Transferring the Experience and Technology of Electric Mobility into Aircraft

03/02/2015

Auteurs: Peter Glöckner, Thomas Fiebig, Dirk Spindler

Publication: MEA 2015 More Electric Aircraft

OAI: oai:www.see.asso.fr:10638:18999

Abstract

Collection

MEA 2015 More Electric Aircraft
Authors

Peter Glöckner

Transferring the Experience and Technology of Electric Mobility into Aircraft

Thomas Fiebig

Transferring the Experience and Technology of Electric Mobility into Aircraft

Dirk Spindler

Transferring the Experience and Technology of Electric Mobility into Aircraft

Metrics

Downloaded: 68
Viewed: 14
Size: 281.13 KB
Type: application/pdf
URI: bitcache://3456cac6e2f9eb8ed0ff5e530ebc29ac26dde5ae

License

La SEE (Société de l'Electricité, de l'Electronique et des Technologies de l'Information et de la Communication – Association reconnue d’utilité publique, régie par la loi du 1er juillet 1901) met à la disposition de ses adhérents et des abonnés à ses publications, un ensemble de documents numériques accessibles à partir de son portail des publications. Ces documents incluent notamment les articles des revues REE, 3 EI et e-STA disponibles sous forme numérique ainsi que des publications additionnelles regroupées dans l’espace eREE. Les présentes conditions précisent les conditions de diffusion et d’utilisation de ces documents et des informations qu’ils contiennent. L’accès à ces documents, qu’il se fasse de façon gratuite ou dans le cadre d’abonnements ou d’achats faits à titre onéreux, implique l’acceptation sans restriction de ces dispositions.

Droits de propriété et de diffusion des contenus téléchargés sur le portail des publications
Les contenus rendus accessibles sur le portail des publications sont, en règle générale, protégés par le droit d'auteur. En tant que producteur, et le cas échéant d'auteur, des informations rassemblées dans les contenus accessibles par ce portail, SEE se réserve l'exclusivité des droits de copie et de diffusion de tout ou partie de ces contenus.

Les contenus sont rendus accessibles à titre individuel, pour les besoins de la personne en déttenant des droits d'accès en cours de validité. Aussi, la modification, la reproduction et/ou la diffusion via Internet ou le Web, intranet, extranet ou toute autre forme numérique ou imprimée, de tout ou partie des contenus téléchargés sont interdites. Une tolérance est consentie quant à la reproduction d'extraits limités de ces contenus, dans le cadre de travaux ou d'activités auxquels ils sont utiles, à la condition que l'origine de ces reproductions partielles soit mentionnée de façon lisible et sans ambiguïté. Figurent en particulier : la REE (ou toute autre revue accessible sur le portail) en tant que la source, la référence de la publication et le nom de l'auteur (s'il figure dans la revue).

Ces dispositions s’appliquent également aux figures, illustrations, logos ou images.

**Publication externe des contenus du portail des publications**

Tout extrait des contenus du portail destiné à être utilisé dans des publicités, des communiqués de presse ou du matériel de promotion nécessite un accord préalable écrit de la SEE. Une version préliminaire du document proposé contenant ces extraits doit accompagner chacune de ces demandes. SEE se réserve le droit de refuser un tel usage externe pour quelque raison que ce soit.

**Responsabilités**

La SEE apporte tout le soin possible à la préparation des informations délivrées dans les contenus produits. Cependant elle ne peut être tenue pour responsable d'aucune perte ou frais qui pourrait résulter d'imprécisions, d'inexactitudes, d'erreurs ou de possibles omissions portant sur des informations publiées, ni des résultats obtenus par l'utilisation et la pratique des informations délivrées.

