煤层气利用新方案

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摘　要　在介绍煤层气的常规利用方案的基础上, 提出了两种利用煤层气的新方案: 一是采用变压吸附技术, 纯化瓦斯气, 将低浓度瓦斯气浓缩为高浓度瓦斯气, 加压后成为 CNG, 用作 CNG 气源或较远距离城市的天然气气源; 二是在第一种方案的基础上, 将高浓度瓦斯气全部采用深冷法加以液化, 生产 LNG, 并将 LNG 运送至更远距离用作 LNG 加气站、CNG 加气站气源。最后还以松藻煤电公司为例, 作了新方案的工程预算。

主题词　煤成气　变压吸附　浓缩　压缩天然气　液化天然气　气源　加气站

一、煤层气的常规用途

煤层气综合利用价值很高, 除民用外, 可用于燃气轮机发电、供热、作动力燃料, 还可做甲醇、合成氨等化工产品, 也是农药、医药、染料等有机化工产品的基础原料。一般从生产矿区的采空区抽出的煤层气浓度较低, 并含有较多的杂质, 而在未开采地区采用地面钻井生产的煤层气浓度高、质量好。中等质量的煤层气适合当地民用或供井口瓦斯电厂。高质量的煤层气适合进入天然气管道系统, 输送到远方用户, 供应其他大城市居民、大电厂、化肥厂和化工厂使用。目前国内对煤成气的利用基本上有两种途径: 一是作为矿区周围居民燃料使用或者作为矿区发电用燃料; 二是作为化工原料, 如利用煤层气生产碳黑等化工产品。

图 1 是煤层气的常规利用方案流程示意图。

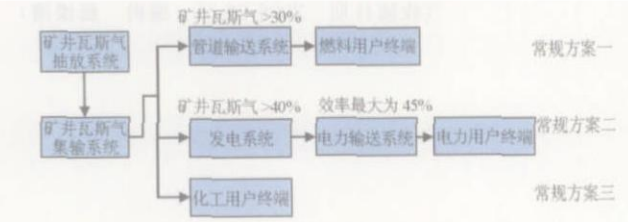

图 1　现有煤层气利用工艺流程示意图

(1) 常规方案一的矿井气的 CH_4 浓度必须高于 30%, CH_4 含量低于 30% 的矿井气必须排放, (而 CH_4 温室效应很强, 比 CO_2 作用大 21 倍。甲烷排入大气, 不仅因其温室效应将引起气候异常, 而且还消耗大气平流层的臭氧, 它对臭氧层的破坏能力是 CO_2 的 7 倍)。如果直接供应家庭用户, 因普通的矿井气不能和天然气互换, 需要用和天然气不一样的计量器具、灶具、管网和其他用气设备。如果用户以前采用的是天然气为燃料, 必须更换计量器具、灶具、管网等。

(2) 常规方案二矿井气用于发电, 可采用往复式发动机、燃气轮机、汽轮机、联合循环系统。但是能够采用的甲烷含量需要更高, 例如采用燃气轮机发电必须使用高达 40% 的 CH_4 含量的煤层气。但是采用优质能源用于发电, 经济效益和环境效益都相当不划算。

二、煤层气利用新方案

考虑到以上方案对煤层气这种优质能源的利用的不充分, 笔者提出了以下 2 种新的利用方案, 方案中涉及到变压吸附和液化天然气, 简述如下。

变压吸附(Pressure Swing Adsorption, 简称 PSA) 是吸附分离技术中的一项用于分离气体混合物的技术。现已广泛应用于化工、石油化工、钢铁、冶炼、电子、金属热处理、啤酒等领域。吸附是指: 当两种相态不同的物质接触时, 其中密度较低物质的分子在密度较高的物质表面被富集的现象和过程。具有吸附作用的物质(一般为密度相对较大的多孔固体) 被称为吸附剂, 被吸附的物质(一般为密度相对较小的气体或液体) 称为吸附质。变压吸附是因

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压力不同而吸附剂吸附性能的差异来选择性吸附进行气体分离的过程。据煤层气中 CH_4、N_2、O_2 物理特性的不同, 采用合适的吸附剂和合适的压力达到提纯煤层气中的 CH_4 成分。

