, in turn, provide cooling to the rotor member **118**, to bearings, and/or to other adjacent areas of the e-machine **110**.

[0033] FIGS. **2**-**4**B show a stator core **202** of the stator member **119** of the e-machine **110** according to example embodiments of the present disclosure. The stator core **202** may be generally cylindrical with a first end **204** and a second end **206** (FIG. **4**A), which are separated along the axis **109**. The stator core **202** may also include an outer radial surface **210** that extends about the axis **109** and that faces outwardly in a radial direction from the axis **109**. Furthermore, the stator core **202** may be hollow and may include an inner radial surface **212** that extends about the axis **109** and that faces inwardly in the radial direction toward the axis **109**. The inner radial surface **212** may define a central bore **214** (FIG. **2**) that is centered on the axis **109** and that extends axially through the stator core **202**. The central bore **214** may be sized and configured to receive the rotor member **118** as shown in FIG. **3**.

[0034] As shown in FIG. **4**B, the stator core **202** may comprise a plurality of (i.e., a stack of) stator laminations **220**, **222**, **224**, **226**, **228**, **230**. There may be any suitable number of stator laminations. The laminations **220**-**230** may be thin discs that are stacked together along the axis **109** to cooperatively define the stator core **202**.

[0035] As shown in FIG. **2**, the inner radial surface **212** may be smooth, continuous, annular, and uninterrupted in the circumferential direction about the axis **109**. In some embodiments, the inner radial surface may have a smooth, continuous, circular cross section taken normal to the axis **109**. There may be minor gaps between the laminations **220**-**230**; however, the inner radial surface **212** may be otherwise smooth along a majority of the length of the stator core **202** as measured along the axis **109**. This smooth inner radial surface **212** may provide improved performance for the e-machine system **100**. For example, the smooth inner radial surface **212** may cooperate with the rotor member **118** to define a radial airgap **232** therebetween (FIG. **3**). The smooth inner radial surface **212** may provide a more uniform airgap **232**, which in turn may provide electromagnetic benefits.

[0036] As shown in FIGS. **4**A and **4**B, the outer radial surface **210** of the stator core **202** may include one or more outer grooves **234** defined thereon. In some embodiments, there may be a plurality of outer grooves **234** that extend in the circumferential direction about the axis **109**. The outer grooves **234** may be continuous and annular in some embodiments. The outer grooves **234** may be spaced apart along the axis **109** on the outer radial surface **210**. The outer grooves **234** may be recessed inward from surrounding areas of the outer radial surface **210**.

[0037] As shown in FIG. **4**B, the plurality of laminations **220**-**230** may have different radii from one another and may be arranged to define respective ones of the outer grooves **234**. As shown, one or more laminations **220**-**230** may have a smaller outer radius than adjacent one(s) of the laminations **220**-**230** so as to define the respective outer groove **234**. Specifically, as shown in FIG. **4**B, the laminations **228**, **230** may have a first outer radius **240** whereas the laminations **220**, **222**, **224**, **226** may have a second outer radius **242** that is larger. Thus, the laminations **228**, **230** (and other laminations like it) may define the respective outer groove **234**.

[0038] Moreover, the stator core **202** may include a plurality of winding openings **250**. The winding openings **250** may, in some embodiments, have a rectangular cross section taken normal to the axis **109**. The winding openings **250** may extend continuously along the axis **109**, through the stator core **202** from the first end **204** to the second end **206**. Four of the winding openings **250** are illustrated in FIG. **3**, namely, a first winding opening **252**, a second winding opening **254**, a third winding opening **256**, and a fourth winding opening **258**. The laminations **220**-**230** may include respective openings that are aligned axially to cooperatively define the winding openings **250** through the stator core **202**. The winding openings **250** may be spaced apart at equal circumferential distances about the axis **109** as shown in FIG. **2**. The winding openings **250** may be elongate in cross section (FIGS. **2** and **3**) with the cross section elongated in the radial direction. The plurality of winding openings **250** may be arranged about the axis **109** so as to radiate from the axis **109** as shown.

