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Leakage and Diffusion Behaviour of a Buried Pipeline of Hydrogen-Blended Natural Gas

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Abstract

Buried Channels are one system of conservation transfer for extensively used feasts similar as natural gas and hydrogen. The safety of these channels is of great significance because of the implicit leakage pitfalls posed by the ignitable gas and the special parcels of the hydrogen admixture. Estimating the leakage geste and quantifying the prolixity range outside the channel are important but grueling pretensions due to the hydrogen admixture and presence of soil. This study provides essential information about the prolixity geste and attention distribution of underground hydrogen and natural gas admixture leakages. Thus, a large- scale experimental system was developed to pretend high- pressure leaks of hydrogen admixture natural gas from small holes in three different directions from a channel buried in soil. The prolixity of hydrogen- unravel natural gas in soil was experimentally measured under different conditions, similar as different hydrogen admixture rates, release pressures, and leakage directions. The experimental results vindicated the connection of the gas leakage mass inflow model, with an error of6.85. When a larger proportion of a single element was present in the hydrogen- unravel natural gas, the leakage pressure showed a lesser prolixity range. In addition, the prolixity range of hydrogen- unravel natural gas in the leakage direction was larger at 3o'clock than that at 12o'clock. The hydrogen mix carried methane and diffused, which docked the methane achromatism time. Also, a quantitative relationship between the attention of hydrogen- unravel natural gas and the prolixity distance over which the hydrogen- unravel natural gas reached the lower limit of the explosion was attained by quantitative analysis of the experimental data.

Keywords: Buried pipelines; Natural gas; Hydrogen; Leakage behavior; Diffusion range

Introduction

One of the stylish campaigners to break the problem of energy storehouse is the product of hydrogen from redundant electricity created substantially from renewable sources. The hydrogen therefore produced can be fed into being natural gas networks, but with preventives because hydrogen changes significantly the physical parcels of the gas admixture. The accoutrements used in the hydrogen conflation and storehouse systems are perfecting fleetly. The European Commission's communication "A Hydrogen Strategy for a Climate-Neutral Europe" was published in July 2020, which highlights the crucial precedence of hydrogen in achieving the EU's 2050 decarbonisation targets. In the unborn hydrogen is anticipated to play a significant part in bridging the current gaps in renewable energy storehouse and, in addition to reducing GHG emigrations, in compensating for seasonal oscillations in energy requirements. Is the needlessness of new structure construction, this significantly reduces investment costs. In order to achieve climate impartiality, a number of transnational hydrogen systems have been launched in recent times. These have examined the possibility of producing, transporting and distributing of hydrogen, as well as the hydrogen forbearance of presently available gas appliances. When probing the blending of hydrogen in natural gas networks, all exploration agree that the operating network is suitable for small-scale hydrogen uptake, but there are a number of critical issues in the content due to the material and energy parcels of hydrogen. The thing of the Hyde ploy design, for illustration, was the determination of the maximum hydrogen bit that can safely be fed into the natural gas grid without the need to modify consumer outfit. Grounded on their tests the maximum hydrogen content allowed was 15 by volume [1]. The ideal of the H21 Leeds City Gate design was to support the feasibility and profitable viability of a civil hydrogen switchover, and to examine the feasibility of using pure hydrogen in the Leeds natural gas network from both a specialized and profitable point of view. Grounded on their rearmost results, PE pipe material had been set up to be the most suitable material for hydrogen in the distribution network. The French GRHYD design aims to determine the maximum proportion of hydrogen that can be mixed into the distribution network without modifying the available gas appliances. During the tests a outside of 20 of hydrogen by volume rate was achieved. The HIPS- NET design's ideal was the determination of hydrogen forbearance of being natural gas networks. The design was completed in 2018, it set up that the maximum hydrogen rate that can safely be mixed into natural gas networks is 10 by volume. This hydrogen- content didn't need any revision of distribution network rudiments nor consumer outfit. The h2howi design focuses on the specialized feasibility of converting a natural gas channel for pure hydrogen distribution. The possibilities of transporting and distributing pure hydrogen are being delved. The HIGGS design, launched in 2020, was aimed to study the goods of hydrogen on the high- pressure natural gas transmission network. Results are anticipated in December 2022. The thyga design investigates the goods of hydrogen on gas consuming appliances. Grounded on the results the presence of hydrogen in the natural gas can reduce emigrations, but the combustion characteristics of the gas change unfavourably with adding hydrogen content, compared to the pure natural gas case. According to their tests, honeyre-ignition occurs at hydrogen content [2].

