(10) Publication No: **IN202641070668 A1**
(22) Date of Filing: 05-06-2026

(43) Publication Date: 12-06-2026
Journal No: 24/2026

(19) Intellectual Property Office, India

(12) INDIAN PATENT APPLICATION

(54) Title: **Fractal geometry-based rotor for electric motors and method of manufacturing the same**

(51) International Classification:
H02K1/22, H02K1/26, H02K15/021, G06F30/20

(21) Application No: **202641070668**

(31) Priority Document No: **--**

(32) Priority Date: **--**

(86) International Application No: **--**
Filing Date: **--**

(87) International Publication No: **--**

(61) Patent of Addition to Application No: **--**
Filing Date: **--**

(62) Divisional to Application No: **--**
Filing Date: **--**

(71) Name of Applicant(s):
1. Gummaluri Venkata Surya Subrahmanya Sharma,
2. Lagudu Venkata Suresh Kumar,
3. Gummaluri Sesha Aruna Kumari,

(72) Name of Inventor(s):
1. Gummaluri Venkata Surya Subrahmanya Sharma
2. Lagudu Venkata Suresh Kumar
3. Gummaluri Sesha Aruna Kumari

(57) Abstract:

The present disclosure relates to a fractal geometry-based rotor (100) for an electric motor and a method of manufacturing the same. The fractal geometry-based rotor (100) comprises a rotor body (102), a central bore (104) formed through the rotor body (102) and arranged about a longitudinal rotational axis, and a plurality of peripheral profile features (106) disposed along an outer boundary (108) of the rotor body (102). Each peripheral profile feature (106) comprises a fractal geometry-based profile (110) having one or more geometric segments (112). The fractal geometry-based profile (110) is derived from at least one of a Sierpinski, Koch, modified snowflake, Mandelbrot-step, rooted-tree, stepped, or branched geometry. The self-similar fractal geometry increases the effective surface area to enhance heat dissipation, redistributes mechanical and centrifugal loads to reduce stress concentration and deformation, and improves the efficiency and reliability of the electric motor.

FORM 2

THE PATENT ACT, 1970

(39 of 1970)

&

The Patent Rules, 2003

COMPLETE SPECIFICATION

(See section 10 and rule 13)

1. TITLE OF THE INVENTION:

Fractal Geometry-Based Rotor for Electric Motors and Method of Manufacturing the Same

2. APPLICANT:

Name: 1. Gummaluri Venkata Surya Subrahmanya Sharma

2. Lagudu Venkata Suresh Kumar 3. Gummaluri Sesha Aruna Kumari

Nationality: 1. Indian 2. Indian 3. Indian

Address: 1. Professor, Mechanical Engineering Department, RAGA-4, GMRIT Staff Quarters, GMRIT Deemed to be University, GMR Nagar, Rajam-532127, Vizianagaram District, Andhra Pradesh, India.

2. Associate Professor, Electrical and Electronics Engineering Department, GMRIT Deemed to be University, GMR Nagar, Rajam-532127, Vizianagaram District, Andhra Pradesh, India.

3. RAGA-4, GMRIT Staff Quarters, GMRIT Deemed to be University, GMR Nagar, Rajam- 532127, Vizianagaram District, Andhra Pradesh, India.

3. PREAMBLE TO THE DESCRIPTION:

The following specification particularly describes the invention and the manner in which it is to be performed:

4. DESCRIPTION:

Field of the invention:

[0001] The present invention relates generally to electric vehicle propulsion systems and electric motor rotor design, and more particularly to a fractal geometry-based rotor for electric motors having rotor slot configurations and/or peripheral profile configurations derived from iterative fractal geometries to enhance heat dissipation, improve stress distribution, and increase motor efficiency and reliability.

Background of the invention:

[0002] Electric motors are widely employed in electric vehicle propulsion systems, industrial drive systems, and other rotating electrical machines for converting electrical energy into mechanical output. In such motors, a rotor is generally arranged to rotate relative to a stator and may include rotor slots, rotor bars, magnetic structures, peripheral profiles, and associated core features depending on the type of motor configuration. Conventional rotor structures are generally designed to provide torque generation, magnetic flux interaction, rotational stability, and mechanical support during operation of the electric motor.

[0003] In electric vehicle applications, the rotor is subjected to demanding operating conditions, including high rotational speeds, centrifugal loading, cyclic mechanical stresses, thermal loading, and electromagnetic interactions. Conventional rotor slot and rotor profile configurations are commonly selected to satisfy basic electromagnetic and mechanical requirements. However, such configurations may exhibit localized stress concentration, uneven heat distribution, limited heat dissipation capability, rotor deformation, vibration, acoustic disturbances, thermal degradation, and reduced operational efficiency under high-speed or continuous-duty conditions.

