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Generalized One-Dimensional Flow Inside Thermo-Electrically Controlled Micronozzle

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ABSTRACT

Flow inside micronozzles suffer from low efficiencies due to low Reynolds numbers. Present study go straight to solve the generalized Quasi-One Dimensional flow equation inside micronozzle numerically considering the heat supplied and removed to the subsonic and supersonic flow, respectively. The technique used to supply heating upward the throat then supply cooling downward the throat is new, thermoelements are used as nozzle walls and the electrical current forces the heat to move from cold side to hot side inside the thermoelement depending on Peltier concept. Heating the subsonic flow upward the throat then cooling supersonic flow downward the throat accelerate the flow and then improve the thermal efficiency of the nozzle.

1. INTRODUCTION

The effects of area change, of friction and of heat transfer on compressible flow have been separately considered in the literature. Brief attention was given to some situations in which at least two of these effects had to be simultaneously considered, e.g. variable area adiabatic flow with friction, variable area frictionless flow with heat transfer [[7]], and one dimensional flow with both friction and heat transfer were considered. Shapiro [[9]] solved one dimensional flow inside circular pipe and gave the examples for combined effects when happen simultaneously: friction with area change for adiabatic flow, and also he solved the example of combined friction with heat transfer.

The mass addition or removal may be associated with the use or a porous wall though which the gas passes, or it may be a way of modeling a combustion process, e.g., when considering the flow in the combustion chamber of a solid-fueled rocket engine there is at the walls, i.e., at the surface of the propellant, an effective injection of gas into the flow as a result of the combustion. So attention must be given to all of these effects when they can happen simultaneously. Present study deals with convergent-divergent nozzle have one or two other effects in addition to change area effect. Adding or removing heat to the flow across the nozzle wall or electro-resistor fins or even by combustion inside nozzle happens actually in mostly applications. However, combining two effects has been involved in the previous work, the third effect is expected to role an important in the new technologies in addition to solving two effects with more complexity, for example, heating upward and cooling downward in a convergent divergent nozzle. Micro nozzles analyzing differs from macro nozzle analyzing, Reynolds number is changed decreasingly due to minimizing the characteristic length of the flow region, sequentially the friction increases and it effects significantly nozzle efficiency. The characteristics of the flow will be changed and need to more analyzing.

2. FLOW ANALYSIS

2.1 Raylich flow

If heat is added to the flow, the Mach number tends towards 1 while if heat is extracted from the flow, the Mach number moves away from 1 in both subsonic and supersonic flow, i.e., heating