Slip Ring Assembly Having a Brush Assembly Axially Applied to a Conductive Busbar Ring

Patent #10,109,970

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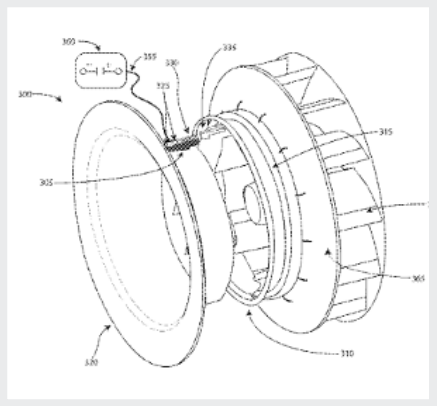
Technology Overview

Slip Ring Assembly Having a Brush Assembly Axially Applied to a Conductive Busbar Ring – Patent #10,109,970

This invention is a novel slip ring assembly that transfers power directly to the rotating aerodynamic surfaces of a centrifugal turbomachine without placing wires in the turbomachine's flow path. An exemplary embodiment of the slip ring assembly comprises a non-conductive slip ring and a brush assembly. The non-conductive slip ring has two conductive busbar rings connected along its outer surface. The conductive busbar rings are separated by a distance that prevents electrical shorting between them. There are two conductive brushes connected to the inner surface of the brush assembly. The first conductive brush maintains radial contact with the first conductive busbar ring to provide power to the slip ring assembly. The second conductive brush maintains contact with the second busbar ring to provide ground to the slip ring assembly.



Capabilities

- Transfers power directly to the rotating aerodynamic surfaces of a centrifugal turbomachine without placing wires in the turbomachine's flow path.

Benefits

- Application for plasma actuation on turbomachinery

Benchmarks

Benchmarks are unique qualities that are used to compare against existing patents, patent filings, and commercially available products in this assessment tool.

Index Number	Title	Description
1	**Plasma Actuation on Turbomachinery**	The application was for plasma actuation on turbomachinery, which is a form of active/aerodynamic flow control to allow control of the aerodynamics of blades themselves.

Market Research

Executive Summary

This section provides insights into market size, trends, and barriers to entry for the commercial applications of the technology, as well as recommendations for deeper market research. Potential markets include use in Wind turbines, Compressors, and Pumps. The fastest growing market is the Wind Turbines, with a Compound Annual Growth Rate (CAGR) of 7.27%.

Potential Markets

Wind Turbines
Machines that turn the motion of the wind into electricity

Market Insights

Market Size

- The global Wind Turbine Components Market was valued at $54 billion in 2022 and is estimated to be worth $82.3 billion by 2030, (a CAGR of 7.27% from 2023-2030).

Market Trends

- As more people begin to favor new technologies, the demand for energy is likely to rise. In the coming years, green fuel initiatives and methods for conserving renewable energy are anticipated to encourage greater use of wind power.
- The market for wind turbines is expanding due to the efforts of environmental groups and agencies to promote the use of renewable energy to reduce pollution and mitigate climate change.
- This market is anticipated to expand, as these power sources offer numerous advantages: a long lifespan, low development costs, low maintenance costs, and high working efficiency.

Barriers to Entry – High

- The technology requires adaptation for use in wind turbines

Key Players

- Enercon GmbH, GE Renewable Energy, Nordex SE, Northern Power Systems Corp, Siemens Gamesa Renewable Energy

Market Research (cont.)

Potential Markets	Market Insights
Compressors Mechanical devices that increase the pressure of a gas by reducing its volume	**Market Size** • The global Air Compressor market was valued at approximately $31.8 billion in 2021 and is expected to reach $55.9 billion by 2030 (a CAGR of 5.5% between 2022 and 2030). **Market Trends** • Increased usage in the Packaging, Transportation, Construction, and Pharmaceutical industries will lead to market growth. • Industrialization will lead to an increase in manufacturing activities; this will create opportunities for market growth. • Compressor applications have increased, and they will provide significant opportunities for market growth during the forecast period. **Barriers to Entry – High** • The growing number of gas compressor stations has led to increasing concerns around air quality; air monitoring systems are widely being installed to measure the impact of air and gas compressors. **Key Players** • Aerzener Maschinenfabrik GmbH, Ciasons Industrial Inc., Desran Compressor (Shanghai) Co.Ltd., Doosan Corporation (Doosan Infracore Portable Power) , Atlas Copco AB, Berkshire Hathaway Inc.
Pumps Devices that move fluids or slurries by mechanical action, typically converted from electrical energy into hydraulic energy	**Market Size** • The global Industrial Pumps market was valued at $69.8 billion in 2021 and is expected to grow at a CAGR of 6.3% during the forecast period. **Market Trends** • The Fiber and Textile industry requires pumping solutions to accurately measure color pigments, dye, bleach, etc. • Handling abrasive chemicals like latex, wastewater, sludge, etc. can be extremely difficult to handle. • The Chemical industry has perhaps the greatest demand for industrial pumps that are part of the manufacturing process, and offer protection to employees and their surrounding work environment. • Asia Pacific dominated the industrial pumps market in 2021 and is expected to account for the largest market share over the forecast period. **Barriers to Entry – High** • Increasingly strict rules and regulations regarding wastewater treatment necessitate the demand for industrial pumps. **Key Players** • Xylem, Grundfos Holding A/S, EBARA CORPORATION, Flowserve Corporation, Schlumberger Limited