[0039] The winding openings **250** may be shaped, sized, positioned, and otherwise configured to receive windings **260** of the stator member **119**. A portion of the windings **260** is shown in FIGS. **3** and **4**A. An end turn **262** of the windings **260** may extend outward from one of the winding openings (e.g., the first winding opening **252**) and may turn back inward to be received in an adjacent winding opening (e.g., the second winding opening **254**). There may be such end turns **262** at the first end **204** and the second end **206** of the stator core **202**.

[0040] Moreover, the stator core **202** may include at least one yoke flow channels **270** that extends through the stator core **202** along the axis **109**. The plurality of stator laminations **220**-**230** may include respective openings that collectively define the yoke flow channels **270**. As shown, the stator core **202** may include a plurality of yoke flow channels **270** arranged about the axis **109**. The plurality of yoke flow channels **270** may be spaced equally about the axis **109**. The yoke flow channels **270** may be radially disposed proximate the outer radial surface **210** of the stator core **202** (FIGS. **2** and **3**). As shown, there may be nine yoke flow channels **270** in some embodiments. There may be more or less yoke flow channels **270** in other embodiments.

[0041] As shown in FIGS. **2** and **3**, the yoke flow channel (s) **270** may have cross section taken normal to the axis **109** with four sides. Specifically, as shown in FIG. **3**, the yoke flow channel **270** may have an inner radial side **272**, an outer radial side **274**, a first side **276**, and a second side **278**. The cross section may be arcuately curved about the axis **109** such that the inner and outer radial sides **272**, **274** are curved. Thus, in some embodiments, the yoke flow channels **270** may have arcuately-curved elongated cross sections taken normal to the axis **109**. Also, the yoke flow channels **270** may be sized, shaped, positioned, etc. so as to align or overlap radially with at least one of the winding openings **250**. For example, as shown in FIG. **3**, one yoke flow channel **270** may radially overlap at least two adjacent ones of the winding openings **250**.

[0042] As shown in FIGS. **4A** and **5**, at least one yoke flow channel **270** may be axially straight and parallel to the axis **109**. At least one yoke flow channel **270** may include a first end **266** that is open proximate the first end **204** of the stator core **202** and a second end **268** that is open proximate the second end **206** of the stator core **202**. In some embodiments, each of the yoke flow channels **270** may include a respective open first end **266** and open second end **268**.

[0043] As represented in FIG. **4**A, the yoke flow channels **270** may be fluidly connected to the outer grooves **234** of the stator core **202**. The outer grooves **234** may be recessed inwardly in the radial direction far enough so as to intersect and fluidly connect to the yoke flow channels **270**. Stated differently, the yoke flow channels **270** and the outer grooves **234** may be disposed at a common radius so as to fluidly connect. In other words, the yoke flow channels **270** may be interrupted by the outer grooves **234**.

[0044] The stator core **202** may further include at least one tooth flow channel **280** that extends through the stator core **202** along the axis **109**. The plurality of stator laminations **220-230** may include respective openings that collectively define the tooth flow channels **280**. As shown, there may be a plurality of tooth flow channels **280** arranged about the axis **109**. The plurality of tooth flow channels **270** may be spaced equally about the axis **109**. The tooth flow channels **280** may be radially disposed proximate the inner radial surface **212** of the stator core **202**. Accordingly, the winding openings **250** may be disposed radially between the tooth flow channels **280** and the yoke flow channels **270**. In some embodiments, the tooth flow channels **280** may be circular in cross section taken normal to the axis **109**. The tooth flow channels **280** may have different cross sectional shapes (e.g., rectangular or otherwise polygonal) in other embodiments. In some embodiments, the tooth flow channels **280** may be aligned radially with respective ones of the winding openings **250** (i.e., substantially aligned in the same angular location, aligned along an imaginary, straight, radial line from the axis **109**, etc.) with respect to the axis **109**. Also, as shown in FIG. **3**, an imaginary, straight, radial line **269** from the axis **109** may intersect at least one tooth flow channel **280**, winding opening **256**, and yoke flow channel **270** due to the angular positioning and "radial overlapping" of these features.

