Modelling Inserts for the Assembly of Hydraulic Robotic Parts Manufactured with Carbon Fiber Composites

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HYDROïD is a full-size underdevelopment hydraulically actuated robot [1]. It is developed as a platform for scientists to better understand the human being's motion. Developing humanoids must take into consideration several aspects, but most importantly the human morphology, the lightweight requirement, and the capacity to provide high forces in low volumes. The first generation of the robot made use of a hydraulic group with external tubes circulating pressurized oil to the metallic actuators. Those tubes are the main source of leakage and a hindrance for the control. The elimination of these tubes in the second generation decreased the danger of leakage by allowing the hydraulic integration of the tubes inside the parts of the robot, it also decreased the overall weight of the robot. The manufactured robotic parts with metals are manufactured in lengthy and expensive procedure. Therefore, the third generation of HYDROïD is manufactured with a new methodology [2] that combines plastic additive manufacturing with carbon fiber composite materials. The shell design of the robotic part includes the oil passages, it is printed with plastic and then filled with random fiber composite material to reinforce it (**Error! Reference source not found.**). Applying this method to some parts, the robot acquires high power to weight, high power to volume ratios.

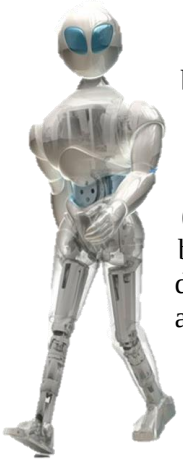

Figure 1: HYDROïD

The assembly of these parts must be non-permanent to allow for their frequent change and their assembly with the commercial components. The possible assembly methods (Commercial inserts, gluing) could not be used in our application as they risk damaging the composite material allowing for the infiltration of oil and jeopardizing the leak proof characteristic required. The development of an insert with a smooth external diameter using the Lamé's equations for thick walled cylinder assured a strong assembly, leak proof, and non-permanent [3]. A numerical simulation is conducted through MATLAB to calculate the maximum Push Through Force (PTF) that can be applied on the insert. The dimensions of the insert, its material, the carbon fiber content, and the matrix characteristics controlling the PTF are represented in the study. The suitable choice of these values explained as per the mathematical model, allows for an optimized design of the robotic composite parts.

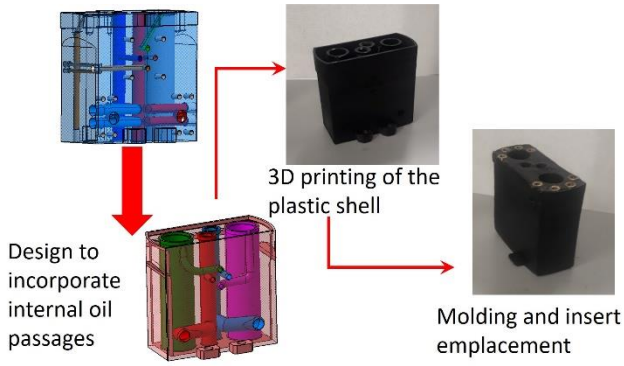

Figure 2: Design and manufacturing of the elbow part, with the incorporated modelled inserts

The design of the elbow part of HYDROïD relies on the obtained results to assemble the elbow part to the adjacent one applying this methodology. The elbow is manufactured, carbon fiber is moulded and drilled for the placements of the inserts. The modelled smooth inserts are pressed inside to allow for the assembly and leak proof functioning of the arm.

References:

[1] S. Alfayad, A. M. Tayba, F. B. Ouezdou, and F. Namoun, "Kinematic synthesis and modeling of a three degrees-of-freedom hybrid mechanism for shoulder and hip modules of humanoid robots,"

Journal of Mechanisms and Robotics, vol. 8, no. 4, p. 041017, 2016.

[2] M. El Asswad, S. AlFayad, and K. Khalil, “Experimental estimation of friction and friction coefficient of a lightweight hydraulic cylinder intended for robotics applications,” International Journal of Applied Mechanics, vol. 10, no. 08, p. 1850080, 2018.

[3] V. Vullo et al., “Circular cylinders and pressure vessels,” Stress Analysis and Design. Springer, Berlin, 2014.