液化天然气(LNG)是天然气经过净化处理、低温液化后的液体天然气,体积仅为原来的1/625,比天然气更清洁、热值更高,在储存、运输、贸易和应用等方面更有优势,在天然气产业的发展过程中,液化天然气将是重要的组成部分。

1. 方案1

采用变压吸附技术,纯化瓦斯气,将低浓度瓦斯气浓缩为高浓度瓦斯气(高浓度瓦斯中的 CH_4 含量接近于天然气,原则上可与天然气互换而无需改变天然气用户的表、灶具、管网和其他用气设备,也可以用作CNG汽车加气站的气源,售价可相应下降一点)。除在矿区及周边地区发展CNG加气站外,剩余部分的产品气可管输至离矿区临近的一些无天然气气源的小城镇发展民用气及CNG加气站,最远端可并入远距离城市的天然气储配站,作为天然气的补充气源。

此方案流程示意图见图2。此方案的优点是:将长输低热值燃气改为短输高热值燃气,从而可大幅度减少工程投资,大幅度缩短工期,无需更换原有天然气片区管网和用户灶具,同时扩大了瓦斯气的用途(可用于CNG加气站)。与加压含氧量较高的低浓度瓦斯气相比,加压含氧较低的高浓度瓦斯气在经济性和安全性方面要好得多。

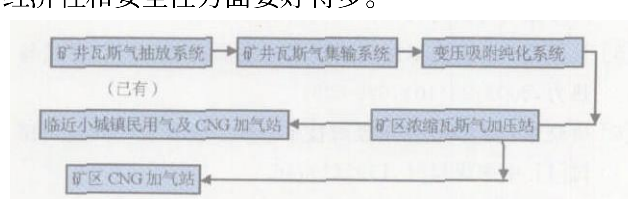

图2　方案1流程示意图

该方案采用低温工艺,基础投资大,在分离大量气流时经济效益才特别显著。但是工艺技术正处于不同的研究和开发阶段,它们也可经济地用于处理 $30\times10^4 m^3/d$ 以下气流。采用该方案生产出的产品可以在更大范围使用,将获利更多。

2. 方案2

利用变压吸附技术,纯化瓦斯气(第一步与方案1相同);第二步将高浓度瓦斯气全部或大部分采用深冷法液化,生产液化天然气,尔后再将液化天然气用LNG槽车运送至LNG加气站、CNG加气站和民用天然气储配站的LNG储槽。在LNG加气站可直接向LNG汽车加气(无需加压);在CNG加气站及民用储配站需汽化后使用。LNG在汽化过程中吸热作用强烈。可处理 $30\times10^4 m^3/d$ 以下气流。采用该方案生产出的产品可以在更大范围使用,将获利更多。

增设冷库或冷食品加工厂以回收冷量节能。甚至可以利用LNG的冷量建设空分站(俗称氧气站),生产氧气、氮气、液氧、液氮、液氩以期获得更大的经济效益。

此方案的流程示意图如图3。此方案的优点是:用槽车输送LNG产品,无需再建管输系统,将工程的环境影响降低至最小,工程投资相对长输方案也较低,建设工期相对也较短,见效快,受益地区可以更远(数百至上千公里),经济效益有可能更好。特别是可能为发展LNG汽车开辟了广阔而光明的前景。

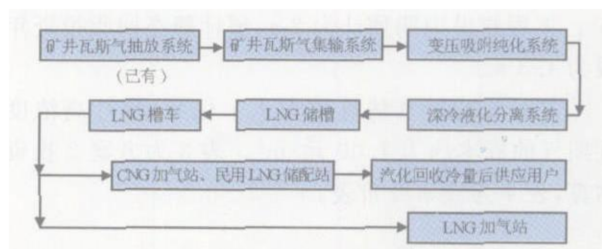

图3　方案2流程示意图

三、方案应用

尽管笔者提出的新方案投资较高,但是效益显著。我们以重庆地区的松藻煤电公司为例,作了新方案的工程预算。松藻煤电公司位于重庆市綦江县打通镇,是西南最大的动力煤生产基地,瓦斯储量 $223\times10^8 m^3$(折合甲烷,下同),近3年瓦斯抽采量均超过 $1\times10^8 m^3$,并且每年以 $2000\times10^4 m^3$ 的速度增长,去年的抽放量已经达到 $1.2\times10^8 m^3$。但瓦斯利用效果不理想,目前,该公司每年瓦斯的利用率不高,仅用于矿区内居民煮饭、洗澡及取暖等。