[0004] Various approaches have been proposed to improve the performance of electric motor rotors. For example, the non-patent literature entitled “A Comprehensive Disturbing Effect Analysis of Multi-Sectional Rotor Slot Geometry for Induction Machines in Electrical Vehicles” discusses an analysis of multi-sectional rotor slot geometries for induction machines used in electric vehicles, including performance, vibration, and acoustic effects. The non-patent literature entitled “Optimized rotor slot shape for squirrel cage induction motor in electric propulsion application", "Optimal shape design of rotor slot in squirrel-cage induction motor considering torque characteristics", and "Optimal design of stator and rotor slot of induction motor for electric vehicle applications" discuss optimization of rotor slot shapes or stator and rotor slot dimensions for squirrel-cage induction motors and electric vehicle applications. The non-patent literature entitled "Rotor Shape Multi-Level Design Optimization for Double-Stator Permanent Magnet Synchronous Motors" discusses a rotor shape multi-level design optimization for reducing mechanical stress in a double-stator permanent magnet synchronous motor. Such approaches generally focus on modifying slot dimensions, changing rotor shape parameters, optimizing selected performance characteristics, or reducing mechanical disturbances.

[0005] Other identified approaches relate to electromagnetic or thermal enhancement of motor components. Patent document US11776729B2, entitled "Fractal switching systems and related electromechanical devices", relates to fractal switching systems and related electromechanical devices using fractal-shaped electromagnetic structures. Patent document CN108134491B, entitled "Design method of rotor iron core of permanent magnet synchronous motor", relates to a design method for a rotor core of a permanent magnet synchronous motor for reducing harmonic content, improving efficiency, and reducing vibration and noise. Patent document CN221552934U, entitled "Motor rotor convenient for heat dissipation", relates to a motor rotor configured for heat dissipation using heat conduction and heat dissipation structures. These approaches indicate continuing interest in improving electromagnetic performance, heat dissipation, and mechanical reliability of rotating electrical machines.

[0006] Although such approaches may provide improvements for selected operating parameters, they may not adequately address the combined thermal, structural, and electromagnetic requirements of electric motor rotors in a unified rotor geometry. Slot shape optimization techniques may improve torque, efficiency, or vibration characteristics, but may remain limited to conventional geometric modifications. Heat dissipation structures may improve cooling, but may require additional openings, passages, or components that can affect rotor strength, manufacturing complexity, or design compactness. Fractal electromagnetic structures may improve selected electromagnetic characteristics, but may not specifically provide a rotor slot and/or rotor peripheral profile architecture configured to simultaneously improve heat dissipation, stress distribution, and rotor performance in an electric motor.

[0007] Accordingly, there remains a technical need for an improved rotor configuration for electric motors, particularly for electric vehicle propulsion systems, which can enhance thermal dissipation while maintaining or improving mechanical strength and operational efficiency. There is also a need for a rotor design that can reduce stress concentration and deformation under centrifugal loading while providing increased effective surface area and geometry-driven thermal management. Further, there is a need for a manufacturable rotor structure that can be developed using computer-aided design and fabricated using precision manufacturing techniques suitable for complex rotor geometries.

[0008] Existing solutions may be insufficient because improvements in motor rotors are often pursued through isolated design modifications directed to one performance aspect at a time, such as slot optimization, stress reduction, vibration control, or heat dissipation. Such isolated approaches may not provide a geometry-driven rotor architecture capable of concurrently addressing thermal pathways, stress redistribution, electromagnetic interaction, and manufacturability. Therefore, an improved rotor design is desirable in which the rotor slot configuration and/or peripheral profile configuration itself contributes to thermal and structural performance without relying solely on separate cooling structures or conventional slot-shape modifications.

[0009] The present invention addresses the above-noted technical need by providing a fractal geometry-based rotor for electric motors and a method of manufacturing the same. In particular, rotor slot configurations and/or rotor peripheral profile configurations are derived from iterative fractal geometries, including one or more of Sierpinski, Koch, modified snowflake, Mandelbrot-step, and rooted-tree geometries, to increase effective surface area, improve heat dissipation, redistribute mechanical stress, reduce deformation, and improve operational efficiency and reliability of the motor. The invention thereby provides a rotor architecture suitable for electric vehicle propulsion systems and other electric motor applications requiring enhanced thermal, structural, and operational performance.

Objectives of the invention:

[0010] The primary objective of the present invention is to provide a fractal geometry-based rotor for electric motors that improves heat dissipation by incorporating rotor slot profiles and/or peripheral profiles derived from iterative fractal geometries.

[0011] Another objective of the present invention is to provide a fractal geometry-based rotor configured to reduce localized stress concentration in a rotor body during high-speed rotational operation.

[0012] Another objective of the present invention is to provide a fractal geometry-based rotor that improves distribution of centrifugal and mechanical loads across the rotor structure, thereby reducing deformation and enhancing structural stability.

[0013] Another objective of the present invention is to provide a fractal geometry-based rotor for electric vehicle propulsion systems that improves operational efficiency by enhancing thermal management and reducing thermally induced performance losses.

[0014] Another objective of the present invention is to provide a fractal geometry-based rotor having self-similar geometrical features selected from one or more of Sierpinski, Koch, modified snowflake, Mandelbrot-step, and rooted-tree configurations.

[0015] Another objective of the present invention is to provide a fractal geometry-based rotor in which the rotor slot configuration and/or peripheral profile configuration contributes to both mechanical strength and heat transfer performance without relying solely on separate cooling components.