**Utilisation des informations recueillies lors du téléchargement de contenu**

Le portail des publications est susceptible d'utiliser des « cookies » afin notamment de permettre l'utilisation de paniers d'achat et de personnaliser les parcours sur le site. SEE se réserve la possibilité d'utiliser les informations recueillies lors des téléchargements pour ses besoins internes et notamment pour l'amélioration de ses services, sans qu'elles puissent être cédées à des partenaires commerciaux. Conformément à la loi "informatique et libertés" du 6 janvier 1978, chaque utilisateur du portail dispose d’un droit d’accès et de rectification aux informations qui le concernent. Pour exercer ce droit, les utilisateurs doivent s'adresser à SEE – 17 rue de l’amiral Hamelin – 75783 Paris Cedex 16, par simple lettre ou en utilisant le formulaire de contact disponible sur son site.

Paris, le 28 avril 2013

**Sponsors**
Transferring the Experience and Technology of Electric Mobility into Aircraft Dr. Peter Glöckner (1), Dr. Thomas Fiebig (2), Dirk Spindler (3) 1 : FAG Aerospace GmbH & Co. KG, Georg Schäfer Straße 30, 97421 Schweinfurt, Germany, peter.gloeckner@schaefler.com 2 : Schaeffler Technologies GmbH & Co. KG, thomas.fiebig@schaefler.com, 3 : Schaeffler Technologies GmbH & Co. KG, Dirk.Spindler@schaefler.com

Abstract The civil aviation market will continue to grow with 4-5% each year within the next 20 years. In addition, the public debate on the worldwide civil air traffic is dominated by environmental und climate issues, even though only 2% of the man-made carbon dioxide (CO2) emissions are due to air transportation. Therefore, the aerospace industry will have to focus on a low-emission and quiet air traffic and on the conservation of natural resources and our environment by enabling electric-technologies - already being utilized in applications in the automotive and industrial sector - for aircraft systems. Rolling bearings are one of the components which significantly determine the reliability and mechanical efficiency of aerospace applications such as aircraft and rotorcraft engines and transmission systems. They have to withstand very demanding operating conditions. Advanced solutions in aspects of design, analysis, materials and surface technologies are required in order to meet the environmental, reliability and economical requirements of advanced aerospace bearing systems. Additionally, electromechanical or mechatronical systems already used in automotive applications are an increasing part of the development for aerospace applications. These systems should replace conventional hydraulic systems and add additional functionality, higher quality and better controllability using the experiences made within the automotive applications. The challenge is to transfer systems like a wheel-hub drive (e.g. for electric taxiing applications) or a rotation-symmetrical actuator like a roll stabilizer to the extreme constraints for aerospace applications, like space, power availability and weight. This is part of current examinations. In this contribution, highly energy efficient rolling bearing systems as well as current e-mobility development trends for automotive and industrial applications are discussed. Furthermore the transfer of these developments into aerospace applications is presented with the examples of the wheel hub motor, the roll stabilizer and linear actuations such as the planetary roller spindle drive. Aerospace Rolling Bearing Systems Advanced bearing design solutions contribute to lower friction power losses and increased system efficiency. For example, highly integrated aircraft engine main shaft bearings (cf. Figs. 1, 2, and 3) present significant weight, functional, and maintenance benefits compared to standard design bearings. This is achieved by integration of functional features such as elastic spring beam fixations (Fig. 1) or cooling channels in the outer diameter (Fig. 2). Fig. 1: Highly Integrated Mainshaft Ball Bearing For these two examples weight savings of up to 30% and power loss reductions of up to 25% are accomplished [1]. Fig. 2: Tested Main Shaft Ball Bearing featuring Oil Channels for Direct Outer Ring Cooling The trend for further functional integration is shown in Fig. 3. Starting from catalog-type bearings in the 1960’s, aircraft engine main shaft bearings developed into highly integrated shaft/bearing modules in the late 1990’s. Besides significant reductions in system weight and power loss, the integrated bearing solutions represent increased system reliability, i.e. less maintenance and overhaul. Fig. 3:The Evolution of Aircraft Engine
Mainshaft Bearings

