天然气管道泄漏分析及动态处理技术

胡忆沩 *
(吉化集团公司有机合成厂)

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摘　要　由于管内天然气的不断冲刷 ,温度、压力、振动、季节变化 ,地质变化 ,人为等因素的影响 ,使天然气输送管道不可避免地会发生密封失效的问题 ,如不及时处理 ,密封失效的程度将会扩大 ,导致天然气大量泄漏 ,造成能源物料流失、污染环境 ,重则引起火灾、爆炸、中毒、伤亡等恶性事故 ,严重威胁着天然气输送管道正常运行。因此 ,泄漏的预防及在动态条件下及时有效地消除泄漏是天然气管道输送管理工作的重要内容。文章分析了天然气输送管道中生产泄漏的原因 ,介绍了在不影响正常操作的条件下 ,消除泄漏的动态密封技术 ,论述了天然气输送管道上法兰泄漏、直管泄漏、三通泄漏、弯头泄漏及填料泄漏的具体消除手段。

主题词　天然气管道　天然气输送　漏气　动态分析　处理　方法

天然气管道输送过程中常见泄漏分析

在天然气管道输送过程中 ,常发生泄漏的部位是管道上的连接部位、焊接部位、流体的转向部位及采用填料密封部位等。

1. **连接部位泄漏**

连接部位是指为了检修或更换零部件而在设备或管道上设置的可拆卸性构件。最常见的连接部位有法兰连接和螺纹连接。

(1) 法兰泄漏

法兰密封是天然气管道输送中应用最广泛的一种密封结构形式。这种密封形式一般是依靠其连接螺栓所产生的预紧力 ,通过各种固体垫片或液体垫片达到足够的工作密封比压 ,来阻止被密封流体介质的外泄 ,属于强制密封范畴。这种连接形式主要存在三种泄漏形式。

1) 界面泄漏。密封垫片压紧力不足、法兰结合面上的粗糙度不恰当、管道温差变形、机械振动等都会引起密封垫片与法兰面之间密合不严而发生泄漏。

2) 渗透泄漏。压力介质通过密封垫片内部的微小间隙而产生的一种泄漏形式。

3) 破坏泄漏。破坏泄漏是由于安装质量欠佳而产生密封垫片压缩过度或密封比压不足而发生的泄漏。

(2) 螺纹连接部位泄漏

螺纹泄漏是由于所使用的缠绕填充材料如四氟乙烯、石棉绳、麻丝等材料经过长期使用后 ,会出现老化、龟裂、变质 ,塑性变形和回弹力下降 ,造成填充材料与丝扣之间密合不严而发生泄漏。

(3) 焊接部位泄漏

由焊接存在的缺陷如未焊透、夹渣、气孔、裂纹引起的泄漏。

2. **冲刷引起的管道泄漏**

由于天然气高速流体在改变方向时 ,对管壁产生较大的冲刷力导致的管道穿孔泄漏。

3. **填料部位泄漏**

主要指阀门填料处或机泵的轴向填料密封处发生的泄漏。

天然气管道泄漏动态处理方法

目前 ,我国用于处理天然气输送管道泄漏采用的方法是“注剂式带压密封技术 ”[1]。即将密封注剂强行注射到夹具与泄漏部位部分外表面所形成的密封空腔内 ,迅速地弥补各种复杂的泄漏缺陷 ,在注剂压力远远大于泄漏介质压力的条件下 ,泄漏被强行

*胡忆沩 ,1956 年生 ,高级工程师 ;编著学术专著 7 部 ;吉林省有突出贡献的中青专业专家 ;在国内核心期刊独立发表论文 40 多篇 ;取得专利权 2 项。地址 : (132022) 吉林省吉林市遵义路 7 号。电话 : (0432) 3989055。

止住,密封注剂自身能够维持住一定的工作密封比压,并在短时间内由塑性体转变为弹性体,形成一个坚硬的、富有弹性的新的密封结构,达到重新密封的目的。注剂式带压密封技术机具总成包括:夹具、接头、注剂旋塞阀、高压注剂枪、快装接头、高压输油管、压力表、压力表接头、回油尾部接头、油压换向阀接头、手动液压油泵等组成,如图 1 所示。该技术的特点是:不用停产、停气,属于在线修复技术;安全可靠,适用于易燃易爆介质泄漏的处理;适应性强,无需对泄漏部位进行处理,不破坏原有的密封结构;具有良好的可拆性;可处理泄漏介质的最高温度为 800 ℃,最低温度为 - 186 ℃,最高泄漏介质压力为 30 MPa。

