



Cladding-Technology-Shanxi-Co.,-Ltd- CLADDING-MPS-020-Flux-Cored-Wire- Cladding-Layer-Process-Specification

药芯焊丝堆焊参数设置与保护气体及焊缝质量要求

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1. 目的

1.1 Purpose

规范科雷丁技术（山西）有限公司药芯焊丝堆焊工艺的参数设置、保护气体选用及焊缝质量要求，确保法兰堆焊、管件堆焊、钢管堆焊、轴套管堆焊、模具堆焊修复等业务的工艺稳定性和产品质量一致性，满足客户对增材制造与精密堆焊技术服务的质量期望。

To standardize the parameter settings, shielding gas selection and weld seam quality requirements for flux cored wire cladding processes at CLADDING-Technology-Shanxi-Co.,-Ltd,



ensuring process stability and product quality consistency for flange cladding, pipe fitting cladding, steel pipe cladding, shaft sleeve cladding, mold cladding repair and other businesses, meeting customer expectations for additive manufacturing and precision cladding technical services.

2. 适用范围

2.1 Scope

本文件适用于公司采用药芯焊丝（Flux Cored Wire）进行 TIG/MIG 复合堆焊、电弧增材制造及工业零部件表面强化与再制造修复工程中的参数设定、保护气体配置与焊缝质量检验。

This document applies to parameter setting, shielding gas configuration and weld seam quality inspection in TIG/MIG hybrid cladding, arc additive manufacturing and industrial component surface strengthening and remanufacturing repair projects using flux cored wire at the company.

3. 职责

3.1 Responsibilities

部门/岗位	Department/Position	职责内容	Responsibilities
工艺技术部	Process Technology Department	制定与更新药芯焊丝堆焊工艺参数标准；审核特殊工况下的参数调整方案	Develop and update flux cored wire cladding process parameter standards; Review parameter adjustment plans for special working conditions
生产部	Production Department	按照工艺参数执行堆焊作业；记录实际工艺参数与生产数据	Execute cladding operations according to process parameters; Record actual process parameters and production data
质量部	Quality Department	监督工艺参数执行情况；组织焊缝质量检验与不合格品处理	Supervise the implementation of process parameters; Organize weld seam quality inspection and nonconforming product



			handling
设备部	Equipment Department	维护焊接设备与送丝系统；确保保护气体供应系统正常运行	Maintain welding equipment and wire feeding ; Ensure normal operation of shielding gas supply
采购部	Procurement Department	采购符合技术要求的药芯焊丝与保护气体	Procure flux cored wire and shielding gas meeting technical requirements

4. 管理内容与程序

4.1 Management Content and Procedures

4.1.1 药芯焊丝选用原则

Flux Cored Wire Selection Principles

药芯焊丝的选用应根据母材材质、堆焊层性能要求及工况条件综合确定。公司常用药芯焊丝规格包括Φ1.2mm、Φ1.6mm、Φ2.0mm、Φ2.4mm，适用于不同厚度基材与不同熔敷效率要求的堆焊作业。

Flux cored wire selection shall be determined based on base material, cladding layer performance requirements and operating conditions. Commonly used flux cored wire specifications include Φ1.2mm, Φ1.6mm, Φ2.0mm, Φ2.4mm, suitable for cladding operations on different thickness substrates with different deposition efficiency requirements.

应用工况	Application	推荐焊丝规格	Recommended Wire Size	典型用途	Typical Use
精密薄层堆焊	Precision thin layer cladding	Φ1.2mm	Φ1.2mm	轴套管精密修复	Shaft sleeve precision repair
常规表面强化	Standard surface strengthening	Φ1.6mm	Φ1.6mm	法兰密封面堆焊	Flange sealing surface cladding
高效熔敷作业	High efficiency deposition	Φ2.0mm	Φ2.0mm	钢管大面积堆焊	Large area steel pipe cladding
重熔敷量工况	Heavy deposition	Φ2.4mm	Φ2.4mm	模具大面积修复	Large area mold repair



	requirement				
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4.1.2 焊接工艺参数设置

Welding Process Parameter Settings

4.1.2.1 电流与电压参数

Current and Voltage Parameters

药芯焊丝堆焊的电流与电压参数应根据焊丝直径、堆焊层厚度要求及母材导热性能进行匹配设置。

Current and voltage parameters for flux cored wire cladding shall be matched according to wire diameter, cladding layer thickness requirements and base material thermal conductivity.

