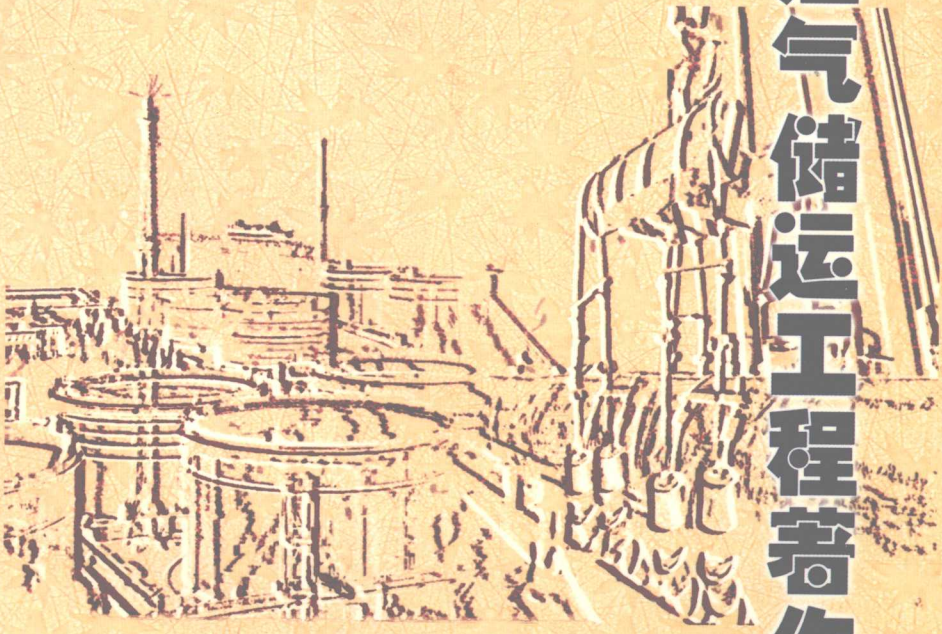
潘家华油气储运工程著作选集



第二卷

石油工业出版社

潘家华油气储运工程著作选集

第二卷

石油工业出版社

内 容 提 要

本卷荟萃了著名的油气储运工程技术专家潘家华撰写的论文20篇，主要论述我国管道运输业的发展及前景；管道输送用钢管的发展趋势；管道断裂问题；油气管道断裂力学分析；LPG库的设计与运营；普及和发展我国管道内检测技术以及管道安全的科学管理等，是作者根据油气管道工业不断发展的新形势，对管材选择、螺旋焊管质量、管道断裂事故、管道运行安全等诸多问题进行科学研究和实践经验的总结。本选集理论精辟，见解独特，视野开阔，资料翔实，是一部集科学性、实用性、指导性和可读性于一体的科技文献。

选集不仅适用于油气储运界的工程技术人员，而且对石油化工、给排水、城市燃气与热力管网、煤与矿浆管道等作业的技术人员和有关高等院校的师生有重要的参考价值。

图书在版编目(CIP)数据

潘家华油气储运工程著作选集.第2卷:汉英/潘家华著.
北京:石油工业出版社,2001.2
ISBN 7-5021-3260-0

Ⅰ.潘…
Ⅱ.潘…
Ⅲ.石油与天然气储运-文集-汉、英
Ⅳ.TE8-53

中国版本图书馆CIP数据核字(2000)第80861号

石油工业出版社出版
(100011 北京安定门外安华里二区一号楼)
油气储运杂志社排版　河北省廊坊市特教印刷厂印刷
新华书店北京发行所发行
*
850×1168毫米 32开本 8.75印张 236千字 印1—2000
2001年2月北京第1版　2001年2月河北第1次印刷
ISBN7-5021-3260-0/TE·2471
定价:35.00元

序

潘家华教授的油气储运工程论文，是中国石油管道事业宝贵的理论财富，第二卷、第三卷所收录的内容，涉及管道用钢、管道安全运行以及管道工业发展的各个方面，是他近十年来潜心研究成果的撷英，必将对管道事业发展产生重要影响。

中国石油管道由1970年东北"八三"会战开始，已经走过了三十年的光辉历程。随着国家"西部大开发"战略的实施，涩宁兰天然气管道、兰成渝成品油管道、忠武天然气管道相继开工建设，特别是"西气东输"工程即将动工，标志着管道事业进入了新的发展时期。三十年来，管道事业从无到有，从小到大，凝聚了无数科技工作者的心血和汗水，潘家华教授就是广大科技工作者的杰出代表。他以身作则，潜心研究，不仅解决了生产上的许多技术难题，而且带动了一大批有志投身管道事业的青年人，为丰富油气储运工程理论、为管道事业进一步发展奠定了基础。

