# Accepted Manuscript

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PII: S0360-5442(18)31261-1

DOI: 10.1016/j.energy.2018.06.196

Reference: EGY 13238

To appear in: *Energy* 

Received Date: 3 January 2018

Revised Date: 26 June 2018

Accepted Date: 27 June 2018

Please cite this article as: Bian J, Cao X, Yang W, Edem MA, Yin P, Jiang W, Supersonic liquefaction properties of natural gas in the Laval nozzle, *Energy* (2018), doi: 10.1016/j.energy.2018.06.196.

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## ACCEPTED MANUSCRIPT

#### Supersonic liquefaction properties of natural gas in the Laval nozzle

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Abstract: In view of the excellent performance of the supersonic separator for natural gas 10 dehydration, a new type of natural gas liquefaction process using the Laval nozzle is 11 proposed in this paper. Theoretical and numerical studies of the supersonic flow and 12 liquefaction process of the methane-ethane binary system in this nozzle are carried out. The 13 effects of the inlet temperature, inlet pressure, back pressure and component composition on 14 the liquefaction process are analyzed. The results show that the critical liquefaction 15 temperature and pressure of the methane-ethane binary system decrease under low inlet 16 temperature or high inlet pressure conditions and the range of the liquid phase region 17 18 increases, which promotes the liquefaction process. With the increase of the back pressure of the nozzle, the position of the shock wave moves forward and the liquefaction environment is 19 more completely destroyed. For a multi-component natural gas, in which the heavy 20 hydrocarbon content is high, natural gas is more easily liquefied using the Laval nozzle. The 21 22 liquefaction efficiency range of the newly designed liquefaction process with the Laval nozzle are 0.0795-0.1321 (HYSYS results) and 0.0718-0.1505 (MATLAB results) when the 23 24 inlet pressure of the process is 2-5 MPa. The nozzle more easily achieves liquefaction compared with a throttle under the same conditions. 25

26 Key words: Natural gas; liquefaction; Laval nozzle; supersonic; phase envelope

### 27 **1 Introduction**

A supersonic separator combines expansion cooling and centrifugal separation in a single compact device with no chemical requirement [1]. It has been introduced to treat natural gas for condensing and separating water and heavy hydrocarbons due to its advantages of being smaller, lighter, and less expensive as well as having fewer emissions than the conventional dehydration technology [2-4]. The first team known to carry out research on supersonic separators was an engineering group from the Netherlands named Download English Version:

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