焊丝直径	Wire Diameter	焊接电流	Welding Current (A)	电弧电压	Arc Voltage (V)	适用工况	Application
Φ1.2mm	Φ1.2mm	90-130	90-130	22-26	22-26	精密薄层堆焊	Precision thin layer cladding
Φ1.6mm	Φ1.6mm	140-190	140-190	24-28	24-28	常规表面强化	Standard surface strengthening
Φ2.0mm	Φ2.0mm	180-240	180-240	26-30	26-30	高效熔敷作业	High efficiency deposition
Φ2.4mm	Φ2.4mm	220-280	220-280	28-32	28-32	重熔数量工况	Heavy deposition requirement

4.1.2.2 焊接速度与送丝速度

Welding Speed and Wire Feeding Speed

焊接速度直接影响堆焊层稀释率与成型质量，送丝速度需与焊接电流匹配以保证稳定的电弧燃烧。

Welding speed directly affects cladding layer dilution rate and forming quality, and wire feeding speed shall be matched with welding current to ensure stable arc combustion.

焊丝直径	Wire	焊接速度	Welding	送丝速度	Wire	稀释率控	Dilution
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	Diameter		Speed (mm/min)		Feeding Speed (m/min)	制	Rate Control
Φ1.2mm	Φ1.2mm	150-250	150-250	4.0-6.0	4.0-6.0	≤8%	≤8%
Φ1.6mm	Φ1.6mm	120-200	120-200	5.0-7.5	5.0-7.5	≤10%	≤10%
Φ2.0mm	Φ2.0mm	100-180	100-180	6.0-9.0	6.0-9.0	≤12%	≤12%
Φ2.4mm	Φ2.4mm	80-150	80-150	7.0-10.0	7.0-10.0	≤15%	≤15%

4.1.2.3 焊接极性

Welding Polarity

药芯焊丝堆焊采用直流反接（DCEN）方式，即焊丝接正极、工件接负极，以获得稳定的电弧燃烧和良好的熔深控制。

Flux cored wire cladding shall use direct current electrode negative (DCEN) polarity, with wire connected to positive and workpiece to negative, to achieve stable arc combustion and good penetration control.

4.1.2.4 干伸长

Contact Tip to Work Distance (CTWD)

干伸长（Contact Tip to Work Distance）是影响电弧稳定性和熔敷效率的重要参数，应根据焊丝直径合理设置。

CTWD is an important parameter affecting arc stability and deposition efficiency, and shall be reasonably set according to wire diameter.

焊丝直径	Wire Diameter	干伸长范围	CTWD Range (mm)
Φ1.2mm	Φ1.2mm	12-18	12-18
Φ1.6mm	Φ1.6mm	15-22	15-22
Φ2.0mm	Φ2.0mm	18-25	18-25
Φ2.4mm	Φ2.4mm	20-28	20-28

4.1.3 保护气体配置要求

Shielding Gas Configuration Requirements

4.1.3.1 保护气体种类

Shielding Gas Types



药芯焊丝堆焊应根据堆焊层性能要求和母材材质选择适当的保护气体，常用保护气体包括 CO₂、Ar+CO₂混合气体及 Ar+O₂混合气体。

Shielding gas for flux cored wire cladding shall be selected according to cladding layer performance requirements and base material, commonly used shielding gases include CO₂, Ar+CO₂ mixture and Ar+O₂ mixture.