由于目前川渝地区民用天然气发展很快,再加上CNG汽车加气站的加速发展,天然气供应年缺口达 $10\times10^8 m^3$ 之多。如何开发和利用好松藻煤电公司及重庆周边其他高瓦斯煤矿的煤层气,具有极为重要的经济意义和良好的市场前景。同时,此项目的实施还有良好的社会效益和环境保护效益。

本方案的投资估算约为1.3亿元,预计高浓度瓦斯气的成本约为0.55元/m^3。表1为方案1投资估算,表2为成本分布表。

表 1　方案 1 投资估算表

投资细目名称	投资费用(万元)
矿区地面集输及纯化设施	6000
输气管网(外送部分)	3000
储配设施	3000
设计费用	400
其他费用	600
合　计	13000

表 2　方案 1 成本估算表

成本细目名称	成本(元/ m^3)
矿井气成本(进气价, 按纯瓦斯计)	0.27
纯化浓缩成本	0.1
管输成本	0.1
管理成本	0.08
合　计	0.55

预计平均售价为 1.10 元/ m^3, 利税为 0.55 元/ m^3。工程建设周期预计为 2 a, 预计静态回收投资年限为 4.3 a。

方案 2 的投资估算约为 1.7 亿元, 预计高浓度瓦斯气的成本约为 1.00 元/ m^3。表 3 为方案 2 投资估算, 表 4 为成本分布表。

表 3　方案 2 投资估算表

投资细目名称	投资费用(万元)
矿区地面集输及纯化设施	6000
深冷液化系统	4000
储配设施	3000
专用运输车辆	3000
设计费用	500
其他费用	500
合　计	17000

表 4　方案 2 成本估算表

投资细目名称	成本(元/ m^3)
矿井气成本(进气价, 按纯瓦斯计)	0.27
纯化浓缩成本	0.1
深冷液化成本	0.5(折合气态)
运输成本	0.11
管理成本	0.02
合　计	1.00

预计液化天然气平均售价为 1.8 元/ m^3, 利税为 0.80 元/ m^3。工程建设周期预计为 2 a, 预计静态回收投资年限为 3.88 a(未将冷量回收效益计算在内, 如计入将缩短投资回收年限)。

值得提出的是: 由于新方案中加入了矿井气的纯化工艺, 从而使混合瓦斯气中甲烷含量大于 20% 的都可能使用(而甲烷含量介于 20%～30% 的混合瓦斯气占总的混合瓦斯气的比例是相当高的)。这带来更大的经济效益。

新方案涉及的各技术环节均为成熟工艺。已有先例, 不存在重大技术难题。

由于煤层气利用属于利用归类为节能、环保、安全和综合利用项目, 国家在政策上有所支持。在“十五”规划纲要中, 政府已将煤层气列入了能源发展规划, 对煤层气开发利用提供财政支持和政策优惠, 为此可能在进气价、税收等方面能够主动争取到一些优惠政策。

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NUMERICAL SIMULATION OF FLAMMABLE PIPE GAS EXPLOSION INHIBITION WITH INERT GAS

Chen Siwei, Du Yang (PLA Logistic Engineering Institution). *NATUR. GAS IND.* v. 26, no. 10, pp. 137-139, 10/25/2006. (ISSN 1000-0976; **In Chinese)**

ABSTRACT: The study of the flammable gas explosion in pipeline has great significance. The turbulent model of explosion is founded on the basis of the single-step chemistry reaction. The RNG model is adopted. According to the high rate of reaction and the turbulence phenomena, EBU-Arrehnius combustion model is applied. The governing equations of flow and the reaction equations are solved simultaneously (i.e., coupled together) by the finite volume method (FVM). Process and law of explosion inhibition of flammable gas by inert gas in two-dimension pipe is studied by numerical simulation. The results were well in line with experiment date which can provide theory foundation for process implementation, system design and key parameter calculation of the explosion-proof technology with inert gas.