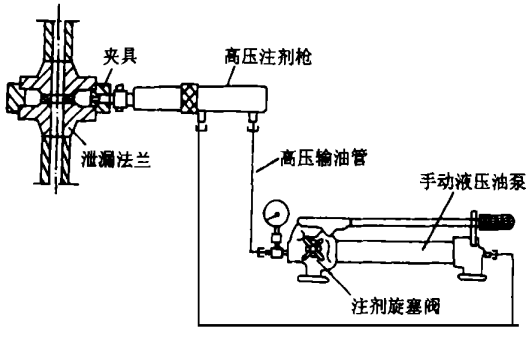

图 1　机具总成示意图

1. 法兰泄漏的处理方法

天然气输送管道上的法兰多设在压缩机的出入口、容器出入口及阀门连接部位等。法兰泄漏处理过程如下:

1) 法兰泄漏测绘。法兰泄漏的测绘包括泄漏法兰的外圆直径;泄漏法兰的连接间隙,至少要测量 4 个点;泄漏法兰副的错口量;泄漏法兰外边缘到其连接螺栓的最小距离。泄漏法兰副的宽度;泄漏法兰连接间隙的深度;泄漏法兰连接螺栓的个数和规格。

2) 钢带围堵法。当两法兰之间的连接间隙不大于 8 mm,输送的天然气压力小于 2.5 MPa 时,可以采用钢带围堵法进行动态密封作业。供这种钢带拉紧器使用的钢带厚度为 0.5 mm,宽为 25 mm。钢带拉紧器用于法兰动态密封作业安装后情况,目前钢带拉紧器所使用的钢带已有商品出售。

3) 凸形法兰夹具法[2]。凸形法兰夹具是"注剂式带压密封技术"中应用最广泛的一种夹具。根据我国目前法兰夹具的设计及现场应用情况,这种凸形法兰夹具又可分为标准法兰夹具、偏心法兰夹具、异径法兰夹具、局部法兰夹具、孔板法兰夹具等等。用户可根据天然气管道泄漏法兰的尺寸、两法兰的连接间隙、两法兰的同轴度来设计选择。

2. 直管段泄漏的处理方法

天然气直管段上泄漏多发生在焊缝或管道的薄弱环节处。

1) 直管泄漏的测绘。直管泄漏需要测绘的现场数据有:泄漏管道的外径;泄漏直管的错口量;泄漏缺陷的几何尺寸;检查并记录泄漏部位管道的壁厚,必要时应进行壁厚检测,以便在夹具设计时采取相应的保护措施,避免在动态密封作业时发生失稳现象。

2) 直径较小管段泄漏的处理。泄漏管道的直径小于 DN80,可以设计方形夹具进行动态密封作业。

3) 直径较大管段泄漏的处理。泄漏管道直径大于 DN80 时,则应当设计制作圆形夹具。

4) 大管径局部泄漏的处理。该法只密封天然气管道泄漏区域的有效部分。

5) 直管螺纹连接泄漏的处理。该法是利用 G 形卡子的特殊功能来实现的。具体步骤是,首先将 G 形卡子固定在螺纹泄漏部位的外表面上,用 G 形卡子上的顶丝顶紧,然后通过顶丝的内孔,用约 Ø8 mm 的长钻头钻透管壁,引出天然气后,安装高压注剂枪,然后按程序进行作业即可。

3. 弯头泄漏的处理方法

在天然气输送管道中,常用的有 90°弯头、45°弯头、90°异径弯头及 180°弯头。

1) 弯头泄漏的测绘。弯头泄漏需要测绘的现场数据有:泄漏弯头的外径;泄漏弯头的内外弯曲半径,确定弯头的形式;泄漏缺陷的几何尺寸。

2) 直径较小弯头泄漏的处理。泄漏弯头直径小于 DN80,可以设计整体弯头夹具进行动态密封作业。

3) 直径较大弯头泄漏的处理。泄漏弯头直径小于 DN100,可以设计焊制弯头夹具进行动态密封作业。

4. 三通泄漏的处理方法

在天然气输送管道中常用的有等径三通、异径三通弯头、等径四通、异径四通。

1) 三通泄漏的测绘。三通泄漏需要测绘的现场数据有:泄漏三通的外径,应测三处,主管两处,支管一处,分别记录为 D、D′和 D″;泄漏缺陷的几何尺寸 b。

2) 直径较小三通泄漏的处理。泄漏三通直径小于 DN80,可以设计整体三通夹具进行动态密封作

谈 川 气 输 汉

张民基 *　　汪军民
(武汉市管道煤气公司)

