



Development of a novel servovalve concept for aircraft

Rendicontazione

Informazioni relative al progetto

DNSVCFA

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[Sito web del progetto](#)

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Periodic Reporting for period 1 - DNSVCFA (Development of a novel servovalve concept for aircraft)

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Sintesi del contesto e degli obiettivi generali del progetto

The aim of this research was to develop a novel servo-valve concept for aerospace and industrial applications having lower complexity, lower manufacturing costs and weight, and greater reliability and efficiency compared to common servo-valve configurations. The fellow's activity alongside the

research group at the Centre for Power Transmission and Motion Control (University of Bath) was at first focused on devising such a new valve concept. The novel idea was conceived after a thorough study of the state of the art, which produced two journal papers. This novel servo-valve concept was at first studied through numerical modelling and optimisation. Afterwards, a prototype was built and tested at the fluid power laboratory of the University of Bath. Both the numerical and the experimental results show the high potential of the novel valve concept in terms of response speed, simplicity of construction and reduction of the internal leakage. The research activity has led to the publications of 7 papers in conferences and journal indexed in Scopus. The possible commercial exploitation of the valve concept, which can have a great impact on European economy and society, is being evaluated among the University of Bath, Moog and the Polytechnic of Bari.

Lavoro eseguito dall'inizio del progetto fino alla fine del periodo coperto dalla relazione e principali risultati finora ottenuti



All the planned work packages have been successfully performed, which have led to the construction of a perfectly working piezoelectric valve prototype capable of overcoming the drawbacks of commonly used two-stage servo-valves. These valves, which are widely used in aerospace and industrial sectors, present a few disadvantages that are still unsolved at the state of the art, such as the high internal leakage and hence high power consumption, and the complexity of the electromagnetic torque motor assembly, which penalizes simplicity, set-up, and manufacturing costs. The proposed architecture of piezo-valve is capable of overcoming all these drawbacks by employing a novel solution for the pilot stage, providing a notable reduction of the internal leakage through the valve, better response times and lower complexity and number of parts (hence, lower weight). This novel idea has been approved by Moog (a world leading manufacturer of servovalves and partner of this action), where the fellow carried out the planned 5 month secondment. The very good results achieved with the simulations and with the experimental tests show that the valve concept is highly viable, providing high performance while removing all the issues of typical servovalves. In addition to the achievement of the research projects, testified by the large publication record, the fellowship program allowed the fellow to become a more experienced researcher in the field of fluid power, since he also attended advanced courses at the University of Bath.

The research activity has been presented/published in:

- [1]. Tamburrano, P., Plummer, A. R., Elliott, P., De Palma, P., Distaso, E., Amirante, R. CFD analysis of the squeeze film damping mechanism in the first stage of servovalves, 74° congresso nazionale ATI, Modena 11-13 Settembre 2019, AIP (American Institute of Physics) Conference Proceedings. Forthcoming. Gold open access.
- [2]. Tamburrano, P., Plummer, A. R., Elliott, P., De Palma, P., Distaso, E., Amirante, R. Internal leakage in the main stage of servovalves: an analytical and CFD analysis, 74° congresso nazionale ATI, Modena 11-13 Settembre 2019, AIP (American Institute of Physics) Conference Proceedings. Forthcoming. Gold open access.
- [3]. Tamburrano, P., Plummer, A. R., Elliott, P., Morris, W., Page, S., Distaso, E., Amirante, R., De Palma, P. 2D CFD analysis of servovalve main stage internal leakage. Proceedings of the ASME/BATH 2019 Symposium on Fluid Power and Motion Control FPMC2019, October 7- 9, 2019, Sarasota, FL, USA. <https://doi.org/10.1115/FPMC2019-1705>. Available on Researchgate. In the

process of being made green open access.

[4]. Tamburrano, P., Plummer, A. R., Distaso, E., & Amirante, R. (2019). A Review of Direct Drive Proportional Electrohydraulic Spool Valves: Industrial State-of-the-Art and Research Advancements. *Journal of Dynamic Systems, Measurement and Control, Transactions of the ASME* 141(2), 020801. <https://doi.org/10.1115/1.4041063>. Green open access (no Embargo).

