

液化天然气(LNG)在燃料工业中竞争的优劣势

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摘 要 30年来,为解决天然气远洋运输及储存而发展起来的世界液化天然气工业得到迅速的发展。文中分析了液化天然气在输送方面与管输天然气;在用作动力燃料方面与核能、煤和石油;在用作汽车替代燃料方面与氢气、甲醇、液化石油气、太阳能和压缩天然气等竞争中的优势和劣势,以提供 LNG 项目建设者一些综合性的考虑,促使我国 LNG 工业的发展。

主题词 燃料 液化天然气 能源 经济评价

天然气是能源中发展最快的重要燃料。其在能源供应中的高热值、低污染以及使用方便,再加上作为化工原料方面的广泛可用性使之在有竞争能力的价格水平上持续处于优势。

为解决天然气远洋长途运输及储存而发展起来的世界液化天然气(LNG)工业,30年来以产量20%的平均年增速率迅速增长,现已占全球天然气贸易总量的25%。今后的20年,世界LNG工业会继续高速发展。据资料估计,到2000年,LNG的贸易量将再增加60%,达 $110 \times 10^9 \text{ m}^3/\text{a}$,到2010年将达 $240 \times 10^9 \text{ m}^3/\text{a}$ 。为适应这种高速发展的需要,无论是现有项目的扩建或是新项目的建立,都需要投入大量资金。有关的权威人士估计,在今后的20年内(1992~2012年),需要的新投资将达800亿美元之巨。发展中国家是LNG工业的气源和液化基地,是主要的出口国。因而发展LNG工业成为首要问题。

LNG项目的发起人和承担者必须清楚地了解LNG工业的发展背景与供求形势,掌握LNG在燃料工业中面对着各种燃料竞争情况下的优势和劣势。既要充分发现LNG工业吸引资本的有利的多种因素,又要预见项目的风险性。这样才可以采用各种方法的优点,最终保证项目的成功。

作为能源供应的一种基本形式,LNG参与多个领域的竞争,主要体现在三个方面,分述如下。

在输气方式方面与管输天然气的竞争

LNG与管输天然气的竞争主要是输送成本的竞争。

输气管线成本是铺设管线及附属设施(如加压

站等)的成本,它随管线的长度大致成正比增加。而LNG输送的方式在气井和用户之间增加了许多耗资巨大的中间环节及设施,比如LNG工厂、基本负荷储存、LNG槽船、终端储存、港口及气化设备等(图1)。无疑大大增加了运输成本,从而提高了产品价格。一般来说,系统整体供应能力愈强,LNG价格的增值愈少。但通常LNG价格是井口气价的3~5倍,甚至更多,比管道气价也要高出1~2倍。所以在连片的美洲大陆、俄罗斯以及澳大利亚本土,天然气的主体供应都毫无例外地采用管道输送,即使非洲的天然气也主要通过管道气态输送到欧洲大陆。只有少数边远居民及工业区在管线敷设完成之前,采用LNG卫星站的方式临时供气。或者利用LNG方式储气调峰。

然而很难设想将阿尔及利亚的天然气用管线输送到美国东海岸,从印尼、马来西亚送到日本,用LNG方式输送进行远洋交易几乎是唯一的选择。

此外,LNG方式比管输天然气交易较为灵活,不但可以转换出售对象,还可以进行现货市场交易。

所有LNG的跨国远洋贸易都可以换取大量的外汇,这是LNG工业的巨大优势。

参与作为动力燃料的竞争

大部分的LNG进口国是将其作为动力燃料来使用的。比如日本,LNG的进口量约占全世界的一半,其中70%以上用于电力部门,占全日本火电燃料构成的21%。作为动力燃料,LNG面临着和多种能源的竞争,其中主要的是与核能、煤和石油的竞争。

确定某种动力燃料的竞争地位有多种因素,仅就经济方面来说,决定于该种燃料使用后所获得单

位电能的总耗费(元/kWh)。而这个总耗费又是建厂及设备投资、运行费用和燃料价格等单项指标的

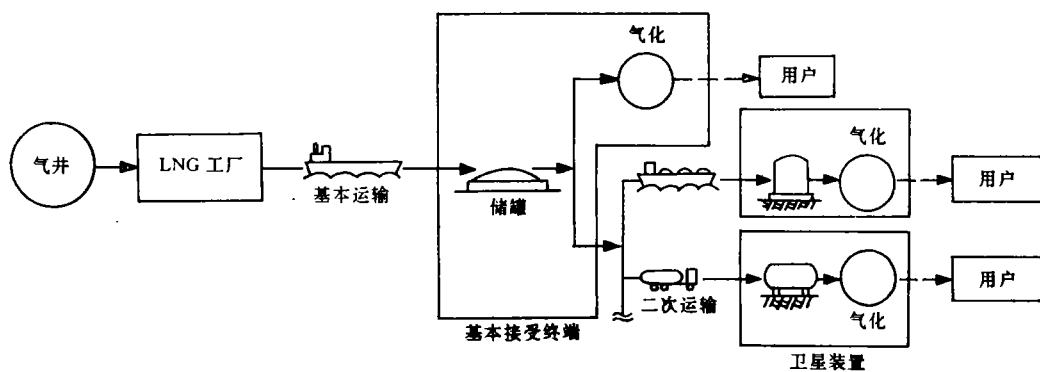


图 1 LNG 工业系统简图

Fig. 1. Schematic diagram of LNG industry system.

