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Subsonic flows passing a duct for three-dimensional steady compressible Euler systems with friction. (Chinese. English summary) [Zbl 07494979]

Summary: This paper studies steady motion of gas in a rectilinear duct with square cross-sections, governed by the three-dimensional (3-d) non-isentropic compressible Euler equations with a friction term. Such flows are called Fanno flows in engineering. We construct respectively special subsonic flows, supersonic flows and transonic shocks in the duct. Since the 3-d steady compressible Euler equations are of quasi-linear hyperbolic-elliptic composite type for subsonic flows, and there is no general theory up to now, we formulate a boundary value problem arising from studies of transonic shocks, and prove the well-posedness of this problem by showing that the special subsonic flows constructed above are stable under small multi-dimensional perturbations. The proof depends on separation of the elliptic and hyperbolic parts in the Euler equations, and designation of a suitable nonlinear iteration scheme. Particularly, there are strong interactions between the elliptic part and the hyperbolic part due to the appearance of friction, and we deduce a linear mixed boundary value problem of a second-order elliptic equation with an integral-type nonlocal term. Its well-posedness is established by applying methods of Fourier analysis and regularity theory of second-order elliptic equations.

MSC:
35M32 Boundary value problems for mixed-type systems of PDEs
35Q31 Euler equations
76G25 General aerodynamics and subsonic flows
76N10 Existence, uniqueness, and regularity theory for compressible fluids and gas dynamics

Keywords:
steady Euler system; subsonic flow; Fanno flow; nonlocal elliptic equations; system of hyperbolic-elliptic composite type

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