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Samples and methods

Grounded on the principle of well position dissipation and drilling and logging data, 69 representative natural gas samples and 11 forces solid asphalt samples were collected in the typical gas budgets in the Lower Triassic Feixianguan conformation and 38 source gemstone samples were collected in the typical structures in the Upper Permian Changing and Longtan conformations. To minimize the impact of air pollution and slice on data dimension, strict processing measures were demanded during natural gas slice A high- pressure sword cylinder with double faucets and ananti-H2S erosion- resistant coating was named for slice. Vacuum outfit was used topre-pump the slice cylinder before slice, and the vacuum position was at least 10 −3Pa [3]. The cylinder was constantly washed 4 – 6 times with natural gas in the high- pressure font during slice and eventually tried in the middle part of the nonstop gas inflow. The natural gas samples were tested for natural gas composition, hydrocarbon isotope composition and noble gas isotopes. The source jewels and force asphalt samples were tested for chloroform bitumen “A” and group element carbon isotopes and GC/ MS studies for impregnated hydrocarbons. The tests were completed in the Key Laboratory of Natural Gas Accumulation and Development, China Petroleum Exploration and Development Institute [4].

1) Natural gas factors were anatomized with a Inheritor 456- GC gas chromatograph (Original manufacturer Tianmei Yituo, USA), with high- chastity helium as the carrier gas, and tested with a double TCD sensor. The carbon and hydrogen isotopes of the natural gas were tested on a Finnigan MAT- 252 M (Original manufacturer Finnigan Mat, Germany). The carbon and hydrogen contents of each element were calibrated to the transnational standard (VPDB and V- SMOW, independently), and the standard divagation was 3‰.

2) The noble gas isotope test standard was SY/ T 7359 – 2017(oil painting and gas assiduity norms of the People’s Republic of China); the experimental terrain was room temperature 20 – 25 °C and relative moisture< 70. The experimental process was divided into the following way. First, the natural gas cylinder was connected to the device injection harborage through a pressure reducing stopcock, and the mechanical pump, molecular pump and ion pump were used to void the system. Second, the zirconium- grounded furnace was hotted to 690 °C for 30 min and also cooled to 350 °C [5]. Third, the injection volume of natural gas samples was controlled by an injection control stopcock and vacuum hand. Fourth, the active gas in natural gas samples was purified with a zirconium- grounded furnace and also amended with rare gas. Fifth, liquid nitrogen was used to separate the He, Ne, Ar, Kr and Xe factors grounded on the different boiling points of these rare feasts. Eventually, He and Ar were consecutively transferred to a rare gas isotope mass spectrometer in a static vacuum for isotope analysis.

3) The experimental terrain for GC/ MS studies of the impregnated hydrocarbons was a temperature of 25°C and relative moisture of 57. The experimental process was divided into the following way. First, the shells of the samples were defiled and crushed to 0.125 mm. Also, the carbon isotopes of the sample excerpts were anatomized after Sechelt birth (chloroform) for 72h. Alternate, asphalting was separated with n- hexane. Impregnated hydrocarbons, sweet hydrocarbons and no hydrocarbon factors were separated consecutively with a silica gel alumina chromatography column and detergents of different oppositeness. Third, the carbon isotopes of each group of factors were tested [6]. Eventually, the impregnated hydrocarbons were anatomized by an Agilent 6890N GC (Original manufacturer Agilent Company, USA) and an Agilent 5977A GC- MS (Original manufacturer Agilent Company, USA). The conditions for GC/ MS were as follows the carrier gas was high- chastity helium with a inflow rate of 1 ml/ min. An HP-5MS (60 m ×0.25 mm ×0.25 μm) column was used with an EI source. The temperature was increased from 100 °C to 120 °C at a rate of 10 °C/ min, to 250 °C at a rate of 4 °C/ min, also to 300 °C at a rate of 1 °C/ min, and held for 40min [7].