综合指数。一般说来,各种动力燃料所涉及的这些单项指数各不相同;各个国家和地区不同,同一种动力燃料的单项指数与综合指数也不尽相同。但是可以肯定的是,任何一种单项指数的下降都会增强该种燃料的竞争地位。

从建厂与设备投资来说,核能最大,其次是煤,然后是油,而LNG的动力厂投资最少。但是LNG动力厂须配备LNG的终端接受装置(储罐、气化设备等),如果把这部分投资加上,LNG动力厂的设备与建厂投资仍低于烧煤动力厂,但高于烧油厂。

从运行费用来比较,基本上仍然依核能、煤、油、LNG的次序逐渐降低。

显然,前面两项的比较可以看出LNG的某些优势的竞争地位。特别是近期电力生产中联合循环工厂的发展,使得热力系统的效率得到充分的发挥,因此单位电能的设备投资、运行费用更为减少,从而使LNG动力工厂在这方面的优势得到进一步的增强。

然而,体现综合竞争能力的第三个单项指数即燃料价格,情况却大为不同。正是由于LNG在气井和用户中间加进了许多中间环节,使得天然气的价格大幅度上涨。一般它的燃料价格低于石油但大大高于煤和核能,这是LNG的劣势方面。

图2给出了按照现行状况画出的日本各种动力燃料单位发电量的成本及其单项花费情况。其中LNG的价格是按4.34美元/MMBtu(MMBtu:英热单位,等于26.85 m³天然气)提供给动力厂的。据图2我们也可以找出LNG燃料与其它不同燃料的单独可比价格。在基本负荷动力工厂,LNG与核能最高可比价格是4.6美元/MMBtu,与煤的最高可比价格是5.0美元/MMBtu。对于效率因子仅有50%~

60%的中等动力厂,LNG最具竞争力,价格为5.5美元/MMBtu的LNG比核能、煤和25美元/桶的油燃料都要合算。当然由于日本已经在LNG的进口与分配系统装置上做出了大量投资,所以LNG的燃料价格可以相对较高。对于正在进行大量基本终端设施投资的一些国家和地区(如韩国、台湾),用电部门所付出的单项燃料价格成分要大大高于LNG的进口价,其LNG的价格承受能力也低,即与其它燃料的可比价格高不上去,竞争能力也较弱。

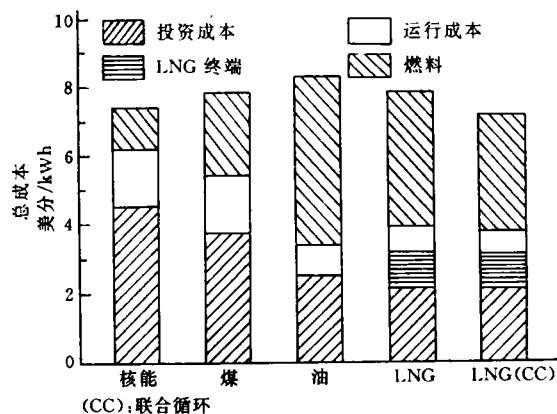


图 2 日本电力燃料成本对比

Fig. 2. Cost correlation of the electric power fuels in Japan.

我国是一个能源生产与消费的大国,也具有自己独特的能源情势。我国煤炭、水力资源丰富,石油、天然气相对较少。以煤、水为主的发电动力结构与能源政策短期内不会改变。石油产品以满足本国石化、汽车燃料的使用为目标。天然气除满足化工原料和其它工业的需求之外,以居民供给燃料为主,很难出口和用于动力燃料。沿海地区或许存在着进口LNG

以满足高品位燃料需求的可能性,但须花费大量的外汇。倘若条件成熟,天然气有可能作为动力燃料使用,则上述比较方法乃是发展我国 LNG 动力工业的衡量依据之一。

参与汽车替代燃料的竞争

鉴于第二次能源危机的影响以及保护环境带来的各国汽车排放法规的不断严格,寻找干净的汽车代用燃料已成为汽车工业近期急待解决的重大技术课题。作为汽车替代燃料选择的主要有氢气、甲醇、压缩天然气、液化石油气及太阳能。