[0016] Another objective of the present invention is to provide a fractal geometry-based rotor that can be designed using computer-aided design and optimized through structural, thermal, and/or electromagnetic analysis.

[0017] Another objective of the present invention is to provide a method of manufacturing a fractal geometry-based rotor using precision manufacturing techniques capable of forming complex fractal slot profiles and/or peripheral rotor profiles.

[0018] Yet another objective of the present invention is to provide a fractal geometry-based rotor that reduces vibration, improves operational stability, and enhances reliability of electric motors operating under variable load and speed conditions.

[0019] Further objective of the present invention is to provide a fractal geometry-based rotor suitable for electric motors, electric vehicle propulsion motors, industrial drive motors, and other rotating electrical machines requiring improved thermal, structural, and operational performance.

Summary of the invention:

[0020] The present disclosure proposes a fractal geometry-based rotor for electric motors and method of manufacturing the same. The following presents a simplified summary in order to provide a basic understanding of some aspects of the claimed subject matter. This summary is not an extensive overview. It is not intended to identify key or critical elements or to delineate the scope of the claimed subject matter. Its sole purpose is to present some concepts in a simplified form as a prelude to the more detailed description that is presented later.

[0021] In order to overcome the deficiencies of existing systems, the present disclosure is directed to solving the technical problem of providing a fractal geometry-based rotor for electric motors having rotor slot configurations and/or peripheral profile configurations derived from iterative fractal geometries to enhance heat dissipation, improve stress distribution, and increase motor efficiency and reliability.

[0022] According to an aspect, the present invention discloses a fractal geometry-based rotor for an electric motor. In one embodiment herein, the fractal geometry-based rotor comprises a rotor body, a central bore, and plurality of peripheral profile features. The central bore is formed through the rotor body. The central bore is arranged about a longitudinal rotational axis of the rotor body. The central bore is substantially circular and is concentrically arranged with respect to the longitudinal rotational axis of the rotor body.

[0023] In one embodiment herein, the plurality of peripheral profile features is disposed along an outer boundary of the rotor body. Each peripheral profile feature comprises a fractal geometry-based profile having one or more geometric segments formed along the outer boundary of the rotor body. The one or more geometric segments comprise a first geometric segment and at least one subsequent geometric segment having a reduced scale relative to the first geometric segment.

[0024] In one embodiment herein, the fractal geometry-based profile is derived from at least one of a Koch geometry, a modified snowflake geometry, a Sierpinski geometry, a Mandelbrot-step geometry, a rooted-tree geometry, a stepped geometry, and a branched geometry.

[0025] In one embodiment herein, the plurality of peripheral profile features are spaced apart from one another along the outer boundary of the rotor body. The spaced-apart peripheral profile features define plurality of recesses along the outer boundary of the rotor body.

[0026] According to an aspect, a method is disclosed for manufacturing a fractal geometry-based rotor for an electric motor. First, at one step, a rotor profile is prepared corresponding to the rotor body, the central bore, the outer boundary, and the plurality of peripheral profile features. At another step, a rotor blank is provided for forming the rotor body. At another step, the central bore is formed through the rotor blank. At another step, the outer boundary of the rotor body is formed based on the rotor profile. At another step, the plurality of peripheral profile features is formed along the outer boundary using at least one manufacturing tool. Further, at another step, each peripheral profile feature is shaped to include the fractal geometry-based profile having the one or more geometric segments, thereby obtaining the fractal geometry-based rotor.

[0027] In one embodiment herein, the at least one manufacturing tool comprises at least one of a wire-cut electrical discharge machining tool, a sinker electrical discharge machining tool, a computer numerical control machining tool, a laser cutting tool, a waterjet cutting tool, or an additive manufacturing apparatus. The central bore is formed by at least one of drilling, boring, reaming, electrical discharge machining, or computer numerical control machining.

[0028] In one embodiment herein, the method further comprises finishing the rotor body after shaping the plurality of peripheral profile features. The finishing comprises at least one of deburring, surface finishing, dimensional inspection, or balancing of the rotor body.

[0029] Further, objects and advantages of the present invention will be apparent from a study of the following portion of the specification, the claims, and the attached drawings.

Detailed description of drawings:

[0030] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention, and, together with the description, explain the principles of the invention.

[0031] FIG. 1 illustrates a schematic view of a fractal geometry-based rotor derived from a Sierpinski geometry, in accordance with a first example embodiment of the present invention.

[0032] FIG. 2 illustrates a schematic view of the fractal geometry-based rotor derived from a Koch geometry, in accordance with a second example embodiment of the present invention.

[0033] FIG. 3 illustrates a schematic view of the fractal geometry-based rotor derived from a snowflake geometry, in accordance with a third example embodiment of the present invention.

[0034] FIG. 4 illustrates a schematic view of the fractal geometry-based rotor derived from a Mandelbrot-step geometry, in accordance with a fourth example embodiment of the present invention.

[0035] FIG. 5 illustrates a schematic view of the fractal geometry-based rotor derived from a rooted-tree geometry, in accordance with a fifth example embodiment of the present invention.

[0036] FIG. 6 illustrates a flowchart depicting a design and analysis method for developing the fractal geometry-based rotor, in accordance with an example embodiment of the present invention.