保护气体类型	Shielding Gas Type	配比	Ratio	适用场景	Application Scenario
纯 CO ₂	Pure CO ₂	100% CO ₂	100% CO ₂	碳钢堆焊、成本敏感工况	Carbon steel cladding, cost-sensitive applications
Ar+CO ₂	Ar+CO ₂	80%Ar+20%CO ₂	80%Ar+20%CO ₂	低合金钢堆焊、减少飞溅	Low alloy steel cladding, reduced spatter
Ar+O ₂	Ar+O ₂	95%Ar+5%O ₂	95%Ar+5%O ₂	不锈钢堆焊、改善润湿性	Stainless steel cladding, improved wetting
Ar+CO ₂ +O ₂	Ar+CO ₂ +O ₂	75%Ar+20%CO ₂ +5%O ₂	75%Ar+20%CO ₂ +5%O ₂	特殊合金堆焊、综合性能优化	Special alloy cladding, comprehensive performance optimization

4.1.3.2 气体流量设置

Gas Flow Rate Settings

保护气体流量应根据喷嘴直径、焊接位置及环境条件进行设置，确保焊缝区域获得充分保护。

Shielding gas flow rate shall be set according to nozzle diameter, welding position and environmental conditions to ensure adequate protection of the weld area.

喷嘴直径	Nozzle Diameter	气体流量	Gas Flow Rate (L/min)	适用条件	Applicable Conditions
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	(mm)				
Φ14	Φ14	12-16	12-16	常规平焊位置	Standard flat position
Φ16	Φ16	15-20	15-20	常规平焊位置	Standard flat position
Φ18	Φ18	18-25	18-25	横焊/立焊位置	Horizontal/vertical position
Φ20	Φ20	20-30	20-30	仰焊位置/有风环境	Overhead position/windy environment

4.1.3.3 气体纯度要求

Gas Purity Requirements

保护气体纯度直接影响焊缝质量，公司要求保护气体纯度不低于 99.95%，CO₂气体纯度不低于 99.9%。

Shielding gas purity directly affects weld quality. The company requires shielding gas purity not less than 99.95%, and CO₂ gas purity not less than 99.9%.

4.1.3.4 气体供应系统检查

Gas Supply Inspection

每日作业前应对保护气体供应系统进行以下检查：

The following inspections shall be performed on the shielding gas supply before daily operations:

- 检查气体管路连接是否牢固，无泄漏现象
- Check that gas pipeline connections are secure with no leakage
- 检查减压阀读数是否正常，压力稳定在设定范围
- Check that regulator readings are normal with pressure stable within set range
- 检查流量计指示是否准确，气体流量符合工艺要求
- Check that flowmeter indication is accurate and gas flow meets process requirements
- 检查气体干燥器工作是否正常，防止水分进入焊接区域
- Check that gas dryer is operating normally to prevent moisture entering welding area

4.1.4 焊缝质量要求

Weld Seam Quality Requirements



4.1.4.1 外观质量要求

Appearance Quality Requirements

药芯焊丝堆焊焊缝的外观质量应符合以下要求：

The appearance quality of flux cored wire cladding weld seams shall meet the following requirements:

检验项目	Inspection Item	质量要求	Quality Requirement	检验方法	Inspection Method
焊缝成型	Weld Formation	焊缝表面平整，波纹均匀，无咬边、未熔合	Flat surface, uniform ripples, no undercut or lack of fusion	目视检查	Visual inspection
焊缝宽度	Weld Width	符合工艺文件规定，宽度偏差 $\leq\pm 10\%$	As specified in process document, width deviation $\leq\pm 10\%$	卡尺测量	Caliper measurement
焊缝高度	Weld Height	符合设计要求，高度偏差 $\leq\pm 0.5\text{mm}$	As required by design, height deviation $\leq\pm 0.5\text{mm}$	焊缝量规	Weld gauge
表面缺陷	Surface Defects	无气孔、裂纹、夹渣等表面缺陷	No porosity, cracks, slag inclusion and other surface defects	目视检查	Visual inspection
飞溅清理	Spatter Cleaning	飞溅清理干净，不影响后续加工	Spatter cleaned thoroughly, not affecting subsequent machining	目视检查	Visual inspection

