粉体高浓度气力输送控制与分配技术

周建刚　沈颐身　马恩祥　等著

冶金工业出版社

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Technology of Powder High Density Pneumatic Conveying and Control and Distribution

Zhou Jiangang Shen Yishen
Ma Enxiang et al.

Beijing
Metallurgical Industry Press
1996

内容简介

本书紧紧围绕“粉体的高浓度输送、控制与分配技术”这一主题，精练地概括了这一领域最近发展动态和取得的成果；着重分析了水平管高浓度输送分层流动机理，建立了分层流动数学模型，用力平衡法对高浓度输送压降进行计算，计算精度高于其它方法；翔实地介绍了粉煤高浓度输送技术在高炉生产中的应用，包括工艺参数的确定、工业装置的设计、输送量的控制和分配方法。

本书适用于化工、冶金专业从事粉料输送的基础研究人员，工程技术人员和生产管理人员及有关专业的大学师生阅读参考。

前　言

众所周知，粉体的高浓度输送技术和稀相输送技术相比有如下特点：

高浓度输送能力大，其输送能力是同样管径稀相输送的3倍。

高浓度输送速度低，这样可以大大减少管道和其它机械元件的磨损，而且降低静电产生的能量，有利于高挥发分煤粉的安全输送。

高浓度输送所需载气量小，在同样喷吹量的条件下，仅是稀相输送所需气量的1/4～1/10。这样在扩大输送量时，无须扩大气源，可以节省动力源。

与稀相输送相比，输送同样的粉料量，采用高浓度输送时，其输送管路的截面积大为减小，这将节省材料。

由于高浓度输送技术主要是在粉料流态化后进行输送，所以粉料流稳定、均匀、脉动现象小。

高浓度输送固气比高，可达到50kg（粉）/kg（气）以上。与稀相输送相比，在输送粉料相同的情况下，鼓入工业窑炉内的冷空气大大减少，这将有利于提高炉内温度，减少热损失。这一优点在高炉大量喷吹煤粉时显得尤为重要。

冶金工业部钢铁研究总院、北京科技大学和中国科学院化工冶金研究所的有关基础理论研究人员和工程技术人员组成联合体，在冶金工业部科技司直接领导下，共同研究和开发了粉体高浓度输送控制及分配技术，并进行了深入的基础理论与实验室研究和工业试验。

近年来，该技术已应用于喷粉冶金和粉煤燃烧等生产过程中，取得了明显的经济效益。本书收集了作者撰写的“粉体高浓度输送、控制与分配技术”方面的技术论文，共计33篇。

本书内容包括综合论述、基础研究和技术应用三个部分。综述部分概括了这一领域最近发展的动态和取得的成果；基础研究部分着重分析了水平管高浓度输送分层流动机理，建立了分层流动数学模型，通过力平衡法对高浓度输送压降进行了计算。计算结果表明其精度明显高于压降比法、经验公式法和附加压降法，可与国外一些学者的模型相媲美，成为目前高浓度输送压降研究的重点和发展方向。在此基础上所研究的浓相气力输送的相图及用光导纤维探测系统对粉体浓度分布的测量都具有一定的理论意义和实用价值；技术应用部分主要介绍了粉煤高浓度输送技术在高炉生产中的实际应用，包括工艺参数的确定、工业装置的设计、输送量的控制和分配方法。在高炉喷煤系统中以流化装置代替传统的给煤器，输送浓度高、速度低、输送稳定；以气力调节煤量方法代替传统的机械调节方法，煤量调节灵活可靠、范围宽，且调节装置寿命长；工业使用盘式或球形分配器结构简单、精度较高、寿命较长，特别是球形分配器的阻损低，适于高浓度煤粉流的均匀分配。经过工业验证的煤粉高浓度输送工艺，已成为当今高炉喷煤的新流程。

总之，这本书是我们“八五”期间在这一领域所作科研工作的总结，是全体研究人员从事理论和实践研究的结果。我们期望它的问世能对同行有所裨益，有助于推动这一领域的研究深入发展。

本书适用于冶金、化工专业从事粉料输送的基础研究、工程技术人员和生产管理人员阅读，也可供大学生、硕士和博士研究生参考。

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1995年11月

Preface

As compared with dilute phase trasportation, high density pneumatic conveying of powder has the following features:

With a high capacity the high density pneumatic conveying, its capacity is three times as large as dilute-phase transportation under same diameter of pipe.

With a lower velocity the high density pneumatic conveying reduces the wear of conveying lines and other mechnical parts, and the energy produced by static electricity. Thus, it is safer to convey the pulveringd coal of higher volatile matter by high density pneumatic conveying.

Since high density pneumatic conveying need only have a less amountof carry gas, as much as 1/4～1/10 rate of gas flow consumed in dilute phase transportation under the same injection conditions, it is not necessary to forward more gas supply for the purpose of increasing transportation powder rate. Therefore, less dynamic source is needed.

