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Numerical simulation and experimental investigation of a novel Scotch yoke for a Gifford-McMahon cryocooler

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A novel GM cycle, called as asymmetric GM cycle is proposed. In an asymmetric GM cycle, the displacer moves slowly when it is close to the upper dead point, but moves rapidly when it is close to the lower dead point. Therefore, the expansion process is longer, while the discharging process is shorter than that in a conventional GM cycle. Meanwhile, the duration of the charging process can be kept the same as that in a conventional GM cycle. Accordingly, the phase shift between the pressure and the displacement can be improved, and the mass flow rate into the expansion space can also be increased. Therefore, the P-V work and the cooling capacity can be increased. In order to realize the novel GM cycle, a novel Scotch yoke is invented. In the novel Scotch yoke, there is a concave part at the upper center of the slide groove and a convex part at the lower center of the slide groove. The effect of the novel Scotch yoke has been confirmed by numerical simulation and experimental investigation. With a conventional Scotch yoke, the cooling capacity is 44 W at 37.4 K at the first stage and 1.0 W at 3.94 K at the second stage. With a novel Scotch yoke, the cooling capacity is 44 W at 35.9 K at the first stage and 1.0 W at 3.96 K at the second stage. The cooling capacity at the first stage at 40 K is improved by about 10%, from 51.5 W to 57.3 W.

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