[0045] In some embodiments, the tooth flow channels **280** may extend continuously from the first end **204** to the second end **206** of the stator core. At least one tooth flow channel **280** may include a first end **286** that is open proximate the first end **204** of the stator core **202** and a second end **288** that is open proximate the second end **206** of the stator core **202**. In some embodiments, each of the tooth flow channels **280** may include a respective open first end **286** and an open second end **288**.

[0046] The tooth flow channels **280** may extend generally in the axial direction. In some embodiments, the tooth flow channels **280** may be axially straight. In some embodiments the tooth flow channels **280** may be substantially parallel to the axis **109**.

[0047] The stator core **202** may be received in a motor housing **302** (FIG. **4**A) of the e-machine housing **124**. The motor housing **302** may include a motor cavity **304** that corresponds in shape with the stator core **202**. The outer radial surface **210** may nest against an opposing inner radial surface **306** of the motor cavity **304**. As such, the inner radial surface **306** and the outer grooves **234** may cooperatively define circumferential flow channels **310** that extend about the stator core **202**.

[0048] Also, the first end **204** of the stator core **202** may face an opposing first axial inner surface **312** of the motor housing **302**. The first end **204** may be spaced away from the first axial inner surface **312** so as to define at least one first end chamber **314**. The first end chamber **314** may be annular and may receive the end turns **262**. Likewise, the second end **206** of the stator core **202** may face an opposing second axial inner surface **313** of the motor housing **302**. The second end **206** may be spaced away from the second axial inner surface **313** so as to define at least one second end chamber **316**, which may be annular and may receive the end turns **262** at the second end **206**.

[0049] The stator core **202** may be in fluid communication with and fluidly connected to the fluid coolant system **180**. The fluid coolant system **180** may include at least one first fluid inlet **182** (FIGS. **4**A and **5**) that extends into the motor housing **302**. The first fluid inlet **182** may be directed radially and may be disposed centrally along the axis **109**. The fluid coolant system **180** may further include at least one first fluid outlet **184** (FIG. **4**A) that extends out of the motor housing **302**. The first fluid outlet **184** may be similarly positioned axially, but may be disposed on an opposite side of the axis **109** from the first fluid inlet **182**. The first fluid inlet **182** and the first fluid outlet **184** may be fluidly connected to one or more of the circumferential flow channels **310**. Accordingly, during operation coolant from the first fluid inlet **182** may flow about the stator core **202** in the circumferential flow channels **310**. This fluid may reach one or more yoke flow channels **270** and may flow toward the first end **266** and the second end **268**. Flow along the yoke flow channels **270** may also distribute the coolant to additional circumferential flow channels **310** positioned further in the axial direction. In the yoke flow channels **270**, the fluid may flow from the first end **266** into the first end chamber **314** to cool the end turns **262**, and fluid may also flow from the second end **268** into the second end chamber **316** to cool the other end turns **262** therein. This coolant may flow arcuately in the first and second end chambers **314**, **316** and the coolant may outlet via the first fluid outlet **184**.

Coolant flow along these pathways may efficiently cool the stator core **202**, the end turns **262**, and/or other components of the e-machine **110**.

[0050] As shown in FIG. **4**A, the fluid coolant system **180** may further include at least one second fluid inlet **283** in the motor housing **302**. The second fluid inlet **283** may extend through the housing **302** axially toward the first end **204** of the stator core **202**. The second fluid inlet **283** may be fluidly connected to at least one first end **286** of the tooth flow channels **280** to provide the coolant thereto. The fluid coolant system **180** may additionally include at least one second outlet **285**. The second outlet **285** may be fluidly connected to at least one second end **288** of the tool flow channels **280** to receive the coolant therefrom. Accordingly, during operation coolant from the second fluid inlet **283** may flow into at least one of the tooth flow channels **280** and may flow axially through the stator core **202** from the first end **286** to the second end **288** before exiting via the second outlet **285**. This flow may provide additional cooling to the stator core **202**, to the windings **260**, to the rotor member **118**, and/or other components of the e-machine system **100**.

[0051] Accordingly, the stator core **202** of the present disclosure provides efficient cooling for the e-machine **110**. The stator core **202** may also be compact and low weight. Furthermore, the stator core **202** may be manufactured efficiently for added advantage.