Market Research (cont.)

Conclusions

- The Wind Turbine market seems to be a viable market for this invention, although there would most likely need to be some innovation to make the technology suited for this market.
- The Compressor market could benefit from the Slip Ring Assembly Having a Brush Assembly Axially Applied to a Conductive Busbar Ring in internal use for power transfer throughout the machine without cluttering up the device with wires. Although the technology could be useful, there is a tradeoff between cost; a huge price increase in the compressor itself could make it not a viable option.
- The Pump market does not seem to be the best fit for the invention due to the actual use case and low demand for such a technology.

Recommendations

Priority Key:

- **Must:** A critical and time sensitive recommendation to advance technology with respect to the area of focus.
- **Should:** An important recommendation to advance technology but is dependent upon predecessor recommendations or is not time sensitive.
- **Could:** A recommendation that will have insignificant impact on advancing the technology but could be a beneficial consideration.

Recommendations	Priority	ROM Cost	ROM Timeline
Advance TRL and MRL Plan	2	$15,000	4 months
Market Planning and Scouting	3	$35,000	6 months
License technology	1	$15,000	2 months
ROM Total:		**$65,000**	

Level of Market Opportunity

Analyst: DVIRC

Competitor Analysis

Competitor Analysis Intent

The intent of this section is to identify potential commercially available, competing technologies and provide conclusions and recommendations based on the information provided at the time of assessment. The resulting information may be used to identify technology strengths or weaknesses in features or claims, as well as potential licensing partners.

Research Methods

Various resources to uncover information about different companies that perform similar functions

Markets	Competitors
Wind Turbines	• **GE Renewable Energy:** Transformers receive alternating current (AC) electricity at one voltage and increase or decrease the voltage to deliver the electricity as needed. A wind power plant will use a step-up transformer to increase the voltage (thus reducing the required current), which decreases the power losses that happen when transmitting large amounts of current over long distances with transmission lines. • **Nordex SE:** Turbine with hub heights of 84 to 141 meters is ideal for complex locations. The maximum rated power can be adjusted (e.g. 3 MW) to also meet project-specific grid requirements. Nordex limits the sound power level of the N117/3600 to a maximum of 103.5 decibels. • **Enercon GmbH:** Annular generator, time-tested gearless drive technology, low level of wear thanks to slowly rotating machine, low mechanical stress due to highly variable speed, yield-optimized control system, high level of power quality, uninterrupted winding.
Compressors	• **Aerzener Maschinenfabrik GmbH:** Biogas compressor series C is an oil-free screw compressor in three sizes for volume flows up to 1900 m^3/h and 3.5 bar overpressure. Suitable for boosting the intake pressure of biogas treatment plants (BGTP) or as an essential part of biogas injection plants (BGIP) for the compression of biomethane to inject into gas grids. • **Howden:** Unique free-floating piston system uses a cushion of process gas to support the piston, eliminating rider ring wear and greatly extending intervals between maintenance. • **Desran Compressor:** With a higher power factor, larger inertia ratio, lower rotor current, and without the excitation loss, Desran PM motor improves efficiency by 5%-12%. With direct connection, efficiency can be improved another 3%. In low load mode, the efficiency of PM VSD compressor is 15% to 35% higher than that of a standard screw air compressor.

Competitor Analysis (cont.)

Markets	Competitors
Pumps	• **Roth Pump Company:** Pumps can handle continuous, non-pulsating differential pressures up to 2000 psi (141 kg/cm²) and up to 5400 ft. (1646m) Total Dynamic Head (TDH). • **Baker Hughes:** Pump systems combine a multistage centrifugal pump, a thrust chamber, and an efficient electrical motor in a single sturdy skid. Design speeds up manufacturing while delivering maintenance cost reductions of up to 88% compared to other systems. • **Pentair Flow Technologies, LLC:** The industry's first heat pump charged with non-ozone depleting refrigerant, R410A. 100% titanium heat exchanger assures corrosion-free performance for extended life.
Substitutes	
	Non-consumption

Conclusions

The Slip Ring Assembly Having a Brush Assembly Axially Applied to a Conductive Busbar Ring has commercial potential if it can be proven to add value to other the competitors currently in the market.

