中文：

在矿井中，两相流中的两相即易燃易爆气体和煤粉颗粒给井下工作人员的生命健康和安全带来极大威胁。因此，排除井下空气中煤粉颗粒的干扰实现 高效、快速以及实时的矿井气体在线检测，对于井下作业人员的生命安全和防止瓦斯爆炸事故的发生都有重要意义。 本文模拟矿井中气固两相流的真实环境，搭建了气体红外光谱数据的采集系统，采集了五种极性矿井气体的红外光谱数据，包括二氧化碳（CO2）、甲烷（CH4）、乙烷（C2H6）、 丙烷（C3H8）和丁烷（C4H10）， 然后建立支持向量机（SVM）及其改进模型和 极限学习机（ELM）及其改进模型，对矿井下气固两相流中的混合气体进行定 量分析研究，并对各种模型的结果进行比较分析，提出了一种基于 FTIR 技术的矿井下气固两相流中气体组分的在线测量方法。 本文的结构安排如下：

第一章，主要介绍本文的研究背景和目前主流的气体检测方法以及其各自的优点和缺点。论述了在气体检测领域，红外光谱技术的国内外发展现状、研究重点和未来发展趋势，同时介绍了本文的研究目的和研究意义。

第二章，主要介绍红外光谱分析技术的基本原理，包括红外光谱的产生及其如何划分、红外光谱法的基本原理和红外光谱定量分析技术。阐述了红外光谱应用于多组分混合气体定量分析的相关理论、光谱数据预处理方法和各种模型的原理和评价标准。

第三章，详细介绍气固两相流中气体组分红外光谱数据采集系统，以及其中最为重要的配气装置的研发，设计了合理的配气方案。根据本文的研究目标研发了简单、易操作的配气装置，可以根据配气方案精确地计量输入到气体池中气体的量，通过红外光谱仪得到每个样本的红外光谱图，分析每种气体的特征吸收峰、吸收波段等，为气体定量分析模型提供可靠的实验数据。

第四章，利用小波变换对原始光谱数据进行降噪处理，然后采用两种特征提取方法即峰值提取法（PEM）和主成分分析法（PCA）对降噪后的数据进行特征提取和降维，最后建立基于 SVM 的矿井下气固两相流中气体组分的定量分析模型。以甲烷（CH4）为例，采用不同参数寻优方法，对SVM 模型的预测精度进行分析，确定利用 PSO 算法对 SVM 的惩罚参数 c 和核函数参数 g 进行寻优，建立基于 PSO 算法的改进 PEM-SVM 模型和改进 PCA-SVM 模型。结果表明，在预测 C2H6、C3H8 和 C4H10 三种低浓度气体时，改进 PEM-SVM 模型的预测精度较高，在预测 CH4 和 CO2 两种高浓度气体时，改进 PCA-SVM 模型预测的精度较高，最后整合两个模型的优点，建立了 PEM-PCA-SVM 集成模型。

第五章，利用极限学习机（ELM）对矿井下气固两相流中气体组分进行定量分析，采用峰值提取法（PEM）和主成分分析法（PCA）对小波降噪后的数据进行特征提取和降维处理，提高了建模效率，并对极限学习机算法做出了改进，建立了基于 D-ELM 的矿井下气固两相流中气体组分的定量分析模型，即PEM-D-ELM 模型和 PCA-D-ELM 模型，并整合了两个模型的优势，建立了集成 PEM-PCA-ELM 模型。使用测试集样本对 PEM-PCA-ELM 模型进行测试验证并和 PEM-PCA-SVM 模型进行比较，发现 PEM-PCA-ELM 建模速度较快，但在预测精度方面不及 PEM-PCA-SVM 模型。

English Version：

Two-phase flow in the coal mine includes flammable and explosive gas and coal particles, brings a great threat to workers’ health and lives. Therefore, eliminating the interference of coal particles is important for high efficient, rapid and real-time on-line detection of mine gas, also it is significant for the safety of mine workers and can avoid gas explosion accidents. In this thesis, simulating the real environment of mine, and an experiment system was set up to collect the gas spectra of methane(CH4), ethane(C2H6), propane(C3H8), butane(C4H10) and carbon dioxide(CO2). Then, a support vector machine (SVM) and its improved model and extreme learning machine (ELM) and its improved model are established to quantitatively analyze the mixed gas in the gas-solid two-phase flow in the mine, and the results of each model are compared. This thesis presents an on-line measurement method of gas composition in gas - solid two - phase flow based on FTIR technology. The structure of this thesis is as follows:

The first chapter introduces the research background and current mainstream gas detection methods and their respective advantages and disadvantages. The development status, research focus and future development trend of infrared spectroscopy in gas detection field are discussed. At the same time, the purpose and significance of this thesis are also introduced.

The second chapter introduces the basic principle of infrared spectroscopy, including the generation of infrared spectrum and how to divide it, the basic principle of infrared spectroscopy and the quantitative analysis of infrared spectroscopy. The theory of infrared spectroscopy applied to the quantitative analysis of multi - component mixed gas, the principle of spectral data preprocessing and the principle and evaluation standard of various models are described.

In the third chapter, we introduce the infrared spectrum data acquisition system of gas component in gas-solid two-phase flow, and the development of the most important gas distribution device, and design a reasonable gas distribution scheme. According to the research objectives of this thesis, a simple and easy-to-operate gas distribution device is developed. The amount of gas input to the gas pool can be accurately measured according to the gas distribution scheme. The infrared spectrum of each sample is obtained by infrared spectrometer. Characteristic absorption peak, absorption band, etc., provide reliable experimental data for the gas quantitative analysis model.

In the fourth chapter, the original spectral data is denoised by wavelet transform, and then the feature extraction and dimension reduction of the data after noise reduction are carried out by two kinds of feature extraction methods: peak extraction method (PEM) and principal component analysis (PCA) Finally, a quantitative analysis model of gas composition in gas-solid two-phase flow based on SVM is established. Taking the methane (CH4) as an example, the prediction accuracy of the SVM model is analyzed by different parameter optimization methods. The PSO algorithm is used to optimize the penalty parameter c and the kernel function parameter g of the SVM algorithm. PEM-SVM model and improved PCA-SVM model is established based on the PSO algorithm. The results show that the prediction accuracy of the improved PEM-SVM model is high when the two kinds of low concentration gas of C2H6, C3H8 and C4H10 are predicted. The accuracy of the improved PCA-SVM model is high when the high concentration of CH4 and CO2 are predicted. Finally, the advantages of the two models are integrated, the PEM-PCA-SVM integrated model is established.

In the fifth chapter, the gas components in the gas-solid two-phase flow in the mine were quantitatively analyzed by the ELM. The data were reconstructed by PEM and PCA. After feature extraction and dimension reduction, the modeling efficiency is improved, and the algorithm of ELM is also improved. Quantitative analysis models of gas components in gas-solid two-phase flow based on D-ELM are established, PEM- D-ELM model and PCA-D-ELM model, and the integrated PEM-PCA-ELM model is established integrating advantages of the two models. The PEM-PCA-ELM model was tested and verified by using the test set samples and compared with the PEM-PCA-SVM model. The PEM-PCA-ELM model is found to be faster, but the prediction accuracy of PEM-PCA-SVM model is not as good as PEM-PCA-SVM model.