[0052] In this document, relational terms such as first and second, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. Numerical ordinals such as "first," "second," "third," etc. simply denote different singles of a plurality and do not imply any order or sequence unless specifically defined by the claim language. The sequence of the text in any of the claims does not imply that process steps must be performed in a temporal or logical order according to such sequence unless it is specifically defined by the language of the claim. The process steps may be interchanged in any order without departing from the scope of the invention as long as such an interchange does not contradict the claim language and is not logically nonsensical.

[0053] Furthermore, depending on the context, words such as "connect" or "coupled to" used in describing a relationship between different elements do not imply that a direct physical connection must be made between these elements. For example, two elements may be connected to each other physically, electronically, logically, or in any other manner, through one or more additional elements.

[0054] As used herein, the term "axial" refers to a direction that is generally parallel to or coincident with an axis of rotation, axis of symmetry, or centerline of a component or components. For example, in a cylinder or disc with a centerline and generally circular ends or opposing faces, the "axial" direction may refer to the direction that generally extends in parallel to the centerline between the opposite ends or faces. In certain instances, the term "axial" may be utilized with respect to components that are not cylindrical (or otherwise radially symmetric). For example, the "axial" direction for a rectangular housing containing a rotating shaft may be viewed as a direction that is generally parallel to or coincident with the rotational axis of the shaft. Furthermore, the term "radially" as used herein may refer to a direction or a relationship of components with respect to a line extending outward from a shared centerline, axis, or similar reference, for example in a plane of a cylinder or disc that is perpendicular to the centerline or axis. In certain instances, components may be viewed as "radially" aligned even though one or both of the components may not be cylindrical (or otherwise radially symmetric). Furthermore, the terms "axial" and "radial" (and any derivatives) may encompass directional relationships that are other than precisely aligned with (e.g., oblique to) the true axial and radial dimensions, provided the relationship is predominantly in the respective nominal axial or radial direction. As used herein, the term "substantially" denotes within 5% to account for manufacturing tolerances. Also, as used herein, the term "about" denotes within 5% to account for manufacturing tolerances.

[0055] While at least one exemplary embodiment has been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention. It being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. A stator core configured for an e-machine of an e-machine system, the stator core configured to fluidly connect to a fluid coolant system of the e-machine system, the stator core comprising:

a first end;

a second end that is separated from the first end along an axis;

an inner radial surface facing radially toward the axis and extending along the axis between the first end and the second end;

an outer radial surface facing radially away from the axis and extending along the axis between the first end and the second end;

an outer coolant groove defined on the outer radial surface of the stator core, the outer coolant groove extending about the axis;

a yoke flow channel extending through the stator core along the axis, the yoke flow channel in fluid communication with the outer coolant groove; and

the outer coolant groove configured to receive coolant of the fluid coolant system and provide the coolant to the yoke flow channel, which provides the coolant to at least one of the first end and the second end.

2. The stator core of claim **1**, wherein the inner radial surface is smooth and continuous about the axis.

3. The stator core of claim **2**, wherein the outer radial surface has a cross section taken normal to the axis, wherein the cross section is smooth and continuous.

4. The stator core of claim **1**, further comprising a tooth flow channel extending through the stator core along the axis, the tooth flow channel configured to receive coolant of the fluid coolant system;

a winding opening extending through the stator core along the axis, the winding opening configured to receive stator windings of the e-machine therein; and

the winding opening disposed radially between the yoke flow channel and the tooth flow channel.

5. The stator core of claim **4**, wherein the tooth flow channel has a cross section taken normal to the axis, wherein the cross section is substantially circular.

6. The stator core of claim **4**, wherein the tooth flow channel extends axially straight through the stator core substantially parallel to the axis.

7. The stator core of claim **4**, wherein the tooth flow channel is aligned radially with the winding opening with respect to the axis.

8. The stator core of claim **1**, wherein the yoke flow channel has a cross section taken normal to the axis, the cross section being elongate in a circumferential direction about the axis.

