工厂设计软件在管道设计中的开发应用

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摘　要　工厂设计软件（CADDS Plant Design）在石油化工等领域已得到了广泛的应用。借助于工厂设计软件，设计人员可以在三维空间进行配管设计直至建立整个管道模型。对建立的模型可进行优化处理和碰撞检查，通过对模型进行消隐和宣染处理，可生成色彩和图形逼真的三维模型，从三维模型中可抽取管道平面布置图、单管图、三维管网图及各种材料报表。工厂设计软件是从国外引进的软件，遵循的设计标准与我国标准有一定差异。因此，要将软件应用于国内的管道设计，其关键是要根据我国国情（标准、规范、符号）对软件进行二次开发，建立适合我国现代标准的数据库、图形符号库。文中就工厂设计软件的应用和开发方法进行了探讨，并阐述了应用软件给工程设计带来的良好效果及软件二次开发应用中应注意的问题。

主题词　计算机辅助设计　管线设计　开发　应用

随着计算机技术的高速发展，计算机辅助设计(CAD)技术已广泛应用于各个设计领域。借助工厂设计软件，设计人员在计算机上构造管道、设备、结构等专业的三维模型，通过对所构造的软模型进行修改、优化、碰撞检查，生成最后模型，并最终从模型中提取出各种施工图及相应的设备材料报表。工厂设计软件的实际应用打破了传统的配管平面图设计模式，使现有的设计思想、设计方法、设计程序及设计管理等全过程都发生了一系列的变革，为工程设计人员提供了一种崭新的设计方法和手段。

在传统的设计中，设计人员根据工艺流程及仪表控制图(P&ID)，利用自己的三维空间想象力来表达三维配管设计。由于人的三维想象力有限，因此这种设计模式限制了设计质量的提高。在一些大的、复杂的装置中，设计人员还需制作硬塑料模型来展现整个设计的全貌，并借助它来检查管道的碰撞问题，改进设计质量。但由于手工制作的硬模型精度低，修改不方便，而且其最大缺点是不能提取数据，模型的修改不能直接反应在施工图上。因此硬模型对于提高配管设计质量的作用也是很有限的。

工厂设计软件为真三维软件，三维设计软件使设计人员真正实现了思维过程与设计过程一致。工厂设计软件的设计步骤是：首先在图形工作站或图形终端上建立三维工厂模型坐标系，然后在工厂模型坐标系下，按照实际尺寸建立设备模型和结构模型，接着根据 P&ID 图及配管草图，在三维空间做配管设计，直至建立整个管道模型。建立的模型以三维方式显示。设计人员能对模型中的管道与管道、管道与设备、设备与结构等可能发生碰撞的地方进行碰撞检查，并能随时修改发生碰撞的地方，这样基本上消除了现场施工中经常出现的碰撞问题。通过对模型进行消隐和宣染处理，可生成色彩和图形逼真的三维模型。三维模型建立完后，设计人员能从中抽取管道立体平面布置图、单管图、三维管网图及各种材料报表。

国外引进的工厂设计软件在我国设计实践中的应用和推广，其关键问题是要进行本地化、实用化的开发，建立适合我国设计规范标准和习惯的数据库、子图库及材料报表格式，使软件更好地应用于国内工程设计中。

四川石油管理局勘察设计研究院（以下简称我院）引进的美国 CV 公司的工厂设计软件（CADDS Plant Design）就是应用于管道设计的一个计算机辅助设计软件，下面对这一软件的功能，二次开发途径作一简介。

软件功能描述

(1)可以建立并使用用户的管道元件库。

(2)任意构造设备。

(3)智能地部署管线。

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(4)自动插入配件(阀门、弯头、三通、大小头等)。

(5)检查分析布管的正确性。

(6)全面或局部检查管线之间、管线与基础、设备或其它构筑物之间有无发生碰撞。

(7)自动生成详图。

(8)自动生成上色图。

(9)自动抽取单管图。

(10)自动产生详细材料表或汇总材料报告。

(11)自动标注尺寸及标高。

软件的二次开发

CADDS Plant Design 三维管道设计软件是一个开放性的,在参数文件、数据库、子图库支持下的真三维管道模型生成软件。该软件的参数文件、数据库及子图库均可对用户开放,由用户根据需要增减修改。从某种意义上来说,对该软件的用户化过程,即对支持该软件运行的参数文件、数据库、子图库进行用户化修改扩充的过程。因此,对该软件的参数文件、数据库、子图库的组织、结构安排及具体规定的了解是进行用户二次开发的前提。该软件的参数文件、数据库、子图库与软件及操作间的关系见图1。