Experimental results

Geochemical characteristics of natural gas

Characteristics of natural gas compositions

There were great differences in the relative contents of natural gas factors in different gas budgets of the Feixianguan conformation in the ESB. According to the bracket scheme for H2S gas budgets developed by Dai (1985), the gas budgets of the Feixianguan conformation in the study area were divided into two orders H2S-rich gas budgets (H2S content lesser than 2) and H2S-poor gas budgets (H2S content lower than 2). The H2S-rich gas budgets are extensively distributed east of the Kaijiang- Liangping trough. The methane content in the hydrocarbon gas ranged from 71.160 to 92.417, with a normal of 79.225. The ethane content ranged from 0.020 to0.215, with a normal of 0.057. The heavy hydrocarbon contents of propane and over were nearly undetectable. The drying measure of natural gas was lesser than99.700, with a normal of 99.882, which indicated that it belongs to a typical dry gas force. The content of no hydrocarbon feasts was high and substantially included H2S and CO2, in which the content of CO2 was between 0.460 and 18.030, with a normal of 7.633. The H2S content ranged from 2.020 to17.760, with a normal. In addition, the no hydrocarbon feasts contained small quantities of N2, He, and H2 **[8]**

Characteristics of carbon isotopes

The natural gas of the Feixianguan conformation in the ESB was dry gas, and utmost samples had little propane content. Thus, only the carbon isotopes of methane and ethane could generally be measured, and only methane could be measured in some sample. The results showed that the distribution of δ13c1 values for natural gas in the Feixianguan conformation was fairly concentrated, and there was no significant difference between H2S-rich gas budgets and H2S-poor gas budgets. The δ13c1 values of H2S-rich gas budgets were between−33.50‰ and−28.90‰ and were substantially distributed between −32‰ and −29‰. The δ13c1 values of H2S-poor gas budgets were between−33.80‰ and−28.63‰ and were substantially distributed between −33‰ and −30‰. The distribution of δ13c2 values was fairly wide. The δ13c2 values of the H2S-rich gas orce were−32.40‰ ~-26.81‰, with normal of−28.94‰, and those of the H2S-poor gas budgets were−37.00‰ ~-26.93‰, with a normal of−33.44‰. There was a significant difference between the two gas budgets [9].

Geochemical characteristics of reservoir asphalt

The distributions of n- alkanes were generally complete in the asphalt samples of the Feixianguan conformation budgets in the ESB, and the carbon figures were nc12- nc34. There was no egregious “barrel package” (“ UCM ”, Unresolved Complex Admixture) in the birth for alkane chromatography, indicating that there was no significant biodegradation [10]. The distribution of n- alkanes generally showed a “single peak and post-peak” with the main carbon peak near nc24. The σnc21 −/ σnc22 value was 0.01 −1.43, with an average value of 0.22. The Pr/ Ph value was 0.37 −0.67, with a normal of 0.54. The pr/ nc17 was 0 −0.67, with a normal of 0.45. The Ph/ nc18 ranged from 0 to 0.83, with a normal of 0.45. The C35H – 22S/ C34H – 22S values were 0.43 −0.81, with a normal of 0.57. Ts (Ts Tm) ranged from 0.31 to 0.53, with an normal of0.44. The gammacerane indicator (Ga/ C30H) was0.06 −0.36, with a normal of0.21. The distribution of ααα20r – C27, C28 and C29 regular steranes was the "V" type, and the C29 regular sterane proportion was slightly larger than the C27 regular sterane proportion [11]

Conclusions

The disquisition of hydrogen blending to the high pressure natural gas transmission system is of great significance, since the global trends towards carbon impartiality specify the energy storehouse in hydrogen a doable option. Since the parcels of hydrogen differs greatly from the natural gas, the effect of hydrogen amalgamation must be examined in detail. The natural gas transmission system drivers are interested in maintaining the current operating conditions of the network as the hydrogen content is increased in the gas admixture.

The increase of outturn capacity of the channel due to hydrogen amalgamation under identical pressure conditions is quantified. The change in compressibility factor is considered in the computations presented.

The transmittable energy content decreases if hydrogen is mixed with the natural gas, a relative index the transmittable energy factor (TEF)- is defined to quantify the change from the pure natural gas case.

A new practical equation is developed that directly provides the value of TEF of a gas transmission channel, that depends on the average pressure, temperature and the hydrogen content of the gas admixture.

The change in power demand of the contraction is delved in detail. As hydrogen is mixed to the natural gas both the change in transmittable inflow rate and a advanced hydrogen attention increases the needed contraction power. Since the energy capacity diminishments due to hydrogen amalgamation the relative contraction power is increased by 260 if pure hydrogen is transferred.

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