Technology Readiness Level – Hardware

Technology Readiness Level Intent	Current TRL
The intent of this document is to determine the level of effort required to advance the technology from its current state to a desired future state. Project tasks may be proposed to assist in technology advancement. The *Technology Readiness Level (TRL) Deskbook* version July 2009 served as the reference document for the TRL assessment. TRLs run from 1 to 9.	**4**

Research Methods

TRL determination has been conducted on applicable levels as seen below. The assessment was conducted by reviewing the following materials:

- Technology Overview
- Patent No. 10,109,970
- Q&A call with inventor

Findings

The Slip Ring Assembly Having a Brush Assembly Axially Applied to a Conductive Busbar Ring is comprised of multiple non-conductive slip rings and a brush assembly. The main purpose of the device is to transfer power directly to the rotating aerodynamic surfaces of a centrifugal turbomachine without placing wires in the turbomachine's flow path, providing power through rotation. This adaptation of the invention remains in the proof-of-concept phase, as it has not been prototyped, categorizing it as TRL 4. It is expected that the invention would be comprised of 10% commercial off the shelf parts (COTS) and the remaining comprised of manufactured parts. The technology will have to be tested first with electrical and rotating machinery testing followed by fluid dynamic performance (independently) and rotating without electrical actuation before putting it together and testing as a system.

Conclusions

For the Slip Ring Assembly Having a Brush Assembly Axially Applied to a Conductive Busbar Ring to advance readiness levels, many steps will need to take place, starting with the creation of a Technical Data Package (TDP) and Bill of Materials (BOM) for the invention. A prototype for this variation was not created, so further prototypes and testing are crucial for pushing this invention through the readiness levels.

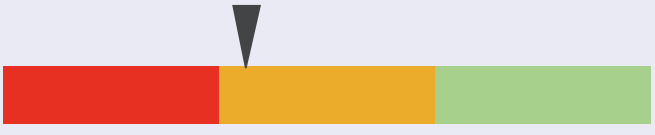
Technology Readiness Level – Hardware (cont.)

Recommendations

Priority Key:

- **Must:** A critical and time sensitive recommendation to advance technology with respect to the area of focus.
- **Should:** An important recommendation to advance technology but is dependent upon predecessor recommendations or is not time sensitive.
- **Could:** A recommendation that will have insignificant impact on advancing the technology but could be a beneficial consideration.

Recommendations to advance TRL to 9	Priority	ROM Cost	ROM Timeline
Develop TDP	Must	$1,000	1 month
Develop Cost Model	Must	$1,000	1 month
Develop prototype	Must	$3,500	3 months
Validate prototype in operational setting	Must	$2,500	2 months
Complete Design for Manufacturing	Should	$2,500	2 months
Study necessary compliance approvals/accreditations	Must	$4,000	3 months
Discuss potential to license technology to OEMs	Could	$2,000	2 months
Finalize Cost Model	Should	$1,000	1 month
Third party TRL revision	Could	$3,500	2 months
Finalize TDP	Should	$1,000	1 month
ROM Total:		**$22,000**	**16-18 mos**



Analyst: DVIRC

TECHNOLOGY VIABILITY ASSESSMENT POWERED BY MILTECH

Manufacturing Readiness Level

Manufacturing Readiness Level Intent	Current MRL
The intent of this assessment is to determine the level of effort required to advance the technology from its current state to desired future state. Project tasks may be proposed to assist in the advancement of the technology. The *Manufacturing Readiness Level (MRL) Deskbook* version 2.0 served as the reference document for the MRL assessment. MRLs run from 1 to 10.	**3**

Research Methods

Although a contractor has not been identified, an MRL determination has been conducted on applicable levels as seen below. The assessment was conducted with the following events and materials:

- Q&A interview with the inventor
- Patent No. 10,109,970

Findings

The MRL will generally track with the TRL but be slightly lower. The following is an assessment of the technology's current MRL and reasoning for the rating.

The Slip Ring Assembly Having a Brush Assembly Axially Applied to a Conductive Busbar Ring has not been prototyped, categorizing the device as a MRL 3. The components used in this device are not novel; the novelty lies in what the technology sought to achieve.

The Slip Ring Assembly Having a Brush Assembly Axially Applied to a Conductive Busbar Ring is comprised of multiple non-conductive slip ring and a brush assembly. The main purpose of the device is to transfer power directly to the rotating aerodynamic surfaces of a centrifugal turbomachine without placing wires in the turbomachine's flow path, providing power through rotation. The device has had pre-production drawings and final production drawings, but there is no formal TDP or BOM at this time. Although there has not been a cost model created yet, the inventors received a quote for another variation of this device for approximately $25,000.