张民基等. 谈川气输汉. 天然气工业 ,2001 ;21(4) :100～103

摘　要　武汉地处我国经济地理中心 ,是内陆主要商贸、金融、科技教育中心和重要的工业基地。由于武汉市能源消耗结构的特点是煤炭主导型和能源外购型 ,随着经济的发展 ,环境污染日益凸现。文章分析了四川天然气进汉后将会对优化武汉市能源结构 ,带动相关工业发展 ,改善城市基础设施水平 ,加快城市建设步伐 ,减轻重质能源对环境的污染以及促进经济发展和社会繁荣等方面发挥的重要作用 ;介绍了武汉市如何解决现有燃气输配系统与天然气接轨问题的方法 ;指出了天然气来汉目前尚存在诸如建设资金的筹措、上游单位工期的确定、下游用户落实情况等问题。最后提出武汉市应采取加强环保立法 ,鼓励用气 ,加快天然气配套工程进度等措施以实现川气输汉上下游工程进度协调发展的建议。

主题词　武汉　能源　四川　天然气输送　天然气利用

武汉市能源消耗结构的特点是煤炭主导型和能源外购型。1997 年煤炭占全市能源总消费量的 41.1 %;其次是石油及油品、电力 ;液化石油气和人工煤气只占能源总消耗量的 3.8 %。武汉市没有一次能源资源 ,原煤主要由陕、晋、豫调入 ,原油主要来源于江汉、胜利油田等 ;电力主要由湖北省电网统配。现行的能源消耗结构制约着武汉市的环境质量。武汉市大气污染类型属煤烟型 ,但随着汽车尾气排放量剧增 ,已呈现向 NO_X 型转化的趋势。

为配合四川地区天然气输往武汉 ,武汉市于 1999 年先后编制了《武汉市天然气利用规划》和《武汉市城市天然气输气工程预可行性研究报告》。按

业。

3) 直径较大三通泄漏的处理。泄漏三通直径小于 DN100 ,可以设计焊制三通夹具进行动态密封作业。四通泄漏处理的方法与三通相似。

5. 填料泄漏的处理方法

当天然气输送管道上的填料部位发生泄漏时 ,可以采用一种非常简便的 G 形卡具处理法。其动态密封作业的程序是 : ①按泄漏阀门填料盒尺寸选择 G 形卡具型号 ; ②试装 ,确定钻孔位置 ,并打样冲眼窝 ; ③用 Ø10 mm 的钻头在打样冲眼窝处钻一定位密封孔 ,深度按 G 形卡具螺栓头部形状确定 ; ④安装 G 形卡具 ,检查眼窝处的密封情况 ; ⑤用 Ø8 mm 的长杆钻头将余下的填料盒壁厚钻透 ,引出泄漏介质 ; ⑥安装注剂专用旋塞阀及高压注剂枪进行注剂作业。目前 G 形卡具的商品规格有三种 ,即大、中、小三个型号。作业时根据泄漏阀门填料盒的外部尺寸 ,可选择不同型号的 G 形卡具。

6. 密封注剂选择

由于天然气管道输送的多是常温或低温的流体介质 ,应当选择常温或低温环境下 ,塑性和流动性好的热固性密封注剂品种 ,但此种密封注剂在常温及低温下是不能完成固化过程的 ,可采用外部加热的方式 ,促其固化。而选择非热固型的双组分密封注剂 ,现配现用 ,则可在常温或低温下固化。

采用注剂式带压密封技术处理天然气输送管道上发生的泄漏 ,只要能够设计制作出可与泄漏部位外表面相吻合的夹具 ,就能够实现动态条件下的再密封。

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*张民基 ,高级工程师 ,1955 年生 ;现任武汉市管道煤气公司党委书记兼副经理。地址 : (430034) 湖北省武汉市桥口区古田三路长丰北垸特 1 号。电话 : (027) 83831939。