对工厂设计软件(CADDS Plant Design)的二次开发一般应遵循如下步骤。

1. 前期准备

对软件进行二次开发,首先应确定管道设计所采用的标准(目前我院采用的是原石油部标准)。对于标准未涉及的部分应根据实际情况,依照国际惯例和使用习惯统一规范,建立标准。然后在此基础上收集设计所需资料,包括选用设备的样本,阀门样本以及各种管子配件的规格和标准,并规定材料报表的格式。

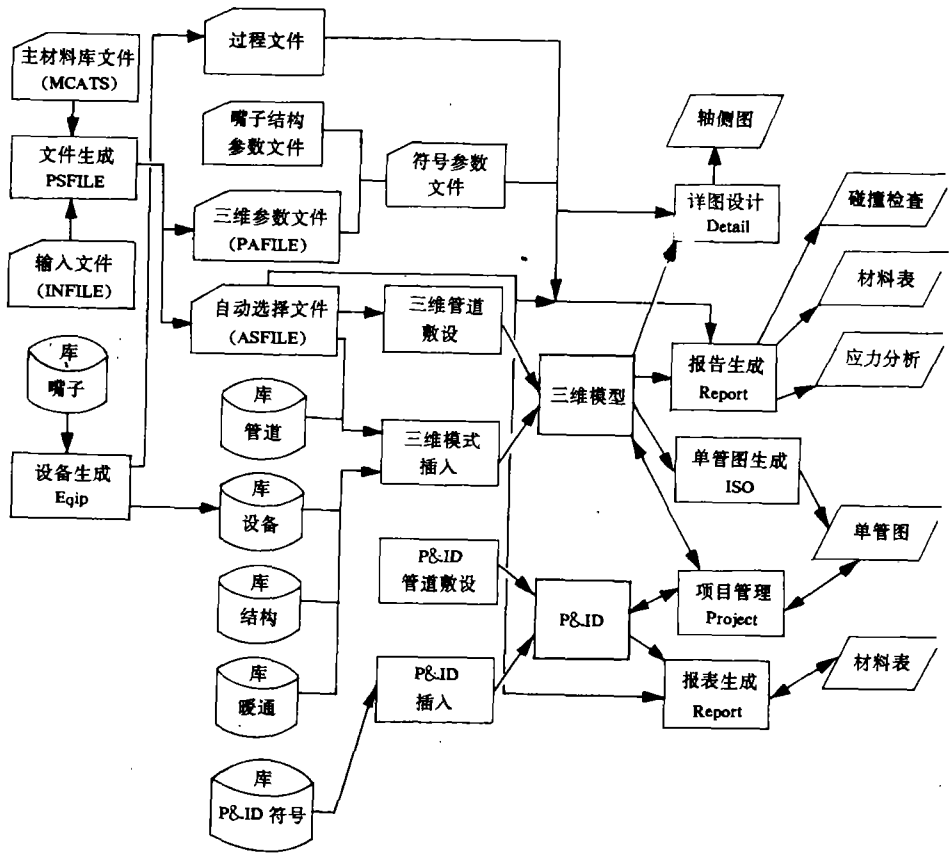

图1　文件、数据库、子图库与软件操作关系图

Fig. 1. Relation among document, database, subpicture base and softwar.

注:方框内文字表示软件操作或命令,P&ID 表示工艺流程及仪表控制

2. 建立子图库

管线、管件的图形表示及必要说明信息(属性)是以一个个子图的形式组织在图形库中。图形库包括标准管线和配件图形库、设备管嘴图形库及型钢元件图形库。

子图应制作成 NFIG 形式,使用基本的 CADDS

命令(点、线、圆弧等)来生成。每个子图至少应具备如下属性:COMPNAME——子图的名称,在生成各类报告时作为元件的名称;STOCKNO——子图必要的说明信息,如规格、型号、厂家等以便在生成材料表等报表时使用;FITTYPE——软件规定的管件类型代号,如10代表法兰。每个NFIG的两个端点应放置ENDTYPE特性以检查端面类型的匹配性,起点应放置CONNECTOR特性,在抽取材料和统计材料时使用。连接两个端点的结点线上应带有INTERNAL特性,以便流体从中流过。

NFIG准备好后,用UNIX提供的编辑命令VI编写用来生成NFIG子图所表示的管件对应的三维实体模型的过程文件,该过程文件包括了生成实体模型所需的命令及几何数据。过程文件编写好后再进行编译,直到无误。

3. 建立数据库

子图库建立好后,就要建立相应的数据库。建立数据库有以下几个步骤:

(1)建立材料库文件(MCAT)。该文件包括所有配件的详细尺寸数据。此数据库应是一个动态库,可随时进行维护,以便适应产品的更新换代和增加新的产品。

(2)建立输入文件(INFILE)。该文件应分管路等级建立,它是用来管理和使用数据库的关键性文件。用输入文件可确定用户自己的输入格式及内容,包括管线、阀门配件,以及尺寸系列,压力等级,端面类型等的定义格式、输入格式和输出格式。输入文件是软件与用户接口的关键性文件,直接影响软件的使用和模型的建立,也是用户二次开发时的重点工作对象。