Manufacturing the device will not require any special or exotic materials or tools. For a manufacturer already in the business of making slip rings, the manufacturing process should not be any different. Assembling the invention would entail 10% COTS parts, with the rest being manufactured parts. The approvals or accreditations will depend on the consumer use of the product. The device will have to be tested first with electrical and rotating machinery, followed by fluid dynamic performance (independently) before testing the rotation without actual electric actuation. Once completed, the system will be assembled and tested. There are no anticipated supply chain issues, but in the future there could be some delays with copper or graphite used in the machine. The device might require software depending on the application, as it can supply steady state power independent of a switch. It is recommended that a switch is used for monitoring the voltage and current.

Conclusions

Until the TRL process (TDP, BOM, testing) is advanced, the MRL will remain low. Further prototyping of this variation of the device is a crucial next step, along with testing the device in a laboratory or field setting.

While the prototype approaches a more developed level, we recommend that the inventors finalize suppliers (including possible backups) to widen sourcing options for COTS parts and avoid supply chain issues. A more thorough MRL assessment should be completed when these suppliers have been identified, and an evaluation can be made in a production environment.

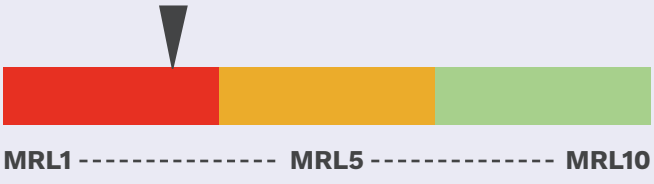
Manufacturing Readiness Level (cont.)

Recommendations

Priority Key:

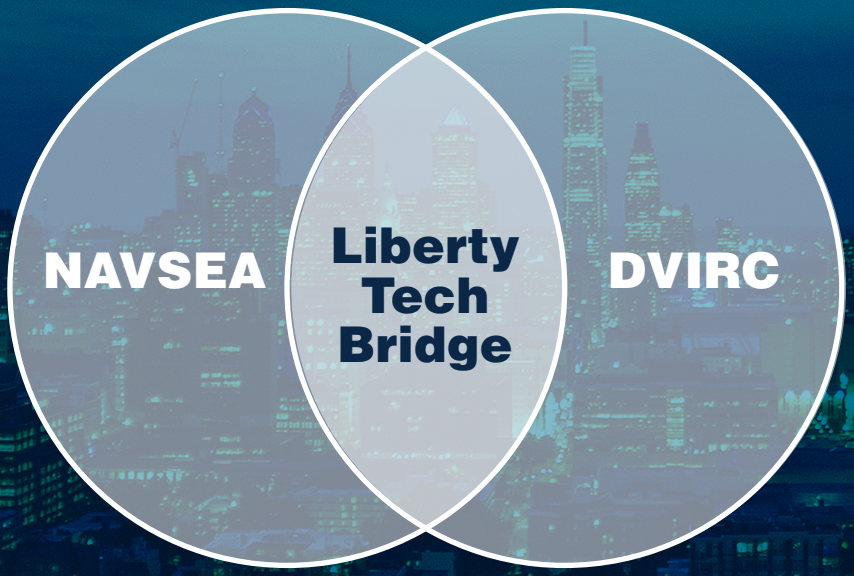
- **Must:** A critical and time sensitive recommendation to advance technology with respect to the area of focus.
- **Should:** An important recommendation to advance technology but is dependent upon predecessor recommendations or is not time sensitive.
- **Could:** A recommendation that will have insignificant impact on advancing the technology but could be a beneficial consideration.

Recommendations to advance MLR	Priority	ROM Cost	ROM Timeline
Develop BoM	Must	$2,000	2 months
Develop Cost Model	Should	$1,500	1 month
Scout assembly/COTS suppliers	Must	$2,000	2 months
Perform Critical Design Review	Must	$2,000	1 month
Complete Design for Manufacturing	Should	$3,500	3 months
Discuss potential to license technology to OEMs	Could	$2,500	2 months
Finalize Cost Model	Should	$1,500	1 month
Finalize BoM	Should	$1,500	1 month
Third party MRL revision	Should	$3,500	2 months
Finalize/Select COTS suppliers	Must	$1,000	1 month
Pilot Production Run	Must	$3,500	1 month
Evaluation and Design Modification	Must	$2,000	1 month
Full-Rate Production Run	Must	TBD	TBD
ROM Total:		**$27,000**	**15-18 mos**



Analyst: DVIRC

TECHNOLOGY VIABILITY ASSESSMENT POWERED BY MILTECH



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