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Abstract

As key components of robot hydraulic drive control system, the hydraulic pipelines (HPs) largely determine the robot performances, and thus, the selection of such components is of critical importance to robot design. In practice, however, there exists a trade-off between the respective requirements on the HPs internal structures and their stiffness properties, since a control system typically requires HPs to be as light as possible, while the breaking stresses like vibrations and pulsed pressures require HPs to be with high stiffness and strength. To help achieve a balance between such HPs requirements, we evaluate the overall stresses experienced by a simply-supported robot HP and estimate the HP fatigue life under the hybrid excitation of water-hammer waves and external vibrations for the first time, to the best of our knowledge. Specifically, we propose a non-steady flowing fluid mathematical model to describe the HP pressures based on water-hammer wave theory and solve it using the method of characteristic (MoC) first, and then present another mathematical model to integrate the external robot link vibrations into such a model. The equivalent stresses for a single-axis pipeline is calculated and its fatigue life is also estimated with this proposed model. Finally, experiments on the pipeline fracture and damage mechanics are conducted to verify the effectiveness of those models. Results show that the

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