(3)建立自动选择文件(ASFILE)和三维参数文件(PAFILE)。这两个文件是在INFILE编好后,在CADDS环境下用GEN PSFILE命令产生的,是按照输入文件的内容及格式,从主材料库文件中生成软件所直接使用的数据库。自动选择文件在建立模型时使用,三维参数文件在生成详图和上色时使用。

(4)建立主目录文件(DRFILE)和端面类型文件(ENDTYPES)。在自动选择文件和参数文件生成后直接编辑这两个文件。主目录文件规定了管号格式、搜寻路径和所使用的文件名称。端面类型文件记录了各种类型的端面应匹配的零件,该文件使自动配法兰、垫片及检查断面一致性成为可能。

4. 生成汉字报表

设计工作完成后,相应的材料统计也随之完成。可以用CVMAC语言将自动生成的各种报表转化为汉字描述,按国内规范标准出报表及文档材料。

工厂设计软件的应用效果

工厂设计软件的应用打破了传统的设计方法,提高了管道设计的质量和效益。具体体现在以下几点:

(1)工厂设计软件的使用使设计人员可利用计算机三维造型功能进行配管研究,并做多方案比较;使装置设计紧凑、部局合理,提高了方案的科学性和可靠性。

(2)图纸质量高,错误少,数据准确。由于经碰撞检查才抽取单管图、施工图,减少了施工返工现象,节约了施工投资。

(3)自动生成材料报表代替人工统计材料和填写材料报表的工作,使得材料统计准确、迅速,从而节省了材料,并为材料采购和现场材料的科学管理提供了完整、准确的信息。

(4)可生成三维管网图。由于三维管网图直观、真实,给施工代来了极大的方便。

工厂设计软件开发应用中应注意的问题

(1)认真分析工厂设计软件的数据库结构、数据库生成软件及其相应关系,摸清图和非图特性的关系和作用,以及数据库是怎样支持三维模型的建立。找出解决问题最有效、最简单的方法,尽量避免走弯路。

(2)在开发过程中应尽量节省数据库二次开发的工作量,认真比较所要建立的数据库与软件提供的数据库之间的异同,充分利用原有库的内容和格式,大部分采用修改的方法,少部分采用新建的方法。

(3)选择适当的汉字系统。汉字的输入和编辑是软件应用推广的一个关键性问题,汉字问题解决不好,势必影响软件的推广应用。

(4)CAD技术队伍的建设。应通过培训、上机操作使大多数设计人员掌握CAD技术,逐渐培养出一支具有新的设计观念,能用工厂设计软件进行三维管道设计的队伍,从而提高设计质量和效益,增强参与国际竞争的能力。

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duction and high H_2S content and the success ratio of DST is enhanced.

SUBJECT HEADINGS: Sichuan Basin, East, Drill pipe, Foumation test, Tehnique.

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Li Jianliang (*Southwest Petroleum Geology Bureau of the Ministry of Geology and Mineral Resources*), Li Hengrang: **APPLICATION OF SEPARABLE PERFORATING-FRACTURING COMBINED BULLET TO THE TEST OF OIL-GAS WELLS, NGI** 16(3), 1996: 53～54

ABSTRACT: In order to eliminate the pollutions caused by drilling , well cementing, well completion and perforation in oil-gas beds and to enhance the oil-gas prodution of carbonate rock and sandstone reservoirs, through a long research and test, a new technique, by combining perforation with high-energy gas fracturing into a operating sequence, is presented. The example shows that the technique not only saves on manpower, material resources and time but also reasonally use energy resources, and is a forceful measure of enhancing oil-gas production.

SUBJECT HEADINGS: Drilling , Well cementing, Oil and gas production, Perforated completion, Shaped charge, Analylical method.

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Zhang Gongshe (*Petroleum Engineering Department of Jianghan Petroleum Institute*), Lin Tao: **A NEW METHOD FOR PRESSURE BUILDUP ANALYSIS OF GAS WELL DRILLSTEM TESTS, NGI** 16(3), 1996: 55～58

ABSTRACT: In the view of the fact that gas well drillstem test with a small change in flow period, the mathematical model of shut-in pressure buildup analysis in the condition of constant-pressure production is set up. Normalized pseudopressure and pseudotime are applied to correlate gas-well DST results with the analogous oil-well test solutions. A straight line equation for pressure buildup analysis is presented. Application of the method to interpreting gas-well DST data may provide the initial reservoir pressure, the formation permeability and the skin effect. A field example is presented.

SUBJECT HEADINGS: Drill pipe, Test, Well test interpretation, Analysis method, Application.

