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Optimization of Bifurcation Performance on Pneumatic Branched Networks in next Generation Soft Robots

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Abstract : Efficient pressure distribution within soft robotic systems, specifically to the pneumatic artificial muscle (PAM) regions, is essential to minimize energy consumption. This optimization involves adjusting reservoir pressure, pipe diameter, and branching network layout to reduce flow speed and pressure drop while enhancing flow efficiency. The outcome of this optimization is a lightweight power source and reduced mechanical impedance, enabling extended wear and movement. To achieve this, a branching network system was created by combining pipe components and intricate cross-sectional area variations, employing the principle of minimal work based on a complete virtual human exosuit. The results indicate that modifying the cross-sectional area of the branching network, gradually decreasing it, reduces velocity and enhances momentum compensation, preventing flow disturbances at separation regions. These optimized designs achieve uniform velocity distribution (uniformity index > 94%) prior to entering the connection pipe, with a pressure drop of less than 5%. The design must also consider the length-to-diameter ratio for fluid dynamic performance and production cost. This approach can be utilized to create a comprehensive PAM system, integrating well-designed tube networks and complex pneumatic models.

Keywords : pneumatic artificial muscles, pipe networks, pressure drop, compressible turbulent flow, uniformity flow, murray's law

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