潘家华教授忠诚于管道事业，尽管已经七十高龄，仍兼任中国石油管道系统技术顾问，兼任天津大学、上海交通大学、石油大学、解放军后勤工程学院等几所高等学府教授。他对管道发展战略以及钢材、管材、焊接、安全等方面技术问题极为关注，进行了大量研究，多次向国家有关部门提出自己的建议，并得到国家有关部门的重视与采纳。在国内许多企业和大型会议上做过学术报告，每每听者芸芸，均感受益匪浅。潘家华教授的文集，无论是对在役管道的运营，还是新管道建设，都提出了自己独到的观点。他的学术观点是建立在大量的实践与科学研究基础上的，目前国内外许多同行、专家、学者都与他保持密切联系。他的书桌、案头经常摆放世界最新的管道发展动态，他的研究成果始终相接于世界前沿水平。

潘家华教授是既有实践经验又有理论建树的管道专家，他任中国石油天然气管道局总工程师时，我任副局长，他既是我的同事，更是令我敬佩和尊重的老师。我任管道局局长时，他已经到退休年龄，但仍为管道事业的发展无私奉献着自己的智慧和学识。我感谢潘老对我的支持和帮助，也感谢他对管道事业的忠诚与奉献。

衷心祝愿潘家华教授健康、长寿，愿他为中国乃至世界管道事业的发展不断做出新的贡献。

中国石油天然气股份有限公司
西气东输项目经理部　陈吉庆
2000年12月30日

序

潘家华教授是原中国石油天然气管道局总工程师，是天津大学等多所高校的兼职教授。1952 年毕业于天津大学机械系。早年曾从事炼油厂机械与设备的教学和设计工作，70 年代初我国开始大规模建设长距离输油管道——东北输油管网时，潘家华同志即投身于管道建设，从设计工程师成为局的总工程师。他特别注重从工程实践中发现问题，从理论上寻找原因，并吸收国外的经验，从而找出解决问题的途径。他在油气储运工程的实践中，第一个将断裂力学的理论用于管道和储罐的选材及设计工作，并不断修改完善有关的设计、施工技术规范。

他是将风险管理的理论和方法引进我国油气储运工程的首创者。他所著的“油罐及管道强度设计”等专著，不仅是高等院校储运专业的教材，也是设计、施工人员的重要工具书。近年来，他作为原总工程师和现高级顾问，更是从我国能源发展战略的高度，对我国油气管道的发展方向和应注意的问题，以及油气战略储备的规划等发表了重要的论证。

继 1993 年出版了第一本潘家华油气储运工程论文集以来，这第二、第三两卷选集荟萃的论文正是潘总根据我国油气管道工业不断发展的新形势，在管材选用、焊管质量，管道断裂事故分析、管道运行安全及风险管理等方面进行科学研究及工程实践经验的总结，不仅适用于油气储运界的工程技术人员和高等院校师生，对石油化工、燃气输配、热力管网、煤及矿浆管道等行业的技术人员也有重要参考价值。

当前我国的油气管道建设正面临一个新的高潮，连绵近 4 000 千米的西气东输工程即将开工建设，中俄油气管道工程也正在规划之中，城市输配气管网正在迅速发展，相信这两本选集的出版无疑是一场及时雨。

梁禽章　严大凡

2000 年 12 月 30 日

目　录

The development of China's long distance pipeline industry

China was one of the first countries to use pipelines as a transportation means. About a century ago, people in Sichuan Province broke the diaphragms inside bamboos, making the bamboos open bamboo pipes. They connected these bamboo pipes together, and wrapped the joints with thin bamboo strips and sealed them with tung oil and lime, thus forming pipelines to transport bitumen or natural gas. According to the historical material recorded in the book entitled *The Summary of Salt Business in Sichuan*, there were as many as twelve bamboo pipelines of this kind in the Sichuan Province then, with a total length up to 200 km, and the number of people specially engaged in pipeline construction had topped 10 000. However, the development of China's modern pipeline industry only dates back over the last two decades. We, therefore, can say that China's pipeline industry is an old as well as new industry.

The distribution of China's long distance pipelines

The total length of China's long distance pipelines is over 10000 km. The first long distance pipeline was laid in Xinjiang Autonomous Region in the late 1950s, the diameter being 150 mm and length being 140 km; it was looped in the early 1960s. With the production increase of Daqing oilfield and the continuous development of new oilfields, China's pipeline industry has now developed into a new stage.