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Lei Zhenzhong (*Drilling and Production Research Institute of Sichuan Petroleum Administration*): **DETERMINING GAS WELL WASHOUT SITUATION BY CHART METHOD, NGI** 16(3), 1996: 58～60

ABSTRACT: Washout is the largest damage to gas wells among various erosions. The causes and affection factors for washout are analysed. The washout increases along with the increment of gas flow velocity. If the gas flow velocity increases 3.7 times, the erosion velocity does 5 times. the formula of calculating washout velocity and the corrective method of considering other influence factors are presented. Washout situations of gas wells can be determined by the chart method in the conditions of known flow pressure at wellhead and known tubing inner diameter, which is very easy for on-the-spot application.

SUBJECT HEADINGS: Gas well, Gas flow, Washout, Calculation, Chart, Application.

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Yang Mao (*Survey and Design Research Institute of Sichuan Petroleum Administration*), Jiang Shengqing: **DEVELOPMENT AND APPLICATION OF CADDS PLANT DESIGN TO PIPELINE DESIGN, NGI** 16(3), 1996: 61～63

ABSTRACT: CADDS Plant Design is widely applied in the field of petrochemistry. Using CADDS Plant Design software, 3-D pipeline-distributing design can be done until set up a complete pipeline model. Because that the software is introduced from oversea, it is very important developing it secondarily according to the conditions of China and a database suitable for the present China's standards should be set up. The methods of applying and developing the software are discussed. The good result of applying the software in the cause of design pipeline-distributing and the problems to which should be paid attentions in sec-

ondarily developing it in China are expounded.

SUBJECT HEADINGS: Computer assisted design, Pipeline design, Development, Application.

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Liu Tingdou (*Chuanzhong Exploration and Development Company of Sichuan Petroleum Administration*), Xu Kefang: **AUTOMATIC CONTROL SYSTEM OF SH GAS DISTRIBUTION STATE**, **NGI** 16(3), 1996: 64～68

ABSTRACT: The automatic control system developed by Chuanzhong Exploration and Development Company of Sichuan Petroleum Administration and Electron Science and Technology University has been applied successfully at SH gas distribution state. Combining computer technology with automatic technology, the system is applied to the stations of natural gas gathering and distributing to enhance the automatic level of production and management. Because the system is of the charateristics of complete functions, reliable and stable performances, good applicability and very cheap, it has a good popularization prospects.

SUBJECT HEADINGS: Natural gas, Gas distribution station, Automatic control, Computer application, Testing, Application.

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Yu Hancheng (*Survey and Design Research Institute of Sichuan Petroleum Administration*), Wang Yukang: **DEVELOPMENT OF HIGH-SULPHURE GAS FIELD AND PILOT TESTING OF WELL WO 63**, **NGI** 16(3), 1996: 69～73

ABSTRACT: The general situation of developing the high-sulphure gas fields abroad is simply introduced. some technical problems in pilot testing of well Wo 63 in east Sichuan in the aspects of making plan, designing flowsheet, selecting material and operating are expounded. The corrosion situation of the well is also introduced and the problems of hydrate genesis and sulphure sedimentation are discussed.

SUBJECT HEADINGS: High Sulphure, Gas field development, H_2S corrosion. Control, East, Sichuan, Gas well, Pilot testing.

Qian Baizhang (*Shanghai Refinery*): **ADVANCED CONTROL NEW DEVELOPMENT OF NATURAL GAS PROCESSING**, **NGI** 16(3), 1996: 74～78

ABSTRACT: In order to enhance the economic benefit of natural gas processing, the newest control project and analog are developed by oversea companies one after another in recent years. The optimal control project for enhacing NGL recovery ratio with the devices of low-temperature oil absorption and expansion refrigeration are enumerated. The design and process control optimal models of desulfurizing device, mult-stream heat exchanger, glycol dehydrating device, ethylene glycol/methanol injection facilities, NGL recovery/stable device and denitrogenation device are introduced. An example of control project is presented.

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Cheng Gengliang (*Natural Gas Research Institute of Sichuan Petroleum Administration*): **APPLICATION OF PHYSICAL SEPARATION PROCESS TO NATURAL GAS PURIFICATION**, **NGI** 16(3), 1996: 79～85

ABSTRACT: At present, most of gas purification techniques are the patterns of chemical reaction. It is necessary developing new techniques to meet the needs of separating many kinds of special unstripped gas and to improve the indexes of equipment, investment, operation cost, purification rate and environmental protection etc. Since the 1980s, physical separation methods are in the accendent of gas purification. The applied situations of the three physical separation such as membrane separation low-temperature fractional distillation and pressure-swing adsorption are introduced.

SUBJECT HEADINGS: Natural gas, Membrance permeation, Low temperature, Fractional distillation, pressure-swing adsorption method. Application, Developing trend.