SUBJECT HEADINGS: Aquifer, Underground gas storage, Geology, Design, Numerical simulation

Zhan Changhong, born in 1973, graduated from the Ha'erbin University of Civil Engineering and Architecture and received his Master's degree in 1988. Now he is a postgraduate studying for a doctorate in the university. Add: Ha'erdin, Heilongjiang (150090), China Tel: (0451) 6282622

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ADSORPTION CHARACTERISTICS OF MIXED GAS

Gu Min (Shantou University) and Chen Changguo and Xian Xuefu (Chongqing University). *NATUR. GAS IND.* v. 21, no. 4, pp. 91～94, 7/25/2001. (ISSN 1000-0976; **In Chinese)**

ABSTRACT: China is very rich in coal-bed gas resources, however, their utilization rate is much lower, because of low concentration of the effective constituent-methane in coal-bed gas exhausted. So it is very important to separate and purify the coal-bed gas. Because various constituents in mixed gas are of competitiveness during commonly adsorbing, the adsorption and desorption of various constituents will be directly influenced in the pressure-changed adsorbing process. Through simulating the process of coal-bed gas (CH_4/N_2), the concentration change characteristics in free-phase and adsorption-phase of various constituents in the adsorption process of mixed gas and their influence on pressure-changed adsorption separation are analyzed in theory in the paper. Finally, the influence of the other constituents in exhausted coal-bed gas on purified constituent of CH_4 is discussed also in the article.

SUBJECT HEADINGS: Mixed gas, Coalbed gas, Composition, Gas adsorption, Adsorption Separation

Gu Min *(female, Doctor of Engineering)*, born in 1969, is mainly engaged in the research on analytical chemistry and electric chemistry. Add: Department of Chemistry, Xiamen University, Xiamen, Fujian (361005), China Tel: (0592) 2181436

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TECHNIQUE OF EVALUATING THE RELIABILITY OF NATURAL GAS PIPELINE OPERATION

Liu Wen (Pipeline Scientific and Technological Research Center of Pipeline Company, PCL) *NATUR. GAS IND.* v. 21, no. 4, pp. 94～97, 7/25/2001. (ISSN 1000-0976; **In Chinese)**

ABSTRACT: The gas pipeline network in Sichuan Province has been operated for 30 years and the pipeline safety and normal gas transmission are seriously influenced because of pipeline aging, heavy corrosion and frequent pipe-explosive accidents in recent years. It is in urgent need for declining accidents and lengthening lifetime of the pipeline system to understand and raise the reliability of the pipeline system operation. The theoretical contents and calculation method of the technique of evaluating the reliability of natural gas pipeline operation are stated; the calculation formulas of reliability indexes of the pipeline, compressor station and whole system of the natural gas pipeline network are given out; the failure pattern of natural gas pipeline and its lifetime distribution model are analyzed; and some measures of guaranteeing the reliability of the pipeline system operation are proposed in the paper.

SUBJECT HEADINGS: Natural gas pipeline, Operation, Reliability, Evaluation, Fault analysis

Liu Wen *(female, engineer)*, born in 1965, graduated in environment engineering from Hebei Chemical Industry Institute in 1987. Now she is engaged in the works of energy-saving monitoring and physiochemical analysis. She published more than ten articles and a book written with the others. Add: No. 51, Jinguang Road, Langfang, Hebei (065000), China Tel: (0316) 2174247

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NATURAL GAS PIPELINE LEAKING ANALYSIS AND DYNAMIC DISPOSAL TECHNIQUE

Hu Yiwei (Organic Synthesis Factory of Jilin Chemical Group Corporation). *NATUR. GAS IND.* v. 21, no. 4, pp. 98～100, 7/25/2001. (ISSN 1000-0976; **In Chinese)**

ABSTRACT: The seal failure will unavoidably happen in natural gas transmission pipeline because of the influences of the gas' scouring unceasingly, the changes in temperature, pressure and vibration, the seasonal variation, the geological condition change and the human factor, etc. If it isn't disposed in time, the seal failure will be getting more and more serious, leading to a great deal of natureal gas' being leaked, which causes energy material loss, environmental pollution, even arouses a malignant accident as fire, explosion, poisoning or fatality, a normal natural gas transmission pipeline operation being seriously threatened. Therefore it is an important substance of gas transmission pipeline management to prevent gas leaking and eliminate it in time and effectively under a dynamic condition. The reasons of

forming gas leaking in natural gas transmission pipeline are analyzed ,a dynamic seal technique of eliminating gas leaking under the condition of uninfluencing normal operation is introduced and some concrete measures of eliminating the leakings at the flange ,straight pipe ,straight tee ,elbow and packing loction of the natural gas pipeline are stated in the paper.