[0037] FIG. 7 illustrates a flowchart depicting a method of manufacturing the fractal geometry-based rotor, in accordance with an example embodiment of the present invention.

Detailed description of the invention:

[0038] Various embodiments of the present invention will be described with reference to the accompanying drawings. Wherever possible, the same or similar reference numerals are used in the drawings and the description to refer to the same or similar parts or steps. The detailed description set forth below in connection with the appended drawings is intended as a description of exemplary embodiments and is not intended to represent the only forms in which the present invention may be constructed or utilized. The description sets forth the functions and the sequence of steps for constructing and operating the invention in connection with the illustrated embodiments. It is to be understood, however, that the same or equivalent functions and sequences may be accomplished by different embodiments.

[0039] The present invention provides a fractal geometry-based rotor 100 for an electric motor, and a method of manufacturing the same. The fractal geometry-based rotor 100 is configured to be received within an electric motor, such as a squirrel-cage induction motor, a permanent magnet synchronous motor, or another rotating electrical machine, and to rotate relative to a stator of the electric motor about a longitudinal rotational axis. The fractal geometry-based rotor 100 is particularly suitable for electric vehicle propulsion systems and other applications in which enhanced heat dissipation, improved stress distribution, and increased operational efficiency and reliability are desired.

[0040] Referring to FIG. 1 to FIG. 5, the fractal geometry-based rotor 100 comprises a rotor body 102, a central bore 104, and plurality of peripheral profile features 106. The rotor body 102 is a generally disc-shaped or cylindrical member that forms the principal structural mass of the fractal geometry-based rotor 100. In one embodiment herein, the rotor body 102 is formed as a stack of plurality of laminations of electrical steel or silicon steel, and in another embodiment herein, the rotor body 102 is formed as a unitary core. The rotor body 102 defines an outer boundary 108 extending circumferentially about the longitudinal rotational axis.

[0041] In one embodiment, the central bore 104 is formed through the rotor body 102 and is arranged about the longitudinal rotational axis of the rotor body 102. The central bore 104 is configured to receive a rotor shaft (not shown) of the electric motor. In one embodiment herein, the central bore 104 is substantially circular and is concentrically arranged with respect to the longitudinal rotational axis of the rotor body 102, thereby promoting rotational balance and minimizing rotor imbalance during high-speed operation.

[0042] In one embodiment, the plurality of peripheral profile features 106 is disposed along the outer boundary 108 of the rotor body 102. Each peripheral profile feature 106 comprises a fractal geometry-based profile 110 having one or more geometric segments 112 formed along the outer boundary 108. The one or more geometric segments 112 comprise a first geometric segment and at least one subsequent geometric segment having a reduced scale relative to the first geometric segment, such that the fractal geometry-based profile 110 exhibits self-similarity and a hierarchical, multi-scale geometry. The self-similar geometry of the fractal geometry-based profile 110 increases the effective surface area of the rotor body 102 at the outer boundary 108, thereby enhancing convective and conductive heat dissipation, while distributing mechanical and centrifugal loads over a larger and more gradually varying boundary so as to reduce localized stress concentration. The self-similar arrangement of the geometric segments 112 increases the effective surface area of the rotor body 102 relative to a substantially smooth rotor boundary having a comparable overall rotor diameter. The increased effective surface area promotes improved convective and conductive heat transfer during operation of the electric motor.

[0043] In one embodiment herein, the plurality of peripheral profile features 106 are spaced apart from one another along the outer boundary 108 of the rotor body 102. The spaced-apart peripheral profile features 106 define plurality of recesses 114 along the outer boundary 108. The recesses 114 cooperate with the peripheral profile features 106 to define alternating projections and recesses that further increase the effective heat-transfer surface area, promote circulation of a cooling medium about the rotor body 102, and provide gradual transitions that mitigate stress concentration under centrifugal loading. The plurality of peripheral profile features 106 and recesses 114 define gradual geometric transitions along the outer boundary 108 of the rotor body 102. The gradual transitions redistribute centrifugal and mechanical loading across the rotor body 102 and reduce localized stress concentration that may otherwise occur at abrupt geometric discontinuities.

[0044] In one embodiment herein, the fractal geometry-based profile 110 is derived from at least one of a Koch geometry, a modified snowflake geometry, a Sierpinski geometry, a Mandelbrot-step geometry, a rooted-tree geometry, a stepped geometry, and a branched geometry. The fractal geometry-based profile 110 may be generated to any selected iteration level, including a first iteration N=1, a second iteration N=2, and a third iteration N=3, where an increasing iteration level corresponds to an increasing geometric complexity, an increasing number of geometric segments 112, and an increasing effective surface area of the outer boundary 108. It is to be understood that the fractal geometry-based profile 110 may be applied to a rotor slot configuration of the rotor body 102, to the peripheral profile of the rotor body 102, or to both. The fractal geometry-based profile 110 is generated through iterative geometric subdivision in which each subsequent geometric segment is derived from a preceding geometric segment at a reduced scale. The iterative subdivision produces progressively increasing geometric complexity and effective surface area with increasing iteration levels.