9. The stator core of claim **8**, wherein the cross section is elongate and arcuately curved about the axis.

10. The stator core of claim **9**, further comprising a plurality of winding openings extending through the stator core along the axis, the plurality of winding openings configured to receive respective stator windings of the e-machine therein; and

wherein the yoke flow channel radially overlaps at least two adjacent ones of the plurality of winding openings.

11. The stator core of claim **1**, wherein the yoke flow channel extends axially straight through the stator core substantially parallel to the axis.

12. The stator core of claim **1**, wherein the yoke flow channel is one of a plurality of yoke flow channels that extend through the stator core along the axis, the plurality of yoke flow channels being in fluid communication with the outer coolant groove.

13. The stator core of claim **12**, wherein the plurality of yoke flow channels are spaced substantially evenly about the axis.

14. The stator core of claim **13**, further comprising a plurality of tooth flow channels extending through the stator core along the axis, the plurality of tooth flow channels configured to receive coolant of the fluid coolant system;

further comprising a plurality of winding openings extending through the stator core along the axis, the plurality of winding openings configured to receive respective stator windings of the e-machine therein; and

the plurality of winding openings disposed radially between the plurality of yoke flow channels and the plurality of tooth flow channels.

15. The stator core of claim **1**, wherein the outer coolant groove extends annularly and continuously on the outer radial surface about the axis.

16. The stator core of claim **1**, further comprising a plurality of laminations that are stacked along the axis to collectively define the outer radial surface, wherein different ones of the plurality of laminations have different radii, the different ones of the plurality of laminations cooperatively defining the outer coolant groove.

17. An e-machine system comprising:

an e-machine with a stator member;

a stator core of the stator member;

a fluid coolant system that is operatively connected to the stator core;

the stator core comprising:

a first end;

a second end that is separated from the first end along an axis;

an inner radial surface facing radially toward the axis and extending along the axis between the first end and the second end;

an outer radial surface facing radially away from the axis and extending along the axis between the first end and the second end;

an outer coolant groove defined on the outer radial surface of the stator core, the outer coolant groove extending about the axis;

a yoke flow channel extending through the stator core along the axis, the yoke flow channel in fluid communication with the outer coolant groove; and

the outer coolant groove configured to receive coolant of the fluid coolant system and provide the coolant to the yoke flow channel, which provides the coolant to at least one of the first end and the second end.

18. The e-machine system of claim **17**, further comprising a tooth flow channel extending through the stator core along the axis, the tooth flow channel configured to receive coolant of the fluid coolant system;

a winding opening extending through the stator core along the axis, the winding opening configured to receive stator windings of the e-machine therein; and

the winding opening disposed radially between the yoke flow channel and the tooth flow channel.

19. The e-machine system of claim **18**, further comprising a housing that defines a cavity that receives the stator core;

wherein the fluid coolant system includes a first inlet through the housing and a second inlet through the housing, the first inlet fluidly connected to the outer coolant groove to supply the coolant thereto, and the second inlet fluidly connected to the tooth flow channel to supply the coolant thereto.

20. A stator core configured for an e-machine of an e-machine system, the stator core configured to fluidly connect to a fluid coolant system of the e-machine system, the stator core comprising:

a first end;

a second end that is separated from the first end along an axis;

an inner radial surface facing radially toward the axis and extending along the axis between the first end and the second end;

an outer radial surface facing radially away from the axis and extending along the axis between the first end and the second end;

an outer coolant groove defined on the outer radial surface of the stator core, the outer coolant groove extending about the axis;

a yoke flow channel extending through the stator core along the axis, the yoke flow channel in fluid communication with the outer coolant groove;

the outer coolant groove configured to receive coolant of the fluid coolant system and provide the coolant to the yoke flow channel, which provides the coolant to at least one of the first end and the second end;

a tooth flow channel extending through the stator core along the axis, the tooth flow channel configured to receive coolant of the fluid coolant system;

a winding opening extending through the stator core along the axis, the winding opening configured to receive stator windings of the e-machine therein;

the winding opening disposed radially between the yoke flow channel and the tooth flow channel;

the inner radial surface being smooth and continuous about the axis; and

the outer radial surface having a cross section taken normal to the axis, the cross section being smooth and continuous.

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