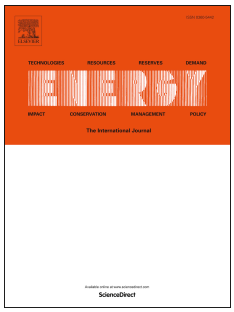
Accepted Manuscript



Supersonic liquefaction properties of natural gas in the Laval nozzle

Jiang Bian, Xuewen Cao, Wen Yang, Mawugbe Ayivi Edem, Pengbo Yin, Wenming Jiang

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.

Supersonic liquefaction properties of natural gas in the Laval nozzle

Jiang Bian [a,b], Xuewen Cao [a,b *], Wen Yang[c], Mawugbe Ayivi Edem [a,b], Pengbo Yin [a,b], Wenming Jiang[a,b]

([a]College of Pipeline and Civil Engineering, China University of Petroleum (East China), Qingdao 266580, China; [b]Shandong Provincial Key Laboratory of Oil & Gas Storage and Transportation Safety, Qingdao 266580, China; [c]South China Branch, Sinopec Sales Co., Ltd., Guangzhou 510620, China)

*Corresponding author at: College of Pipeline and Civil Engineering, China University of Petroleum (East China), Qingdao 266580, China.

E-mail address: caoxw@s.upc.edu.cn (X. Cao).

Abstract: In view of the excellent performance of the supersonic separator for natural gas dehydration, a new type of natural gas liquefaction process using the Laval nozzle is proposed in this paper. Theoretical and numerical studies of the supersonic flow and liquefaction process of the methane-ethane binary system in this nozzle are carried out. The effects of the inlet temperature, inlet pressure, back pressure and component composition on the liquefaction process are analyzed. The results show that the critical liquefaction temperature and pressure of the methane-ethane binary system decrease under low inlet temperature or high inlet pressure conditions and the range of the liquid phase region 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 more completely destroyed. For a multi-component natural gas, in which the heavy hydrocarbon content is high, natural gas is more easily liquefied using the Laval nozzle. The 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 inlet pressure of the process is 2-5 MPa. The nozzle more easily achieves liquefaction compared with a throttle under the same conditions.

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

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