The progress in bearing materials and surface technology development is the basis for weight and friction energy reduction in aerospace bearing systems. The further development of VIM-VAR case hardened bearing steels with increased high-temperature hardness and compressive residual stresses contribute to high-performance bearings and therefore to more compact and higher rotating aircraft engines. The recent introduction of Duplex Hardening - a method of applying a thin nitried layer to raceways and rolling elements made of conventionally hardened aerospace bearing steels - enables even higher shaft rotational speeds and temperatures equivalent to higher aircraft engine efficiency [2]. The primary attributes of a duplex hardened surface are its increased hardness accompanied by increased strength and compressive residual stresses in the near-surface layer providing more resistance and robustness against superimposed tangential stresses from high speed or contamination effects [3]. Simultaneously plastic and ceramic materials were developed throughout the last decades for low weight and energy efficient aerospace bearings. PEEK for instance - a thermoplastic typically reinforced with glass or carbon fibers - is used widespread as aerospace bearing cage material in helicopter and gearbox applications offering weight reductions of more than 80% compared to standard steel cage material. Silicon nitride is used as rolling element (ball or roller) material (Fig. 4) in so called hybrid bearings achieving further weight reductions of more than 40% compared to conventional steel rolling elements. Fig 4: Ceramic Rolling Elements (left) and Hybrid Rolling Bearings (right)

Beyond that, hybrid bearings have been proven to generate less heat and therefore operate at lower bearing temperatures [4]. This results in both increased bearing system efficiency and reliability. Fig. 5: Performance Characteristics of all-steel and hybrid bearings. The combined use of proven and reliable aerospace rolling bearing technology and newly developed e-mobility solutions will feature optimized systems for high efficient future aerospace applications.

E-Mobility Development Trends

In the context of development for e-mobility applications a variety of approaches is regarded which strongly focus mechatronic systems. On one hand there are applications which can be named as supporting systems, e.g. steering systems or leveling devices. On the other other hand there application directly used for the drive train, e.g. hybrid engines or wheel hub drives. This trend for electrification can also be regarded in the area of aerospace applications. The expected benefits are lower weight of components, a better and more accurate controllability, faster reactions, and – last but not least – less power consumption. The latter one has regarded especially in comparison with hydraulic systems wherein the needed hydraulic pressure has to be provided permanently, and that means permanent power consumption which can not be neglected. The question is, in which way, ideas, experiences, and systems already settled in or developed for automotive applications can be transferred to aerospace applications. Two examples should be regarded in detail. A strong trend within the development for electric drive concepts is the use of highly integrated wheel hub drives. The figure above shows the Schaeffler E-Wheel Drive which represents the integration of all necessary components within the space of a rim. This incudes – beside the electric engine – the power electronics as well as the control unit. Transferring this automotive application to the area of aerospace applications the so-called electric taxiing of grounded planes can be an adequate target. Using an electric taxiing system provides a lot of advantages such as less emission (noise and CO2), independence of ground support, and less fuel consumption. All of these advantages result in reduce costs for the airline. The drawbacks of such a system are the additional weight and additional electrical power during ground operation. At the end, the use of such a system has to be valued in consideration of the concrete constraints of operation and a break-even point can be determined. A special challenge of a transfer is to fulfill the technical requirements for the application "Electric Taxiing" e.g. like necessary torque, necessary power, weight, size in comparison to available space, and environmental resistance. All these issues are part of current research activities. At the end a decision for the system will be taken by the customer if the investment and the expenses during operation are significant smaller than the benefit of using this system. An example for a mechatronic system which is one of the above mentioned support applications is a roll stabilizer system. The figure above shows an example for such a roll stabilizer system. Comparable to the wheel hub drive all necessary components are highly integrated within the space of a tube. The diameter of the tube is about 90mm and the length is about 400mm. The benefit of this system is a rotation-symmetrical actuator with a usable torque range of +/- 900Nm, a high lifetime accuracy, and the possibility to measure the adjusted torque range without additional sensors. This system can be used for applications with a reduced installation space and requirements for high precision. In addition, conventional hydraulic systems may be replaced by such an actuator, saving power as well as reducing the necessity for hydraulic pipes. But fulfilling the extreme environmental constraints also remains a challenge for such kind of systems. References


https://www.see.asso.fr/en/node/18999/landing