Daqing oilfield is the largest oilfield in China. All the crude

is pipelined to other areas apart from a small quantity processed by local refinery and fertilizer plants. In 1970, a 516 km long crude pipeline from Daqing to Tieling (near Shenyang City, Liaoning Province) was constructed, of 720 mm diameter and annual capacity of 20 million tons. In 1972, a loop of the same size was constructed.

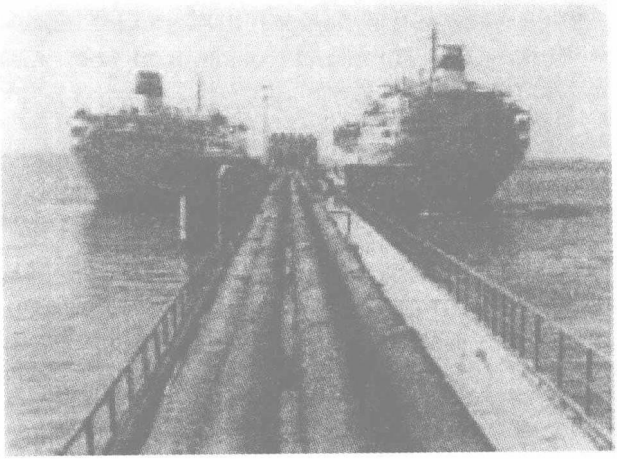


Fig. 1. Qinhuangdao oil wharf

When the Daqing crude oil reaches Tieling, it goes into three pipelines for further transportation. The first one, named the Tieling-Fushun pipeline, transports crude to the adjacent city Fushun to be refined and processed. The second one, named Tieling-Dalian pipeline, transports crude oil to Dalian, where part of the crude is sent to a refinery and the majority sent on Nianyuwan oil port, which can berth oil tankers of 100 000 DWT and from which the crude is exported abroad and shipped to other ports in China. The third pipeline named the Tieling-Qinhuangdao pipeline, runs to Qinhuangdao, where there is an oil port. Also there is a crude pipeline between Qinhuangdao and

Beijing transporting Daqing crude to Beijing to be processed.

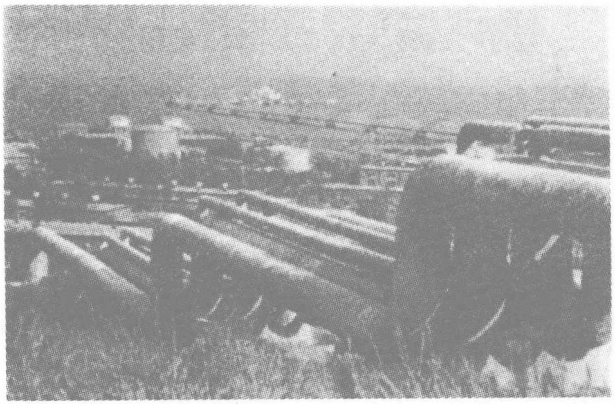


Fig. 2. Nianyuwan terminal with the wharf for the Tieling-Dalian oil pipeline in the background

Shengli oilfield is the second largest oilfield in China. Shengli crude, apart from some processed locally, is transported through two pipelines to other areas. The first one, named the Dongying-Huangdao pipeline, transports crude oil to Huangdao, close to Qingdao City. From an oil port at Huangdao, the crude is shipped by tankers to other domestic as well as foreign ports. The second one, named the Shandong-Nanjing pipeline, transports the rest of the crude to Yizheng on the northern side of the Yangzi River in Jiangsu Province and opposite Nanjing City. This pipeline, constructed and commissioned in 1975, is a 720 mm diameter, 655 km long trunk line running north-south.

As well as these major pipe links, there are many other pipelines transporting crude oil from the oilfields in Central China, Dagang and Northern China. At present in China, a preliminary pipeline network has come into existence with the basic transport directions being from east to west and from north

to south.

