

耐高温、耐火特种电缆

刘永刚 张敬宝 张栋琪 李浩博 任达庆

大庆油田有限责任公司昆仑集团电缆有限公司

摘要: 电缆作为仪器装备间的主要传输线,对生产控制系统有效运行起着至关重要的作用,尤其在有耐高温、耐火要求的石油及化工场所,对耐高温、耐火特种电缆的需求与日俱增。根据产品使用特性,从材料、结构、工艺3方面出发,采用耐温高分子材料,设计了绕包耐火层和多芯不等截面结构,应用无缝绕包、高温连续挤出和不等芯成缆技术,实现产品的规模化生产,产品性能国内领先,长期工作温度可达180~200℃,耐火焰燃烧90min。

关键词: 耐高温;耐火;特种电缆;高分子材料

DOI: 10.3969/j.issn.1002-302x.2017.z1.022

中图分类号: TM249 文献标识码: A

随着工业自动化程度越来越高,以及未来智能化仪表系统要求多类信号集中控制^[1]来提高运营效率,降低采购成本。在石油、化工、矿井、电站及对于公共安全要求高的场所,尤其在新兴的页岩油开采中使用了先进的萃取技术以后^[2],作为仪器装备间的主要传输通道的电缆,需要同时具有耐高温性能和耐火功能,以确保高温环境下正常工作和发生异常火灾时能够继续工作一段时间。选用耐温高分子材料,是实现该特种电缆的必备前提,但随着材料耐温能力的提升,加工性随之会骤然下降。如何保证用其生产的电缆在具有耐高温能力的同时能够满足电气和机械性能成为技术难题。针对上述问题,以氟塑料合成材料、合成硅橡胶材料和云母带材为基础材料,运用无缝绕包、高温一体化连续挤出、连续硫化等技术,实现了耐高温、耐火特种电缆的规模化工业生产,为高温环境下设备的通信、供电使用安全提供保障。

1 选用高分子材料的特性

通过研究,氟塑料和硅橡胶具有较高的耐温能力和耐腐蚀能力,产量充足,产品较成熟。欧美发

达国家已经把氟塑料和硅橡胶广泛应用于有耐高温和耐有机溶剂要求的石油化学工业中^[3]。

1.1 耐温氟塑料特性

耐温氟塑料的熔融黏度大,有较高的可拉伸性,需高温挤出,挤出温度达到275℃以上时才能达到熔融状态,而此时熔融树脂会出现熔融破裂倾向,温度范围极窄,必须保证挤出机的温度稳定和精度控制^[4],需特制高温塑料挤出机在高精度温度控制下进行加工,成品率较低。国内此类电缆的生产刚刚起步,由于其材料特性,加工门槛很高,需要一定的硬件设备和技术支持。

1.2 耐温硅橡胶特性

硅橡胶作为一种合成橡胶,胶料中需加入多种特殊配合剂,才能达到特有的耐高温、耐腐蚀、高强度等特性,但配合剂有导致原胶塑性降低、使材料结构化倾向,需达到助剂与原胶的临界混合比,提高其可加工性^[4]。同时硅橡胶挤出后需进行连续硫化,以提高胶料的弹性并去除硫化时产生的分解物和配合剂中的水分,这一硫化过程在高温常压下进行,必须严格控制温度与出线速度的配合,以防止和克服硅橡胶橡皮起泡和喷霜,加工工艺十

基金项目: 大庆油田有限责任公司科研项目“耐高温、耐火特种电缆的开发”(编号: DQC-2013-dm-KY-002)。

获奖情况: “耐高温、耐火特种电缆的开发”2015年获大庆油田有限责任公司技术创新三等奖。

获专利情况: “耐高温、耐火特种控制电缆”(专利号: ZL201520284220.1)、“多芯不等截面耐高温、耐火控制电缆”(专利号: ZL201520281885.7)。

第一作者简介: 刘永刚,1981年生,2005年毕业于哈尔滨理工大学电气工程及其自动化专业,获学士学位,工程师,从事电缆生产制造、产品开发工作。E-mail: lyg.57@163.com