SUBJECT HEADINGS: Natural gas pipeline , Natural gas transportation , Gas leak , Performance analysis , Disposal , Method

Hu Yiwei *(senior engineer)* , born in 1956 ,published seven books and more than forty articles and obtained two patents ,being one of the youth and middle-aged experts making an outstanding contribution in Jilin Province. Add: No. 7 , Zunyi Road ,Jilin City ,Jilin (132022) ,China Tel: (0432) 3989055

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ON SICHUAN-TO-WUHAN NATURAL GAS TRANSMISSION

Zhang Minji and Wang Junmin (Wuhan Pipeline Gas Company). *NATUR. GAS IND.* v. 21 , no. 4 , pp. 100～103 , 7/ 25/ 2001. (ISSN 1000 - 0976; **In Chinese)**

ABSTRACT: Wuhan is located at the economic and geographical center in China ,being the major commercial ,financial , scientific ,technological and educational center and an important industrial base in the interior of our country. Because the characters of the energy consumption structure are coal-leading type and energy-external buying type ,environmental pollution is getting more and more serious along with economic development. Through introducing natural gas from Sichuan to Wuhan , an important role which will be played in the following aspects , such as optimizing energy structure ,bringing along the development in relevant industries , raising city intrastructure level , quickening urban construction steps , decreasing enviromental pollution caused by heavy energy and promoting economic development and social prosperity , etc. , is analyzed ; the method of how to solve the problem of joining natural gas to existing fuel gas transportation and distribution system is introduced ;and the existent problems of introducing natural gas from Sichuan to Wuhan ,such as raising funds for construction , determining the work periods for upstream sectors and fixing downstream users , etc. ,are pointed out in the paper. Finally , some measures , as strengthening environmental protection legislation , encouraging people to utilize natural gas and quickening the pace of unit natural gas engineering construction ,etc. ,which should be adopted in Wuhan ,and a suggestion of advancing upstream and downstream engineering side by side are proposed in order to realize Sichuan-to-Wuhan natural gas transmission.

SUBJECT HEADINGS: Wuhan , Energy source , Sichuan , Natural gas transportation ,Natural gas utilization

Zhang Minji *(senior engineer)* , born in 1955 ,is a Party committee secretary and deputy manager of the Wuhan Pipeline Gas Company. Add: Qiaokou District , Wuhan , Hubei (430034) ,China Tel: (027) 83831939

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EXPERIENCES IN CULTIVATING NATURAL GAS MARKET ABROAD ANE THEIR INSPIRATION TO CHINA

Li Hongxun (Industrial and Commercial Management Institute , University of Petroleum Dongying). *NATUR. GAS IND.* v. 21 , no. 4 , pp. 103～106 , 7/ 25/ 2001. (ISSN 1000 - 0976; **In Chinese)**

ABSTRACT: The cultivation of natural gas market has been strongly thought of in the high gas-producing and consuming countries in the world. Their basic experiences include :fixing natural resources , synchronously developing gas main and municipal gas transmission pipeline network ,being energetically supported by government departments , setting a competitive natural gas price ,opening up new natural gas markets unceasingly , energetically developing city , especially big city gasification and paying more attention to the influence of scientific and technological progress on opening up natural gas market , etc. The development of the natural gas industry in China is slower with annual outputs of 2500～26000 million cubic meters only , owing to a slowly developed market. Through introducing and analyzing the basic experiences in cultivating natural gas market abroad ,several enlightenments of cultivating natural gas market in China are proposed in the paper in the hope of benefiting the development of the natural gas industry in China.

SUBJECT HEADINGS: World wide , Natural gas , Market Cultivation ,Decision analysis , Enlightenment

Li Hongxun *(Master , associate professor)* , born in 1964 , graduated from a university in 1985 and published more than 20 articles. He is mainly engaged in the teaching and research on petroleum economics and enterprise management. Add: Dongying , Shandong (257061) , China Tel: (0546) 8396911 (H) , (0546) 8392331 (O)

翻译 刘方槐
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