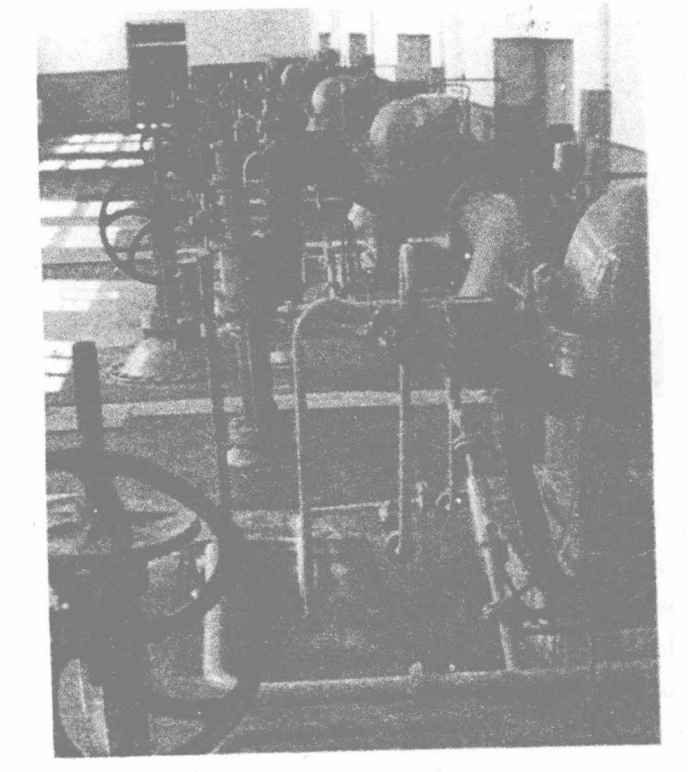


Fig. 3. A typical crude-oil pipeline pump station

China's natural gas pipelines are mainly located in Sichuan Province. China has fewer products pipelines, and petroleum products are now mainly shipped by railway.

The characteristics of China's crude oil for pipeline transportation

Almost all the crudes produced in oilfields in China are highly waxy, have a high pour point and are highly viscous.

Daqing crude, for example, has a pour point of 29 ℃, wax content 27.42% and viscosity 36.8 cp at 40℃. It is much more difficult to pipeline this kind of crude than to pipeline light crude (e.g. Middle East crude), for the following main reasons:

1. Since the ground temperature is below the pour point of the crude, heating during transportation is necessary, or else other measures are required to reduce the pour point for transportation.

2. When the pipeline is shut down for an emergency or other reasons, the crude temperature inside the pipeline decreases as time passes. To restart the pipeline after shutdown, pump discharge pressure must be high enough to overcome the yield stress of the crude in order to establish flow. If the shutdown time extends over a certain limit, then a 'plugging' problem may probably occur. For safe pipeline operation, this situation must be taken into account during the engineering design stage.

3. In the pipeline section adjacent to the suction at a pump station, the crude temperature is relatively low. There is probably a section in which crude has already behaved as a non-Newtonian Fluid. Under such conditions, the viscosity of the crude is related to shear rate, rapidly increasing with the decrease of the shear rate (flow rate). As the viscosity increases, the friction loss increases, resulting in a further reduction of the flow rate that causes the viscosity to increase again, worsening the situation in a vicious circle. Again, the plugging problem may also occur unless enough care is taken.

Chinese pipeline engineers have extensive experience in transporting high pour point, highly-viscous and highly-waxy crude oil, and have conducted a great many technical studies on the subject.

The method we mainly use at present is transportation with heating. The increase of the crude temperature to reduce the viscosity increases the fuel consumption of the heater, but decreases the electrical power consumption of the pump. On the contrary, maintaining the crude at a relatively-low temperature (above the freezing point) decreases the fuel consumption but increases the power consumption. We endeavour to control our pipeline operation using the most economical conditions.

Fig. 4. The Luning pipeline crossing Huaihe river, with one pipeline at each side of the lower bridge

In the past several years, we have conducted heat treatment studies on some of the crudes produced in some oilfields in China, and obtained relatively good results. For example, without heat treatment the freezing temperature of central China crude is 33℃; heat treatment reduces this temperature to 12℃, the yield strength from 584.5 to 225.84 dyne/cm^2(at 20℃), and the apparent viscosity from 1275.56 to 267.5 cp (at 20℃ and shear rate 9 mm/sec). After treatment, the crude tested was kept static for 3 days with no change of the newly-established freezing

temperature. The result of this research has been applied to the operation of the 237 km long 377 mm diameter Puyang-Linyi pipeline.