分复杂。

2 耐高温、耐火特种电缆生产技术

2.1 原料分析方法

为了能够更好地掌握材料的加工特性，在材料的选择阶段，借助红外光谱、套扫描电镜、原子力显微镜和 X 射线分析仪等，从微观方向深入研究材料特性，多方面充分考虑选择性能更优越、经济性更好的原材料，并根据性能要求重新制定材料配方，实现指标的可控性。

2.2 耐火层无缝绕包技术

因选用的材料具有较大的黏度，在不平整的表面外挤制时极易出现断胶情况，导致绝缘层不能实现连续挤出，耐高温电缆无法实现耐火特性的现状。通过对绕包技术的研究，根据绕包前的外径，精确计算绕包角度、包带宽度和绕包节距，实现耐火层无缝绕包，保证了绕包后的外径均匀一致，达到了绕包层不会对绝缘挤出造成影响。

2.3 不等截面成缆技术

为了满足未来智能化仪表系统要求多类信号集中控制要求，将不同截面线芯集合到同一条电缆中，在研究了成缆绞合的单线在绞合中的形变、退扭绞合时单线的扭转、成缆节距、成缆绞合方向等原理后，设计了多芯不等截面成缆结构，可根据不同截面线芯的数量和截面积实行不同的绞合排列和绞合参数，实现了不同截面线芯同缆，达到多类信号集中控制要求。

2.4 绝缘和护套的连续挤出技术

深入研究高聚合物的聚集态，通过大量的试验获得所用氟塑料的熔融指数曲线，找到避免熔体破裂的时间和温度节点，精确控制各段挤出温度、螺杆转速，选取半挤管式模具，重新设计模具的配合角度等技术，实现了绝缘和护套的连续稳定挤出。

3 现场应用情况

随着高温工业的发展，2014—2017 年期间在大庆油田塔 1-11 集油间卸油点新建工程、塔 21 区块产能建设工程、塔 19 区块产能建设工程等工程项目中累计使用耐高温、耐火特种电缆数十万千米，产品能够在高温环境下实现稳定的信号传输、电能输送，能够耐受环境的腐蚀和机械外力，有效减轻了电缆在敷设、安装、使用过程中受到的外界作用，运行平稳、信号传输准确，运行成本得到降低，安全有力地保障了高温环境下油田的产能建设。

4 结束语

该耐高温、耐火特种电缆能够在高温、高腐蚀、易燃等恶劣环境中平稳运行，其无缝绕包技术、绝缘和护套的一体化连续挤出、连续硫化等技术可以从根本上解决普通电缆耐温能力差的缺点，将长期工作温度从 90℃ 提高至 180℃，并可在火焰燃烧下持续供电 90min 以上，产品处于国内领先水平，可为在石油、石化、化工等、冶金高温行业提供安全可靠的产品保障。

【参考文献】

- [1] 汪祥兴. 电子计算机线缆的新进展[A]//上海电线电缆研究所. 电线电缆技术资料汇编特种电线电缆[C]. 上海: 上海电缆研究所信息中心, 2001: 189-190.
- [2] 张大伟. 中国油气资源可持续供给战略与对策[A]//中国石油地质年会学术委员会. 中国石油地质年会论文集[C]. 北京: 石油工业出版社, 2005: 42-43.
- [3] 章基凯. 有机硅材料(第一版)[M]. 北京: 中国物资出版社, 1999: 482-483.
- [4] 徐应麟. 电线电缆手册(第二册)(第二版)[M]. 北京: 机械工业出版社, 2001: 319-321, 471-473.

(收稿日期: 2017-10-13)

Yangzhou Steel Pipe Company is a technological leader in the key production processes like edge milling, forming and high-frequency contact welding process. The edge milling machine adopts the tilting cylindrical cutting tool. The cutter has a diameter of 850mm. FFX forming technology can easily adjust the type of steel pipe with a reasonable structure. The new-type double electrode contact welding equipment can adjust pressure in an elastic way to reduce the scars caused by the electrode on the surface of steel pipe and prevent the electrode from being damaged. Based on the market demands and optimization of product categories, the company has completed development and production of various steel pipes dedicated to special applications, such as casings for ore pulp transmission, low-temperature stations, low yield ratio, anti-acid steel pipes for ultra-high voltage electric transmission tower, X70M high-quality steel pipe and expandable casings. They filled the domestic blanks in many application areas of HFW steel pipes.