[5]. Tamburrano, P., Plummer, A. R., Distaso, E., & Amirante, R. (2018). A review of electrohydraulic servovalve research and development. *International Journal of Fluid Power*, pp. 1- 23. Received 11 Apr 2018, Accepted 08 Oct 2018, Published online: 30 Oct 2018.

<https://doi.org/10.1080/14399776.2018.1537456>. Green open access (Embargo ends: 30/04/20).

[6]. Tamburrano, P., Amirante, R., Distaso, E., & Plummer, A. R. (2018). Full simulation of a piezoelectric double nozzle flapper pilot valve coupled with a main stage spool valve. *Energy Procedia*, 148, pp. 487-494. <https://doi.org/10.1016/j.egypro.2018.08.124>. Gold open access

[7]. Tamburrano, P., Amirante, R., Distaso, E., and Plummer, A.R. (2018). A Novel Piezoelectric Double-Flapper Servovalve Pilot Stage: Operating Principle and Performance Prediction. In *Bath/ASME Symposium on Fluid Power and Motion Control FPMC 2018*, 12 - 14 September 2018, University of Bath, Bath (UK). <https://doi.org/10.1115/FPMC2018-8864>. Available on Researchgate. In the process of being made green open access.

[8]. Workshop entitled "Intelligent Fluid Power transmission And Control (IFPAC), University of Bath, Bath, UK, 2nd-5th July, 2019"

[9]. Department seminars at the University of Bath and at the Polytechnic University of Bari.

[10]. Exhibition event MECSPE at Fiera del Levante, Bari, involving lots of industries on November, 29 th 2019.

[11]. Web site: "<https://www.researchgate.net/project/Marie-Curie-Individual-Fellowship-Development-of-a-novel-servovalve-concept-for-aircraft>".

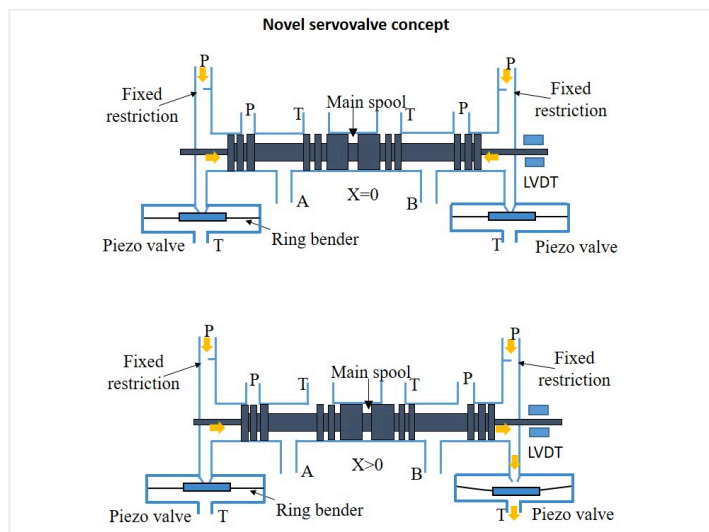
Progressi oltre lo stato dell'arte e potenziale impatto previsto (incluso l'impatto socioeconomico e le implicazioni sociali più ampie del progetto fino ad ora)

The two year's research has developed a novel architecture for servo-valves: the main advantage of this architecture is the reduction of the internal leakage, which results in power savings, and the reduction of complexity, because the torque motor with all its drawbacks is removed. The simulation results and the experimental results achieved with a valve prototype confirm that the novel idea has a high potential for real implementation in aircraft and for industrial applications. The implementation of this valve concept can have a huge impact on systems efficiency compared to conventional two stage servovalves, because the power consumption will be reduced dramatically, and even the construction times will be reduced by virtue of a simpler configuration.

The next months will be fundamental to discuss a plan for the commercial exploitation of the full valve. Given the optimum results, the valve concept has the potential to be implemented both in aircraft and in industry. With regard to the former, the ring benders need a proper coating to avoid corrosion caused by Hyjet (the oil used in Aircraft). Further studies need to be done to devise proper coating for the ring benders.

In addition to the optimum results of the research, the fellowship has been fundamental for the fellow

to improve as a researcher and to enlarge his contacts with the fluid power community, given all the conferences he has attended as a speaker, thus presenting the research to a very wide audience of researchers and professors expert in the field. Also the secondment at Moog has been fundamental for him to assume a more industry-oriented approach in his research.



novel-servovalve-concept.jpg

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