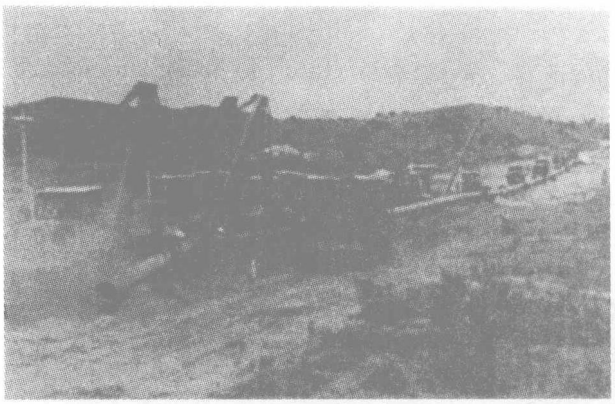


Fig. 5. Pipelaying

We believe that it is effective to use additives (e.g. drag reducers) to solve the bottle-neck problem, and we have been conducting research in this field. Similarly, we have also been studying transportation of high pour point and highly-viscous crude oils by the water-oil emulsion and heat tracing methods.

The challenges ahead

Pipeline engineers in China have been confronted with the following challenges:

1. Although the exisiting crude oil pipelines in China have now operated smoothly for more than a decade, the economic targets are relatively low, with relatively-outdated technical process and a low level of automation and control; the equipment used (such as heaters, pumps. etc.) is comparatively inefficient, and some safety measures are not very complete. Therefore, almost all the existing pipelines need upgrading or renovation.

2. China is a country very rich in oil and gas resources, and with the development of oilfields, many new pipelines will be constructed. When the oilfields in the Xinjiang Autonomous Region and in Qinghai Province are developed, the construction of pipelines for those fields will be a very arduous task, because the pipeline must traverse the Gobi and other uninhabited areas.

3. To enter new areas where pipelines can offer their services, Chinese pipeline engineers will have to extend their expertise as widely as possible.

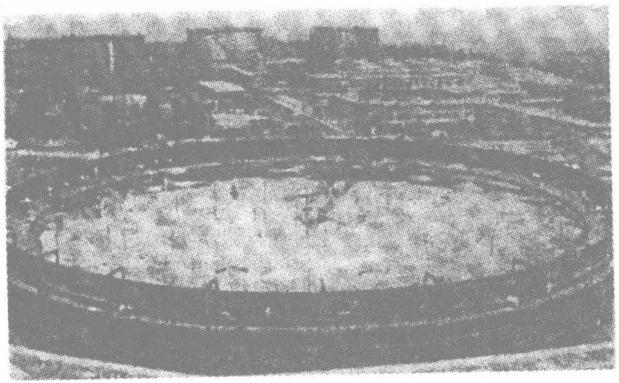


Fig. 6. A typical view of a nearly-complete oil tank with a floating roof

In the world today, coal-slurry pipeline technology has been successfully used for commercially-operated pipelines. China has vast coal resources, and from the development point of view, coal slurry pipelines have a very bright future in China. At present pipelining the coal produced in Shanxi Province to other areas is being actively considered as the first of several such projects.

With the development of offshore oil resources, Chinese pipeliners are working jointly to construct offshore pipelines with foreign countries.

The district heating pipelines transporting hot water at 100 ~150℃ in urban areas in China are laid in conduits. In recent years, many countries have adopted the method of directly burying insulated pipelines underground; this latter concept requires less capital investment, and minimizes heat loss. We are also eager to develop this technology in China.

In China the pipeline industry is a new industry and an industry with boundless prospects and a great future. Pipeliners in China are willing to learn from their foreign colleagues and make technological progress together with them.

选自 "PIPES & PIPELINES INTERNATIONAL"
September~October 1984

The development of China's oil and gas pipeline industry

China is the first country that constructed long distance pipeline. The ancient Chinese used bamboos to build pipelines, which were called *jian* (筧 or 槚). Recorded in the book *The Annals of Salt - making Methods in Sichuan* was " … With the diaphrams being broken through, the Mottled bamboos or Nan bamboos were bell-and-spigot jointed and the joints were wrapped with hemps and sealed with tung oil and lime, thus forming bamboo pipeline going with the contour of the ground." In the ancient times when man could not make steel pipes, it was really a great creation to use bamboo pipes to transport natural gas or bittern.

The meaning of the ancient Chinese word *zhijian* (置筧) is to construct pipeline on the ground. According to the historical material recorded in the book *The Summary of Salt Business in Sichuan*, there had been as many as twelve bamboo pipelines with the total length up to two to three hundred Chinese *Li*, and the number of the people specially engaged in the pipeline construction had already come to above ten thousand.

However, only after 1949 did China start the construction of her modern long distance pipeline. The Baxian-Chongqing natural gas pipeline, 55. 6 km long and 426 mm O. D., came into operation in March 1963. Since then, more than ten natural gas pipelines have been built in Sichuan Province and all of them are now in normal operation.

In the late 50's, China's first long distance crude oil pipeline