High density conveying also uses less raw material because its section area of conveying line is smaller than that of dilute phase pneumatic conveying line, when they convey the same rate of powder.

The fact that the high density conveying technique is practised after coal powder is fluidized means stable and even powder flow and less common pulsating phenomenon.

High solid/gas ratio of high density pneumatic convey (about 50 kg solid/kg gas or a little more) blows less cold air into industrial furnace, which results in higher furnace temperature and less calorific loss. This is a very important strongpoint when a large amount of

pulverized coal is injected into the Blast Furnace.

The research work and development of the technology of high density pnuematic conveying of powder and its control and distribution have been carried out successfully. Further theoretical study, lab and industrial test have been completed. Under the direct leadership of Department of Science & Technology of Ministry of Metallurgical Industry, professors and engineers from many units, including Central Iron & Steel Research institute, MMI, University of Science & Technology Beijing and Institute of Chemical Metallurgy of Chinese Academy of Sciences, worked together and did a satisfactory job.

Recent years, the technology has been used in the production process of jet metallurgy and pulverized coal combustion, and remarkable economical benefits have been got. Research papers on powder high density pneumatic conveying and control and distribution technology (total 33 papers) written by the researchers are collected here in the book.

Under the title of "technology of powder high density pneumatic conveying and control and distribution." This collected papers consist of three part, i. e. technical reviews, fundamental research papers and technical application. The first part summaries the recent development and achievement in this field. The second part includes analysis of a mechanism of stratified flow in horizontal high density pneumatic conveying, and the establishment of a mathermatic model of stratified flow state, and the calculation of the pressure drop of high density conveying through a method of equilibrium of forces. The calculation shows that its accuracy is distinctly higher than pressure drop ratio method, experience formula method and additional pressure drop method, and it compares favourably with the models by some foreign scholars, and has become the current development derection and a key problem studied in high density convey-

ing pressure drop. The study on the phase-diagram in dense-phase pneumatic transport and the application photocouductive fiber probe system to meassuring concentration distribution of powder based on the above research are fairly theoretically significant and practically valuable. The third part introduces emphatically practical application of dence-phase conveying technology of pulverized coal in Blast Furnace production. This part includes determination of process parameter, design of industrial installation and control of conveying rate and distribution of powder flow. In the pulverized coal system on Blast Furnace, and fluidized unit replaces traditional feeder, It has higher conveying density and lower velosity and static conveying. The method of pneumetic adjustment coal rate replaces traditional method of machine adjustment, it has elastic and reliable regulation of coal discharge mass flow rate, and its regulation extent is wide and the regulation unit has long service life. The structure of the ball-like or tray-like distributor of industrial application is simple, and has a higher distribution accuracy, and a longer service life. As a result of its low pressure drop the ball-like distributor suits even distribution of high density flow of pulvirized coal. The process of high density conveying of pulverized coal tested industrially has become a new technological process at the precent Blast Furnace coal injection.

In brief, the collected papers provide a sumary of the research work in this field during the eigth five-year plan in our country. It is the achievements of all members engaged in theory and practice research. To some extent, it will contribute to the further research work of this field.

This proceedings suitable for members of metallurgical and chemical fundamental research, and engineering technique and production managemant, and is a good reference look for the college

studants of university and including post graduates and Ph. D students.

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November, 1995

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高炉喷煤新流程及高浓度输送相图

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摘　要：本文对几种常见的高炉喷煤稀相输送流程进行分析对比，提出了一种适合于高炉喷煤高浓度输送的新流程，即喷粉罐底部流化，上出料总管输送，补气调节，炉前分配器分配。同时，为此新流程建立了管道高浓度输送数学模型，进而制成非柱塞高浓度输送相图，它对高炉大煤量喷吹有重要的实用价值。

关键词：高炉喷煤、喷煤流程、高浓度输送、相图

1. 引　　言

高炉氧煤强化炼铁工艺是要在高富氧条件下向高炉风口喷吹大量以至超量煤粉，我国原有的喷煤设备能力难以达到要求，原因是：国内喷吹系统一般为稀相输送方式，固气比 5～10kg（粉）/kg（气），输送能力低，耗气量大，若增加喷煤量，必须扩大输煤管直径，但这对于煤粉分配器和氧煤枪的合理结构及保持炉缸热制度都带来不利因素。此外，增加喷煤量的同时，输送管内速度相应增加，势必造成管道磨损问题，引起设备事故（漏煤、停喷）。解决上述问题的有效办法是采用先进的煤粉高浓度输送技术，它可以提高固气比，降低输送速度，在适宜的输送管路直径范围内，达到大能力的煤粉输送以及均匀分配的技术要求。为提高我国喷煤系统装备水平，满足高炉氧煤强化炼铁的需要，研