[0045] According to a first embodiment of the invention, FIG. 1 illustrates a schematic view of the fractal geometry-based rotor 100 in which the fractal geometry-based profile 110 of each peripheral profile feature 106 is derived from the Sierpinski geometry. In this embodiment, each peripheral profile feature 106 comprises a substantially triangular first geometric segment projecting outwardly from the outer boundary 108 of the rotor body 102, and at least one subsequent triangular geometric segment 112 of reduced scale arranged in self-similar relation along the sides of the first geometric segment. The plurality of triangular peripheral profile features 106 is arranged successively about the outer boundary 108, and the recesses 114 are defined between adjacent triangular peripheral profile features 106. The triangular, self-similar geometry redistributes centrifugal stresses along the inclined faces of the geometric segments 112 and increases the peripheral surface area available for heat dissipation.

[0046] According to a second embodiment of the invention, FIG. 2 illustrates a schematic view of the fractal geometry-based rotor 100 in which the fractal geometry-based profile 110 of each peripheral profile feature 106 is derived from the Koch geometry. In this embodiment, each peripheral profile feature 106 comprises a first geometric segment defining a lobed or scalloped projection along the outer boundary 108, and at least one subsequent geometric segment of reduced scale superimposed upon the first geometric segment to define a self-similar, undulating profile. The plurality of lobed peripheral profile features 106 and the intervening recesses 114 together define a substantially flower-like or cloud-like peripheral profile. The rounded, repeatedly subdivided Koch-derived profile provides a continuously varying boundary that increases the effective surface area for heat transfer while avoiding sharp re-entrant corners, thereby reducing stress concentration.

[0047] According to a third embodiment of the invention, FIG. 3 illustrates a schematic view of the fractal geometry-based rotor 100 in which the fractal geometry-based profile 110 of each peripheral profile feature 106 is derived from the snowflake geometry. In this embodiment, each peripheral profile feature 106 comprises a radially projecting first geometric segment defining a main arm, and at least one subsequent geometric segment of reduced scale defining one or more side-branches extending from the main arm. The plurality of branched peripheral profile features 106 is distributed about the outer boundary 108, and the recesses 114 are defined between adjacent arms. The branched, self-similar snowflake geometry substantially increases the effective surface area of the rotor body 102 and provides plurality of heat-dissipation pathways, while the gradual branching distributes mechanical loads across the main arms and the side-branches.

[0048] According to a fourth embodiment of the invention, FIG. 4 illustrates a schematic view of the fractal geometry-based rotor 100 in which the fractal geometry-based profile 110 of each peripheral profile feature 106 is derived from the Mandelbrot-step geometry constructed in accordance with a building-block approach. In this embodiment, each peripheral profile feature 106 comprises a first geometric segment defining a stepped rectangular projection along the outer boundary 108, and at least one subsequent geometric segment of reduced scale defining further rectangular steps arranged in self-similar relation upon the first geometric segment. The plurality of stepped peripheral profile features 106 and the intervening recesses 114 together define a stepped, terraced peripheral profile. The rectilinear stepped geometry increases the effective surface area and provides a plurality of discrete load-bearing terraces that distribute centrifugal stresses, while remaining particularly amenable to manufacture by machining processes.

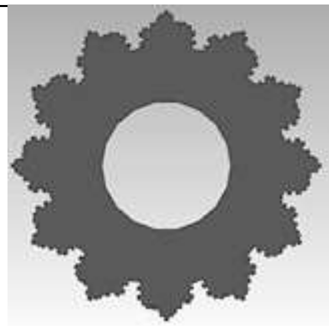
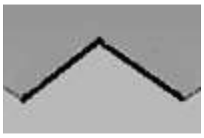
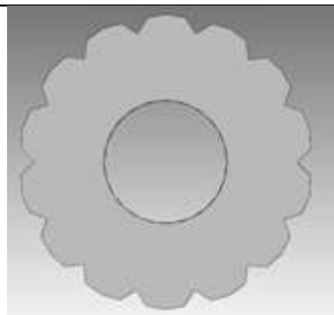
[0049] According to a fifth embodiment of the invention, FIG. 5 illustrates a schematic view of the fractal geometry-based rotor 200 in which a fractal geometry-based profile 202 is derived from the rooted-tree geometry and is embodied as a rotor slot configuration of a rotor body 204. In this embodiment, the rotor body 204 is a substantially cylindrical member having a substantially smooth, circular outer boundary 206, and the fractal geometry-based profile 202 defines one or more rotor slots 208 formed in the rotor body 204 rather than as projections along the outer boundary 206. Each rotor slot 208 extends into the rotor body 204 in a direction substantially parallel to the longitudinal rotational axis, and in one embodiment extends through the rotor body 204 between opposed end faces thereof. Each rotor slot 208 comprises a first geometric segment defining a trunk and at least one subsequent geometric segment of reduced scale defining plurality of branches extending from the trunk in self-similar relation, such that the rotor slot 208 exhibits a hierarchical, self-similar rooted-tree geometry.