4.1.4.2 内部质量要求

Internal Quality Requirements

堆焊层内部质量应通过无损检测进行验证，检测标准与方法如下：



Internal quality of cladding layer shall be verified through non-destructive testing, with inspection standards and methods as follows:

检测项目	Test Item	标准要求	Standard Requirement	检测方法	Test Method
气孔	Porosity	单孔直径 ≤1.5mm, 间距 ≥3 倍孔径, 总 面积≤焊缝面 积 5%	Single pore diameter ≤1.5mm, spacing ≥3 times pore diameter, total area ≤5% of weld area	射线检测 RT	Radiographic testing RT
夹渣	Slag Inclusion	长度≤6mm, 间距≥3 倍长 度, 总面积≤ 焊缝面积 3%	Length ≤6mm, spacing ≥3 times length, total area ≤3% of weld area	射线检测 RT	Radiographic testing RT
未熔合	Lack of Fusion	不允许存在	Not permitted	超声波检测 UT	Ultrasonic testing UT
裂纹	Cracks	不允许存在	Not permitted	渗透检测 PT/ 磁粉检测 MT	Penetrant testing PT/Magnetic particle testing MT

4.1.4.3 硬度要求

Hardness Requirements

堆焊层硬度应根据应用工况和设计要求进行控制, 典型硬度要求如下:

Cladding layer hardness shall be controlled according to application conditions and design requirements, with typical hardness requirements as follows:

应用工况	Application	堆焊层硬度	Cladding Layer Hardness (HB)	测试方法	Test Method
耐磨工况	Wear resistance	250-350	250-350	布氏硬度	Brinell hardness



耐腐蚀工况	Corrosion resistance	180-280	180-280	布氏硬度	Brinell hardness
高温工况	High temperature	200-300	200-300	布氏硬度	Brinell hardness
冲击工况	Impact resistance	220-320	220-320	布氏硬度	Brinell hardness

4.1.4.4 稀释率控制

Dilution Rate Control

稀释率是衡量堆焊质量的重要指标，直接影响堆焊层化学成分和性能。药芯焊丝堆焊稀释率控制要求如下：

Dilution rate is an important indicator of cladding quality, directly affecting cladding layer chemical composition and properties. Dilution rate control requirements for flux cored wire cladding are as follows:

堆焊类型	Cladding Type	稀释率要求	Dilution Rate Requirement	控制措施	Control Measures
第一层堆焊	First layer cladding	≤15%	≤15%	降低电流，减小熔深	Reduce current, decrease penetration
中间层堆焊	Intermediate layer cladding	≤10%	≤10%	优化参数，控制熔宽	Optimize parameters, control weld width
覆盖层堆焊	Cover layer cladding	≤8%	≤8%	采用小电流，快速焊接	Use low current, fast welding

4.1.5 典型工艺参数卡

Typical Process Parameter Cards

4.1.5.1 法兰密封面堆焊工艺参数

Flange Sealing Surface Cladding Process Parameters

参数项目	Parameter Item	设定值	Set Value	备注	Remarks
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焊丝规格	Wire Specification	Φ1.6mm 药芯焊丝	Φ1.6mm flux cored wire	不锈钢药芯焊丝	Stainless steel flux cored wire
焊接电流	Welding Current	160A	160A	直流反接	DCEN
电弧电压	Arc Voltage	26V	26V	-	-
焊接速度	Welding Speed	150mm/min	150mm/min	-	-
送丝速度	Wire Feeding Speed	6.0m/min	6.0m/min	-	-
干伸长	CTWD	18mm	18mm	-	-
保护气体	Shielding Gas	80%Ar+20%CO ₂	80%Ar+20%CO ₂	-	-
气体流量	Gas Flow Rate	18L/min	18L/min	-	-
层间温度	Interpass Temperature	≤150℃	≤150℃	-	-
堆焊层数	Number of Layers	2-3 层	2-3 layers	根据厚度确定	Determine by thickness