燃氢汽车的主要优点是干净,燃烧产物只有水蒸汽,氢来源(电解水生成)取之不尽,用之不竭。但在氢气的储存、运输、供给及燃烧等方面均存在着大量的问题。

以煤为主要能源的国家开发煤基液化燃料,甲醇是最有希望的内燃机代用燃料。甲醇的辛烷值高,低发热量,低公害,排气无黑烟,且其燃烧和使用的大部分问题已解决,但存在着储运防火、低温启动的困难。另外,存在着甲醇车的运行费用较高的问题。

液化石油气(LPG)作为汽车的替代燃料在不少国家已施行,达到了实用阶段。问题在于它只能从一定程度上降低汽车排放污染,只能作为一种过渡性代用燃料,并且由于资源量较少,很难实现大的发展。

太阳能驱动的电动车是实现零污染的重要模式,但由于必须解决无日照行车和夜间行车的障碍,总体看来仍处于研究试制阶段。

天然气作为汽车燃料亦存在着压缩天然气(CNG)和液化天然气(LNG)之争,比较起来,LNG 的优点是:①续驶里程长。液化天然气能量密度比 20 MPa 下的压缩天然气高 3 倍多,这可以提高行驶里程 3 倍以上。②容器重量轻,体积小,成本低。CNG 容器须耐高压,壁厚、材料要求高,LNG 常压低温绝热储存燃料,要求低。③运输安全性好。LNG 常压使

用,且有绝热材料保护,防撞、防爆性好,CNG 高压储放,安全性较差。④可利用 LNG 冷量取代汽车空调。缺点是:①LNG 的价格较 CNG 高;②供给系统配置较为复杂,基本建设费用较高;③停驶期间 LNG 的自然蒸发问题必须合理解决;④LNG 燃料成分的变化问题。由于 LNG 是多组分混合物,其汽化的先后次序不同会引起燃料成分的变化,燃烧时须加以调整才能减少有害气体的排放量。

结 语

LNG 项目是投资大、系统性强、牵扯面广的基础能源利用的项目,在我国可以说是刚刚起步。它在解决油气田放空天然气回收、天然气管网的储气调峰、边远居民区的供气以及作为汽车代用燃料等方面的应用具有可观的经济效益与社会效益。然而综上所述,LNG 项目的发起人与承担者必须了解 LNG 在各种动力燃料工业竞争中的优势与劣势。精细地预见到这一系统工程中将会出现的各种问题,在项目执行的过程中必须踏实有效地解决各个关键技术环节,这样才能最终保证项目的顺利完成并获得预期的经济与社会效益。

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(本文收稿 1994 05 17 编辑 陈国华)

欢迎订阅本刊 1993、1994 年度合订本

本刊现有少量 1993、1994 年度《天然气工业》精装合订本,每册定价 20 元,欢迎订购。联系人:申洪涛。联系电话:(028)3324911 转 212715。

structural axis and culmination high, it is suitable injecting about $1.5 \text{ m}^3/\text{m}$ conventional acidizing fluid to eliminate the pollutions in the near wellhole zone and the depth acidizing will be done in the medium and later periods of gas producing; ②for the wells at the flanks-ends with worse porosity, after conventional acidizing, depth acidizing technology can be immediately used to change the percolation flow conditions; ③the protective measures of oil-gas bearing formations should be thoroughly used in the operation course of drilling, well completion, production and well workover; ④deeply conducting the jobs of evaluating formations and selecting wells; ⑤perfecting the hole texture being favourable for fracture acidizing; ⑥further strengthening the jobs of fracture acidizing.

SUBJECT HEADINGS: Sichuan Basin, Carboniferous period, Gas reservoir, Fracturing acidizing, Result, Analysis, Technology.

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Li You-xing (*Southwest Petroleum Institute*), **Xiao Fang-chun**; **SELECTING THE WALL THICKNESS OF PIPELINE BY RELIABILITY FACTORIAL DESIGN METHOD**, NGI 15(1), 1995: 53~55

ABSTRACT: It only considers if the members have enough intensity but can not solve the problem of reliability while selecting the wall thickness of pipeline by safety factor method in general designing. In the light of circumferential stress and axial stress of gas pipeline, combining reliability design on the base of Mises yield criterion, a new and convenient method, named reliability factor design method and with a clear concept and accurate result, of selecting the wall thickness of gas pipeline is obtained. The method is also suitable for computing cylinder pressure container.

SUBJECT HEADINGS: Gas pipeline, Pipeline design, Reliability, Safety factor.

Li You-xing, lecturer, graduated from Wuhan Water and Electricity Institute in 1966; He published several papers in national periodicals; Now he is engaged in teaching and science researches in the Mechanics Department of Southwest Petroleum Institute. Add: (637001)Nanchong, Sichuan.