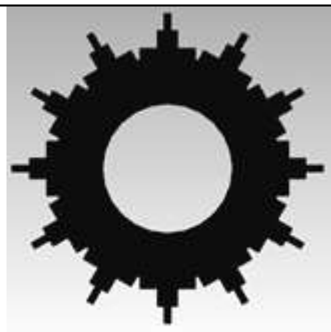
[0050] The one or more rotor slots 208 are disposed within the rotor body 204, for example adjacent to a central bore 210 and/or distributed about the longitudinal rotational axis. The branched rooted-tree slot geometry increases the effective internal surface area of the rotor body 204 to provide plurality of hierarchical heat-dissipation pathways, and is configured to receive an electrically conductive material, a rotor bar, a squirrel-cage winding, or a cooling medium, while distributing centrifugal and mechanical loads through the rotor body 204 so as to reduce localized stress concentration and deformation. It is to be understood that any of the Sierpinski, Koch, modified snowflake, and Mandelbrot-step geometries described herein may likewise be embodied as a rotor slot configuration of the rotor body 204 in the same manner as the rooted-tree geometry. The fractal geometry-based profile 110 and the rotor slots 208 define a plurality of hierarchical heat-transfer pathways extending through the rotor body 204. The hierarchical pathways facilitate thermal dissipation from internal regions of the rotor body toward surrounding cooling media during operation of the electric motor.

[0051] It is to be understood that the foregoing embodiments are exemplary, and that the fractal geometry-based profile 110 may comprise any one of the Sierpinski, Koch, modified snowflake, Mandelbrot-step, and rooted-tree geometries, or a combination thereof. Further, the fractal geometry-based profile 110 is not limited to the specific fractal geometries illustrated herein. The disclosed Sierpinski, Koch, modified snowflake, Mandelbrot-step, and rooted-tree geometries are exemplary. Other self-similar, iterative, hierarchical, derived, modified, hybrid, or mathematically equivalent fractal geometries may likewise be employed in the peripheral profile features 106 and/or rotor slots 208 without departing from the scope of the present invention. Further, two or more peripheral profile features 106 of the fractal geometry-based rotor 100 may be derived from different fractal geometries, and the iteration level of each fractal geometry-based profile 110 may be selected independently. The rotor body 102 may further comprise electrically conductive bars or a squirrel-cage winding (not shown) received within or adjacent to the peripheral profile features 106, or may carry one or more permanent magnets, without departing from the scope of the present invention. In one embodiment, a first peripheral profile feature 106 is derived from a first fractal geometry and a second peripheral profile feature 106 is derived from a second fractal geometry different from the first fractal geometry, thereby enabling localized tailoring of structural and thermal characteristics along different circumferential regions of the rotor body 102.

[0052] Table 1 below illustrates the evolution of the fractal geometry-based profile 110 of each disclosed geometry with increasing iteration level. As described above, the fractal geometry-based profile 110 may be generated to any selected iteration level, including a first iteration (N=1), a second iteration (N=2) and a third iteration (N=3).

[0053] Table 1:

Fractal type	N=1	N=2	N=3	Resultant rotor profile
Triangle inspired from Sierpinski triangle				
Flower or cloud inspired from Koch curve				
Fractal rotor inspired from modified snow flake				

Rectangle step rotor inspired from mandebrot set fractals with building block approach				
Fractal rotor inspired from Rooted tree-set Fractal geometry				

[0054] As shown in Table 1, for each fractal geometry the columns N=1 to N=3 depict the peripheral profile features 106 of the rotor body 102 generated at successively increasing iteration levels, and the final column depicts a resultant rotor profile. With increasing iteration level, the number of geometric segments 112 and the effective surface area of the outer boundary 108 increase, while the outer boundary 108 becomes progressively more self-similar and finely subdivided. The resulting increase in effective surface area enhances convective and conductive heat dissipation, and the progressively more gradually varying boundary distributes centrifugal and mechanical loads so as to reduce localised stress concentration. The illustrated profiles are schematic and the invention is not limited to the particular number of peripheral profile features 106, iteration levels, or proportions shown.

[0055] According to an exemplary embodiment of the invention, FIG. 6 refers to a flowchart 600 of a design and analysis method for developing the fractal geometry-based rotor 100. The method 600 proceeds through a sequence of design, simulation, comparison, optimisation, and validation steps, whereby a fractal geometry-based profile 110 is selected and refined for the rotor body 102 prior to manufacture. At step 602, one or more rotor profiles 101 including the fractal geometry-based profile 110 are modelled using computer-aided design (CAD modelling). In one embodiment, a baseline conventional rotor geometry and plurality of candidate fractal rotor geometries are created, the candidate geometries having peripheral profile features 106 derived from one or more of the Sierpinski, Koch, modified snowflake, Mandelbrot-step, and rooted-tree geometries, each generated to a selected iteration level (for example, N=1, N=2, or N=3). The CAD model defines the rotor body 102, the central bore 104, the outer boundary 108, and the peripheral profile features 106 with the dimensional parameters required for analysis.

