Topic: N141-062

QuesTek Innovations, LLC

Computational Design of Aluminum Alloys for Use in Additive Manufacturing

Current helicopter gearbox housings are often made with magnesium (Mg)-based alloys for their high castability and low density. Replacing Mg alloys with aluminum (Al) alloys would improve corrosion resistance and galvanic degradation. However, current Al casting alloys lack the castability to produce complex housing geometries cost-effectively and as lightweight as competing Mg alloys. Furthermore, current high strength Al alloys cannot be processed via Additive Manufacturing (AM)—they crack during the AM process. A new high-strength Al alloy processed via AM can address both of these issues and enable longer service life in gearbox housings. QuesTek Innovations is using its Integrated Computational Materials Engineering (ICME) technology to develop high strength Al alloys suitable for AM. QuesTek has developed a hot-tear cracking index to predict which alloys will crack upon cooling and used this index to design three high-performance hot-tearing-resistant Al alloys. QuesTek is working with partners to evaluate component-level demonstrations of these alloys.

Technology Category Alignment:

Air Platforms
Engineered Resilient Systems (ERS)
Ground and Sea Platforms
Materials & Manufacturing Processes

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SYSCOM: ONR
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Department of the Navy SBIR/STTR Transition Program

STATEMENT A. Approved for public release; distribution is unlimited.
ONR Approval #

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WHO

SYSCOM: ONR

Sponsoring Program: Sea-Based Aviation Structures

Transition Target: Helicopters with cast Mg or Al gearboxes

TPOC:
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Other transition opportunities:
V22, UH-1Y, AH-1Z, V-280 and OH-58D helicopters, as well as future programs.

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WHAT

Operational Need and Improvement: Current helicopter gearbox housings are often made with magnesium (Mg)-based alloys for their high castability and low density. Replacing Mg alloys with aluminum (Al) alloys would improve corrosion resistance and galvanic degradation. However, current Al casting alloys lack the castability to produce complex housing geometries cost-effectively and as lightweight as competing Mg alloys. Furthermore, current high strength Al alloys cannot be processed via Additive Manufacturing (AM)—they crack during the AM process. A new high-strength Al alloy processed via AM can address both of these issues and enable longer service life in gearbox housings.

Specifications Required:
Solicitation Goals: Properties of or better than cast A357 Al alloy: Tensile strength > 38 ksi, Yield strength > 30 ksi, Elongation > 2%, Fatigue limit $15x10^7$ cycles, Hardness > 100 Hv.

Recommended Goals: Properties of or better than wrought 7050 Al alloy: Tensile strength > 74 ksi, Yield strength > 64 ksi, Elongation > 10%, Fatigue limit $15x10^7$ cycles, Hardness > 162 Hv.

Technology Developed: QuesTek has developed an Integrated Computational Materials Engineering (ICME) framework for the design of AM-processable alloys, which it has used to develop 3 Al alloy concepts with improved AM processability:
• High-strength AM Al • SCC-resistant AM Al • High-temperature AM Al
In the Phase 2, QuesTek is refining these design concepts though prototype atomization and laser-powderbed fusion processing.

Warfighter Value: QuesTek's new high-performance, highly processable alloys for enhanced gearbox performance will offer enhanced production capability for helicopter gearbox housing components made by AM, leading to reduced lead-time, increased part complexity, and a broader supply chain.

WHEN

Contract Number: N00014-15-C-0158 **Ending on:** March 15, 2017

Milestone	Risk Level	Measure of Success	Ending TRL	Date
2nd Generation AM Al Alloys	N/A	Alloy design concepts and selection of alloys for evaluation	2	January 2016
Produce, build, test Gen. 2 Alloys	High	Demonstrate achievable mechanical properties and AM processability	3	December 2016
3rd Generation AM Al Alloys	Low	Alloy design concepts and selection of alloys for evaluation	2	September 2016
Produce, build, test Gen. 3 Alloys	Med	Demonstrate achievable mechanical properties and AM processability	3	March 2017
Down Select Alloy	Med	Selected alloy meets required performance goals	3	March 2017

HOW

Projected Business Model: QuesTek Innovations will obtain intellectual property (IP) for novel alloys designed and developed under this program. QuesTek will license the IP for the new alloys to alloy producers, from which QuesTek will receive royalties from sales.

Company Objectives: Due to increasing interest in new alloys specifically designed for AM and adaptation of traditional wrought and cast alloys to AM processing, QuesTek has been applying its ICME technologies and *Materials by Design*® methodology to AM alloy design and process modeling for over three years. QuesTek is actively participating in over 10 commercial- and government-funded projects focusing on alloy, process, component, and software development for a wide range of material systems and AM processes. QuesTek will further develop this technology to introduce a processable, high performance aluminum alloy to the additive manufacturing market and replace cast aluminum alloys in gear box housing and related applications. This technology will also contribute to the development of novel alloys for additive manufacturing.

Potential Commercial Applications: Initial components that could be replaced by alloys developed under this program are the oil filter manifold and tail rotor gear box housings on the Bell 407 helicopter, which are currently made from cast Mg or from cast A356 and A357 Al.
Procurement of castings is often impacted by the high cost of limited production runs, so moving to an AM-processed alloy could significantly reduce costs. Additionally, Mg experiences severe corrosion in the field and replacing Mg components with AM Al could increase the service life of components and platforms.

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