Chen Geng-liang (*Natural Gas Research Institute of Sichuan Petroleum Administration*); **THE APPLICATION OF STANDARD GAS TO NATURAL GAS ANALYSIS TEST**, NGI 15(1), 1995: 55~58

ABSTRACT: The actions and overseas development trends of standard gas in natural gas analysis test, the quality index of pipeline natural gas, the gas quality standard of China and the magnitude transmission system of the standard gas applied to natural gas analysis test are introduced. Some suggestions how to develop China's standard gas, i.e., ①setting up the magnitude transmission system of China's standard gas from traceable source to criterion as soon as possible; ②further conducting the researches of fractionalizing pressure method; ③developing the exchangeability test between the standard gases at home and abroad; ④paying more attention to the development of standard gas preparation technologies are proposed out.

SUBJECT HEADINGS: Natural gas, National standard, Composition, Analysis, Analysis method.

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Zheng Da-zhen (*Science and Engineering University in Central China*), **SUPERIORITY AND INFERIORITY OF LNG IN FUEL INDUSTRY**, NGI 15(1), 1995: 59~61

ABSTRACT: In recent 30 years, the world LNG industry has been quickly developed. The superiorities and in-

feriorities of comparing LNG with pipeline gas in transportation aspect, LNG with nuclear energy, coal and oil in the aspect as power fuel, LNG with H_2 , CH_3OH , LPG, solar energy and CNG in the aspect as automobile substitutionary fuel are analysed, which provides some comprehensive consideration for the builders of LNG projects to propel the development of China's natural gas industry.

SUBJECT HEADINGS: Fuel, Liquefied natural gas, Energy source, Economic evaluation.

Wu Xian-chun (*Petroleum Chemistry Department of Daqing Petroleum Institute*), Zhang Chao-jun, Zhen Zhi-liang, Gao Yu-qing, Miao Yong-jian; **COMMERCIAL TEST OF SIMULTANEOUSLY REMOVING H_2O AND H_2S WITH COMPOUNDED ABSORBENT**, NGI 15(1), 1995, 62~63

ABSTRACT: It is an economical and effective method to simultaneously remove the H_2O and H_2S from low sulphurous natural gas with compounded absorbent. On the basis of researches in laboratory, the commercial test of the compounded absorbent—MEA+TEG is made with 100# natural gas dehydrating plant of Daqing Natural Gas Company to examine the feasibility of simultaneously removing H_2S and H_2O with the compounded absorbent in the conditions of unchanging the former plant flowsheet, operation process and equipment, which shows the desired results can be achieved.

SUBJECT HEADINGS: Gas desulfurization, Gas dewatering, Sour gas, Desulfurizer, Field testing.

Wu Xian-chun, lecturer, graduated in the Refining Department from Daqing Petroleum Institute with Master's degree in 1984; He has obtained a China's invention patent and published 9 papers; Now he is engaged in the research jobs of processing and utilizing the light hydrocarbons in oil fields. Add: (151400) Daqing City, Heilongjiang. Tel: (0459) 668411—8485 or 8327.

Long Ze-zhi (*Refining Chemistry Department of Sichuan Petroleum Administration*); **THE APPLICATION AND TECHNICAL PROGRESS OF TURBOEXPANDER TO RECOVERING LIGHT HYDROCARBONS FROM NATURAL GAS**, NGI 15(1), 1995, 63~65

ABSTRACT: In the aspect of recovering light hydrocarbons with middle pressure turboexpander in domestic gas fields since 1980s, some manipulation and maintenance experiences have been accumulated to achieve safety and long period operation as well as obvious economic benefit. As adopting overseas advanced techniques, the design and manufacturing qualities of the turboexpanders made in China's manufactories such as Sichuan Cryogenic Equipment Factory and the 609 Institute of China Aeronautics and Astronautics Industry Ministry have been enhanced, which creates favourable conditions for the application of domestic turboexpanders in gas fields. The application and technical progress of domestic turboexpanders in gas fields are introduced.

SUBJECT HEADINGS: Condensate recovery, Turboexpander process, Light hydrocarbon recovery.

Bai Lan-jun (*Enterprise Management Department of Sichuan Petroleum Administration*); **OIL-GAS PRICE THEORY AND METHOD IN MARKET ECONOMIC**, NGI 15(1), 1995, 66~70

ABSTRACT: By the use of product value theory and economic analysis methods, the price theory and pricing methods of oil-gas at home and abroad are analysed, and the suitable scopes, bases and initiatives of every pricing methods are elucidated. The mechanism of forming the price of oil-gas goods is expounded. The oil-gas price management should be suitable to the monopoly (competition) structure of oil-gas trades. The cost and benefit analyses of government price management should be done by government self. The advantages and disadvantages of every theory and pricing methods should be weighed in the light of society and economic benefits. It is a better pattern of forming the prices to encourage the competition in oil-gas market. For the cost prices by the government, relative encouraging