[0056] At step 604, the modelled rotor geometry is discretised into plurality of finite elements (mesh generation), thereby producing a finite element model of the rotor body 102. In one embodiment, the mesh is locally refined in regions of geometric complexity, stress concentration, and steep thermal gradient, such as at the geometric segments 112 and the recesses 114, and a mesh-convergence check is performed so that the computed results are substantially independent of further mesh refinement. At step 606, a structural analysis is performed to evaluate stress distribution and deformation of the rotor body 102 under centrifugal loading. In one embodiment, material properties such as Young's modulus, Poisson's ratio, density, and yield strength are assigned, rotational and constraint boundary conditions are applied, and the analysis yields structural performance indicators such as equivalent (von Mises) stress, total deformation, factor of safety, and the location of peak-stress regions.

[0057] At step 608, a thermal analysis is performed to evaluate temperature distribution and heat dissipation of the rotor body 102. In one embodiment, heat-generation sources and thermal boundary conditions, including convection and ambient conditions, are applied to the finite element model, and the analysis yields thermal performance indicators such as temperature distribution, thermal gradient, heat flux, and the location of maximum-temperature regions, thereby characterising the cooling efficiency and thermal stability associated with the increased effective surface area of the outer boundary 108. At step 610, a comparative analysis is performed between the fractal geometry-based rotor 100 and a conventional rotor based on the structural and thermal results. In one embodiment, the structural and thermal indicators obtained at steps 606 and 608 for each candidate fractal geometry are compared against those of the baseline conventional rotor, so that the relative improvement in stress distribution, deformation, peak temperature, and heat dissipation attributable to the fractal geometry-based profile 110 can be quantified.

[0058] At step 612, the rotor geometry is optimised based on the comparative analysis. In one embodiment, the fractal geometry type, the iteration level, the number and proportions of the peripheral profile features 106, and the dimensions of the geometric segments 112 and recesses 114 are adjusted, and steps 604 to 610 are iterated as required, so as to identify a rotor geometry exhibiting reduced stress concentration and deformation together with enhanced heat dissipation and thermal stability. At step 614, the optimised fractal geometry-based rotor 100 is validated. In one embodiment, validation comprises confirming the consistency, reliability, and stability of the optimised geometry under the simulated operating conditions, and may further comprise fabricating a prototype of the optimised fractal geometry-based rotor 100 and experimentally verifying its structural and thermal performance against the simulated results. The structural analysis and thermal analysis collectively enable evaluation of the influence of the fractal geometry-based profile 110 on stress distribution, deformation characteristics, temperature distribution, thermal gradients, heat flux behavior, and heat-dissipation performance of the rotor body 102 relative to a conventional rotor geometry.

[0059] According to an exemplary embodiment of the invention, FIG. 7 refers to a flowchart 700 and FIG. 8 refers to a schematic representation 800 of the method of manufacturing the fractal geometry-based rotor 100. At step 702 and 802, a rotor profile 101 corresponding to the rotor body 102, the central bore 104, the outer boundary 108 and the plurality of peripheral profile features 106 is prepared using CAD modelling. At step 704 and 804, a rotor blank 103 is provided for forming the rotor body 102. At step 706 and 806, the central bore 104 is formed through the rotor blank 103. At step 708 and 808, the outer boundary 108 of the rotor body 102 is formed based on the rotor profile 101. At step 710 and 810, the plurality of peripheral profile features 106 is formed along the outer boundary 108 using at least one manufacturing tool, such as a wire-cut or sinker electrical discharge machining tool, a computer numerical control machining tool, a laser cutting tool, a waterjet cutting tool, or an additive manufacturing apparatus. At step 712 and 812, each peripheral profile feature 106 is shaped to include the fractal geometry-based profile 110 having the one or more geometric segments 112. At step 714 and 814, the rotor body 102 is finished by deburring, surface finishing, dimensional inspection and/or balancing, thereby obtaining the fractal geometry-based rotor 100.

[0060] It will be readily apparent to a person skilled in the art that numerous modifications and alterations may be made to the embodiments described in the foregoing examples without departing from the principles underlying the invention. All such modifications and alterations are intended to be embraced within the scope of this application.

5. CLAIMS:

I / We Claim:

1. A fractal geometry-based rotor (100) for an electric motor, comprising:

a rotor body (102);

a central bore (104) formed through the rotor body (102), wherein the central bore (104) is arranged about a longitudinal rotational axis of the rotor body (102); and

a plurality of peripheral profile features (106) disposed along an outer boundary (108) of the rotor body (102),

wherein each peripheral profile feature (106) comprises a fractal geometry-based profile (110) having one or more geometric segments (112) formed along the outer boundary (108),

wherein the one or more geometric segments (112) comprise a first geometric segment and at least one subsequent geometric segment having a reduced scale relative to the first geometric segment,

and wherein the fractal geometry-based profile (110) is configured to increase effective surface area of the rotor body (102) and redistribute centrifugal loading along the outer boundary (108) of the rotor body (102).

2. The fractal geometry-based rotor (100) as claimed in claim 1, wherein the central bore (104) is substantially circular and is concentrically arranged with respect to the longitudinal rotational axis of the rotor body (102).

3. The fractal geometry-based rotor (100) as claimed in claim 1, wherein the plurality of peripheral profile features (106) are spaced apart from one another along the outer boundary (108) of the rotor body (102).

4. The fractal geometry-based rotor (100) as claimed in claim 3, wherein the spaced-apart peripheral profile features (106) define plurality of recesses (114) along the outer boundary (108) of the rotor body (102).