Key words: HFW steel pipe, pipe manufacturing process, edge milling, forming, high-frequency welding, pipes for special purposes

DOI: 10.3969/j.issn.1002-302x.2017.z1.020

76 DN1200 Low-temperature Tee of X80 Steel Grade

Liu Jinsheng, Zhu Peng, Li Yuzhuo, Zou Feng, Yan Lijun

(China Petroleum Pipeline Machinery Manufacturing Co Ltd, Langfang 065000, China)

Abstract: Pipeline of high steel grade, large diameter and service under the extreme environment is the international frontier technology of oil and gas pipeline. The designed temperature is -45°C for the domestic segment of the eastern Chinese-Russian natural gas pipeline project. Therefore, the research on pressure piping components for the project is of great urgency. This paper analyzes design, materials and manufacturing process of thermo-extruded tee and summarizes the key technologies of high steel graded, large-diameter and low-temperature thermo-extruded tee, such as structural design, raw material composition, thermoforming and heat treatment control, aiming to provide the related qualified products for the eastern Chinese-Russian low-temperature pipeline of X80 steel grade.

Key words: X80 steel grade, large diameter, low temperature, tee, heat treatment, physical and chemical properties

DOI: 10.3969/j.issn.1002-302x.2017.z1.021

80 Special Thermostability and Fire-resistant Cable

Liu Yonggang, Zhang Jingbao, Zhang Dongqi, Li Haobo, Ren Daqing

(Cable Company of Daqing Oilfield Kunlun Group Co Ltd, Daqing 163001, China)

Abstract: As the main transmission line for instruments and equipment, cable plays an important role in effective operation of production control system. Particularly in the petroleum and chemical worksites which are required to meet the demand for high temperature resistance and fire resistance, the demand for special thermostability and fire-resistant cable is on the rise day by day. Based on the application characteristics of products and focusing on three areas of material, structure and process, the cable adopted temperature-resistant high-molecular material and was designed to have the winding refractory layer and the multi-core unequal cross section structure. It makes use of the technologies like seamless wrapping, high-temperature continuous extrusion and unequal core cabling, bringing about industrialization of products. As a domestic leader, the product can work long under the temperature of $180\sim 200^{\circ}\text{C}$ and in flame for 90 minutes.

Key words: thermostability, fire-resistant, special cable, high-molecular material

DOI: 10.3969/j.issn.1002-302x.2017.z1.022

82 Reinforced Functional Steel Skeleton Plastic Composite Pipe and Its Technology

Feng Haiyan

(Pipe Company of Daqing Oilfield Kunlun Group Co Ltd, Daqing 163001, China)

Abstract: This paper focuses on modification and mechanism study of anti-static temperature-resistant base material and domestic raw material for production of steel skeleton plastic composite pipe. Based on phosphate surface treatment technology and optimization of structural design for pipe pressure grade series, reinforced functional steel skeleton plastic composite pipe was put into mass production. As a result, traditional composite pipe can have some special functions, such as electrostatic conductivity and temperature resistance, in addition to the characteristics of double-sided anti-corrosion, anti-aging, and long service life (more than 50 years). Reinforced functional steel skeleton plastic composite pipe was widely used for oil and gas gathering and transferring of oil fields, mines and chemical enterprises as well as urban water supply, heating, drainage and transmission of high-pressure fuel gas, expanding the application area of pipe. Currently, the annual sales of product are about 260 kilometers while the revenues reach 100 million yuan.

Key words: plastic composite pipe, steel skeleton, anti-static, temperature resistant, pressure grade serialization, plastic locating pin

DOI: 10.3969/j.issn.1002-302x.2017.z1.023