4.1.5.2 轴套管精密修复工艺参数

Shaft Sleeve Precision Repair Process Parameters

参数项目	Parameter Item	设定值	Set Value	备注	Remarks
焊丝规格	Wire Specification	Φ1.2mm 药芯焊丝	Φ1.2mm flux cored wire	低稀释率药芯焊丝	Low dilution flux cored wire
焊接电流	Welding Current	110A	110A	直流反接	DCEN
电弧电压	Arc Voltage	24V	24V	-	-
焊接速度	Welding Speed	200mm/min	200mm/min	-	-
送丝速度	Wire Feeding Speed	5.0m/min	5.0m/min	-	-
干伸长	CTWD	15mm	15mm	-	-
保护气体	Shielding Gas	95%Ar+5%O ₂	95%Ar+5%O ₂	-	-
气体流量	Gas Flow Rate	15L/min	15L/min	-	-



层间温度	Interpass Temperature	$\leq 120^{\circ}\text{C}$	$\leq 120^{\circ}\text{C}$	-	-
堆焊层数	Number of Layers	1-2 层	1-2 layers	薄层精密堆焊	Thin layer precision cladding

4.1.5.3 钢管大面积堆焊工艺参数

Large Area Steel Pipe Cladding Process Parameters

参数项目	Parameter Item	设定值	Set Value	备注	Remarks
焊丝规格	Wire Specification	$\Phi 2.0\text{mm}$ 药芯焊丝	$\Phi 2.0\text{mm}$ flux cored wire	耐磨药芯焊丝	Wear-resistant flux cored wire
焊接电流	Welding Current	210A	210A	直流反接	DCEN
电弧电压	Arc Voltage	28V	28V	-	-
焊接速度	Welding Speed	140mm/min	140mm/min	-	-
送丝速度	Wire Feeding Speed	7.5m/min	7.5m/min	-	-
干伸长	CTWD	22mm	22mm	-	-
保护气体	Shielding Gas	80%Ar+20%CO ₂	80%Ar+20%CO ₂	-	-
气体流量	Gas Flow Rate	22L/min	22L/min	-	-
层间温度	Interpass Temperature	$\leq 200^{\circ}\text{C}$	$\leq 200^{\circ}\text{C}$	-	-
堆焊层数	Number of Layers	3-5 层	3-5 layers	根据厚度确定	Determine by thickness

4.1.6 工艺参数调整与记录

Process Parameter Adjustment and Recording

4.1.6.1 参数调整原则

Parameter Adjustment Principles

当出现以下情况时，允许对工艺参数进行适当调整，但须经工艺技术部审核确认：



When the following situations occur, process parameters may be appropriately adjusted, but shall be reviewed and confirmed by the Process Technology Department:

- 母材材质变化或厚度超出常规范围
- Base material changes or thickness exceeds normal range
- 堆焊层性能要求发生变化
- Cladding layer performance requirements change
- 焊接位置改变（平焊、横焊、立焊、仰焊）
- Welding position changes (flat, horizontal, vertical, overhead)
- 环境温度或湿度异常
- Abnormal environmental temperature or humidity
- 设备状态变化影响焊接稳定性
- Equipment condition changes affecting welding stability

4.1.6.2 参数记录要求

Parameter Recording Requirements

每次堆焊作业应完整记录以下工艺参数信息：

The following process parameter information shall be completely recorded for each cladding operation:

记录项目	Recording Item	记录内容	Recording Content
作业信息	Operation Information	工件名称、规格、数量、作业日期	Workpiece name, specification, quantity, operation date
焊丝信息	Wire Information	焊丝牌号、规格、批次号	Wire grade, specification, batch number
气体信息	Gas Information	气体类型、纯度、流量	Gas type, purity, flow rate
工艺参数	Process Parameters	电流、电压、速度、干伸长	Current, voltage, speed, CTWD
环境条件	Environmental Conditions	环境温度、湿度	Environmental temperature, humidity
质量检验	Quality Inspection	外观检查结果、无损检测结果	Appearance inspection results, NDT results
操作者	Operator	操作者姓名、资格证号	Operator name, qualification certificate



			number
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5. 监督考核

5.1 Supervision and Assessment

5.1.1 工艺参数执行监督

Process Parameter Implementation Supervision

质量部应定期抽查工艺参数执行情况，每月抽查比例不低于当月堆焊作业总量的 20%。

The Quality Department shall regularly spot-check the implementation of process parameters, with monthly spot-check ratio not less than 20% of the total cladding operations for that month.