SUBJECT HEADINGS: oil and gas, pipeline, flammable gas, explosion, inhibition, inert gas, numerical simulation

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APPLICATION OF WEBGIS TO NON-HEAVY GAS CLOUD DIFFUSION SIMULATION

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ABSTRACT: A B/S model web geographic information system (WebGIS) can be set up by integrating computer technology, internet technology and geographic information system. With the application of Gaussian model, the diffusion of non-heavy gas cloud, taking place in instantaneous leak and continuous leak accidents, was simulated in the WebGIS system. By showing the concentration contours of leak gas on an e-map, the distribution and the influence of the gas around the leak source can be visualized. Finally, an engineering case is applied to verify the feasibility of the system and the operation result of the system is shown. It can be concluded that professional information support can be provided to the daily management, accident prediction and emergency planning of the non-heavy gas via combining GIS with numerical simulation of non-heavy gas diffusion.

SUBJECT HEADINGS: geographic information system (GIS), gas cloud, diffusion, simulation, Gaussian model, instantaneous leak, continuous leak

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NEW PROPOSAL FOR COALBED METHANE UTILIZATION

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ABSTRACT: Based on the conventional coalbed methane (CBM) utilization proposal, two new CBM utilization proposals were put forward. The first is pressure wwing adsorption technology (PSA). PSA technology can be used to enrich low-concentration CBM to high-concentration CBM. Then, CBM can be compressed and converted to CNG, which can be served as gas source for CNG or gas source for remote cities. The second is based on the first one. The high-concentration CBM can be liquefied to produce LNG with deep refrigeration method. The LNG resources can be served as gas resources for LNG stations and

CNG stations which are located in remoter places. Songzao C&E Co., Ltd. was taken as an example to perform project budget for the two new proposals.

SUBJECT HEADINGS: coalbed methane (CBM), pressure wwing adsorption technology (PSA), compression, compressed natural gas (CNG), LNG, gas source, gas station

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INFLUENCE OF PORE STRUCTURE OF ACTIVATE CARBON WITH HIGH SURFACE AREA ON ADSORPTION OF METHANE AND CARBON DIOXIDE

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ABSTRACT: Activated carbon with high specific surface area not only has good adsorption storage capacity, but also has excellent gas separation and purification performance. Adsorption isothermal line of methane and carbon dioxide at 298K on three kinds of activated carbons was measured. A method based on the simplified local density theory was applied in calculating the pore size distribution of the activated carbons. Adsorption properties on both methane and carbon dioxide of the three carbons were quite different because of their various pore size distributions, although they almost have the same BET surface area (ranging from 2073 m^2/g to 2123 m^2/g). It was shown that sample K17 was more suitable for adsorption storage of methane, and the three carbon samples had great potential application in the adsorption separation of methane and carbon dioxide.

SUBJECT HEADINGS: high specific surface area, activated carbon, natural gas, carbon dioxide, pore structure, adsorption storage, adsorption separation

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MODEL EXPERIMENT ON THE RESPONSE OF ALARM DETECTOR TO NATURAL GAS LEAKAGE IN UTILITY TUNNEL

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ABSTRACT: Utility tunnel is an integrated underground pipe ditch or pipeline corridor, which is especially used for laying of underground tunnel of municipal pipeline project. Different from traditional direct burial laying method, utility tunnel is an advanced laying method. Model experiment was designed, in according to the similarity theory and disadvantage principle, to simulate minute leakage of natural gas pipe in utility tunnel (narrow-long space) by use of methane. The influences of the leakage flux of methane and the width of cross-section on alarm time of detectors positioned longitudinally was analyzed. The concept of "leakage flux per unit width" was proposed, which was defined as the ratio between leakage flux of methane and width of model section. Meanwhile, the similar condition of the model experiments was obtained. On the basis of the distribution characteristic of experimental data, parabola function was used as the fit function of alarm response curve. Finally, the empirical formula of alarm time was obtained.

SUBJECT HEADINGS: natural gas, pipeline, utility tunnel, methane, gas diffusion, leak flux, automatic alarm, model, laboratory test

Hu Minhua, born in 1963, holds an M. Sc. degree. He is a lecturer of Zhenzhen University.