5. The fractal geometry-based rotor (100) as claimed in claim 4, wherein the plurality of peripheral profile features (106) and the plurality of recesses (114) are configured to redistribute centrifugal loading and reduce localized stress concentration within the rotor body (102).

6. The fractal geometry-based rotor (100) as claimed in claim 1, wherein the fractal geometry-based profile (110) is derived from at least one of a Koch geometry, a modified snowflake geometry, a Sierpinski geometry, a Mandelbrot-step geometry, a rooted-tree geometry, a stepped geometry, and a branched geometry.

7. The fractal geometry-based rotor (100) as claimed in claim 1, wherein the fractal geometry-based profile (110) defines a plurality of heat-transfer pathways configured to enhance heat dissipation from the rotor body (102).

8. The fractal geometry-based rotor (100) as claimed in claim 1, wherein the fractal geometry-based profile (110) is generated through iterative geometric subdivision corresponding to one or more fractal iteration levels.

9. A method of manufacturing a fractal geometry-based rotor (100) for an electric motor, comprising:

preparing a rotor profile (101) corresponding to a rotor body (102), a central bore (104), an outer boundary (108), and a plurality of peripheral profile features (106);

providing a rotor blank (103) for forming the rotor body (102);

forming the central bore (104) through the rotor blank (103);

forming the outer boundary (108) of the rotor body (102) based on the rotor profile (101); and

forming the plurality of peripheral profile features (106) along the outer boundary (108) using at least one manufacturing tool; and

shaping each peripheral profile feature (106) to include a fractal geometry-based profile (110) having one or more geometric segments (112), thereby obtaining the fractal geometry-based rotor (100).

10. The method as claimed in claim 7, wherein the at least one manufacturing tool comprises at least one of a wire-cut electrical discharge machining tool, a sinker electrical discharge machining tool, a computer numerical control machining tool, a laser cutting tool, a waterjet cutting tool, or an additive manufacturing apparatus,

wherein the central bore (104) is formed by at least one of drilling, boring, reaming, electrical discharge machining, or computer numerical control machining, and

wherein the method comprises finishing the rotor body (102) after shaping the plurality of peripheral profile features (106), the finishing comprising at least one of deburring, surface finishing, dimensional inspection, or balancing of the rotor body (102).

6. DATE AND SIGNATURE:

Dated this 05th day of June, 2026

Patent Agent Name: Hima Bindu Atti

INPA - 3925

7. ABSTRACT:

Title: Fractal Geometry-Based Rotor for Electric Motors and Method of Manufacturing the Same

The present disclosure relates to a fractal geometry-based rotor (100) for an electric motor and a method of manufacturing the same. The fractal geometry-based rotor (100) comprises a rotor body (102), a central bore (104) formed through the rotor body (102) and arranged about a longitudinal rotational axis, and a plurality of peripheral profile features (106) disposed along an outer boundary (108) of the rotor body (102). Each peripheral profile feature (106) comprises a fractal geometry-based profile (110) having one or more geometric segments (112). The fractal geometry-based profile (110) is derived from at least one of a Sierpinski, Koch, modified snowflake, Mandelbrot-step, rooted-tree, stepped, or branched geometry. The self-similar fractal geometry increases the effective surface area to enhance heat dissipation, redistributes mechanical and centrifugal loads to reduce stress concentration and deformation, and improves the efficiency and reliability of the electric motor.

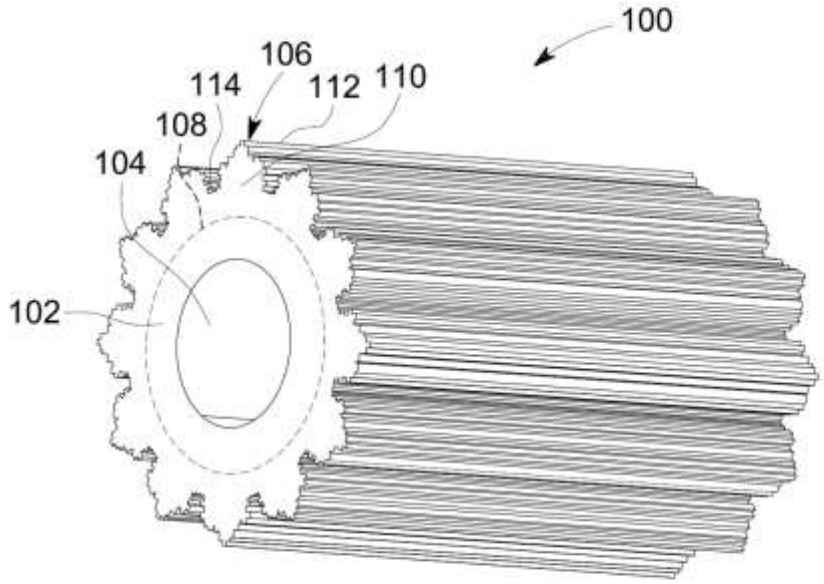


FIG. 1

Digitally Signed By:
Hima Bindu Atti
Date: 05-06-2026 18:53:23