5.1.2 质量指标考核

Quality Indicator Assessment

考核指标	Assessment Indicator	目标值	Target Value	考核周期	Assessment Period
工艺参数执行率	Process Parameter Compliance Rate	≥98%	≥98%	月度	Monthly
焊缝一次合格率	First Pass Weld Quality Rate	≥95%	≥95%	月度	Monthly
参数记录完整率	Parameter Recording Completeness Rate	100%	100%	月度	Monthly
气体纯度合格率	Gas Purity Compliance Rate	100%	100%	月度	Monthly

5.1.3 违规处理

Violation Handling

对违反本文件规定的行为，按以下规定处理：

Violations of this document shall be handled as follows:

- 首次发现参数执行偏差：口头警告，要求立即纠正



- First discovery of parameter deviation: Verbal warning, immediate correction required
- 重复发现参数执行偏差：书面警告，纳入个人绩效考核
- Repeated discovery of parameter deviation: Written warning, included in individual performance assessment
- 因参数执行不当导致质量事故：按公司质量事故处理规定执行
- Quality accident caused by improper parameter implementation: Handled according to company quality accident handling regulations

6. 附则

6.1 Supplementary Provisions

6.1.1 文件管理

Document Management

工艺技术部负责编制、解释和修订，质量部负责监督执行。

This document shall be prepared, interpreted and revised by the Process Technology Department, and supervised for implementation by the Quality Department.

6.1.2 文件修订

Document Revision

本文件每年至少评审一次，当出现以下情况时应及时修订：

This document shall be reviewed at least once per year, and shall be revised promptly when the following situations occur:

- 相关标准或法规发生变化
- Relevant standards or regulations change
- 工艺技术发生重大改进
- Significant process technology improvements occur
- 设备更新或工艺路线调整
- Equipment updates or process route adjustments
- 客户质量要求发生变化
- Customer quality requirements change

6.1.3 相关文件

Related Documents

文件编号	Document Number	文件名称	Document Name
CLADDING-MPS-001	CLADDING-MPS-001	增材制造工艺管理规范	Additive Manufacturing



			Process Management Specification
CLADDING-MPS-010	CLADDING-MPS-010	TIG 堆焊工艺参数与质量要求	TIG Cladding Process Parameters and Quality Requirements
CLADDING-MPS-015	CLADDING-MPS-015	MIG 堆焊工艺参数与质量要求	MIG Cladding Process Parameters and Quality Requirements
CLADDING-MPS-025	CLADDING-MPS-025	焊缝无损检测管理程序	Weld Seam Non-Destructive Testing Management Procedure
CLADDING-MPS-030	CLADDING-MPS-030	焊接材料管理与使用规范	Welding Material Management and Usage Specification

6.1.4 记录表格

Record Forms

表格编号	Form Number	表格名称	Form Name
CLADDING-FRM-020-01	CLADDING-FRM-020-01	药芯焊丝堆焊工艺参数记录表	Flux Cored Wire Cladding Process Parameter Record Form
CLADDING-FRM-020-02	CLADDING-FRM-020-02	保护气体检查记录表	Shielding Gas Inspection Record Form
CLADDING-FRM-020-03	CLADDING-FRM-020-03	焊缝质量检验记录表	Weld Seam Quality Inspection Record Form
CLADDING-FRM-020-04	CLADDING-FRM-020-04	工艺参数调整审批表	Process Parameter Adjustment Approval Form

编制：工艺技术部

Prepared by: Process Technology Department

审核：质量部

Reviewed by: Quality Department

批准：总经理



Approved by: General Manager

生效日期: 2024 年 1 月 1 日

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