科雷丁技术（山西）有限公司
Cladding Technology (Shanxi) Co., Ltd.
增材制造 · TIG 堆焊 · MIG 堆焊 · 精密焊接 · 表面强化 · 再制造修复

Cladding-Technology-Shanxi-Co.,-Ltd-CLADDING-MPS-013-TIG_MIG-Composite-Cladding-Process-Specification

TIG/MIG 复合堆焊工艺参数、层间控制与质量要求

TIG/MIG Composite Cladding Process Parameters, Interlayer Control and Quality Requirements

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| 编制部门 | Prepared By | 工艺技术部 |

| 批准人 | Approved By | 总经理 |

1 目的 Purpose

本文件规定了科雷丁技术（山西）有限公司 TIG/MIG 复合堆焊工艺的技术参数、层间控制要求与质量验收标准，确保法兰、管件、钢管、轴套管及模具等工件的堆焊修复与增材制造过程受控，满足客户技术协议及行业规范要求。

This document specifies the technical parameters, interlayer control requirements and quality acceptance criteria for TIG/MIG composite cladding processes of CLADDING-Technology-Shanxi-

Co.,-Ltd, ensuring that cladding repair and additive manufacturing processes for flanges, pipe fittings, steel pipes, shaft sleeves and molds are controlled and meet customer technical agreements and industry specification requirements.

2 适用范围 Scope

本文件适用于公司承接的以下业务场景：

This document applies to the following business scenarios undertaken by the company:

- 法兰密封面 TIG/MIG 复合堆焊强化
- Flange sealing surface TIG/MIG composite cladding strengthening
- 管件及钢管内壁耐磨耐蚀堆焊
- Wear and corrosion resistant cladding on inner wall of pipe fittings and steel pipes
- 轴套管表面 TIG/MIG 复合堆焊修复
- Shaft sleeve surface TIG/MIG composite cladding repair
- 模具型腔 MIG 高效堆焊与 TIG 精修
- Mold cavity MIG high-efficiency cladding and TIG finishing
- 梯度材料电弧增材制造
- Gradient material arc additive manufacturing

3 职责 Responsibilities

| 部门/岗位 | Department/Position | 职责 | Responsibility |

| 工艺技术部 | Process Technology Department | 编制工艺文件，确定工艺参数，指导现场操作 | Prepare process documents, determine process parameters, guide on-site operations |

| 生产部 | Production Department | 按工艺要求执行堆焊作业，记录层间数据 | Execute cladding operations according to process requirements, record interlayer data |

| 质量部 | Quality Department | 过程检验与成品验收，出具检验报告 | Process inspection and finished product acceptance, issue inspection reports |

| 设备部 | Equipment Department | 焊接设备维护保养，确保设备状态满足工艺要求 | Welding equipment maintenance, ensure equipment status meets process requirements |

4 管理内容与程序 Management Content and Procedures

4.1 工艺参数控制 Process Parameters Control

4.1.1 TIG 堆焊工艺参数 TIG Cladding Process Parameters

TIG 堆焊适用于低稀释率精密成型场合，主要应用于法兰密封面堆焊、轴套管精密修复及模具型腔精修。

TIG cladding is suitable for low dilution precision forming applications, mainly used for flange sealing surface cladding, shaft sleeve precision repair and mold cavity finishing.

| 参数项目 | Parameter Item | 推荐范围 | Recommended Range | 备注 | Remarks |

| 焊接电流 | Welding Current | 80-160A | 根据母材厚度调整 |

| 电弧电压 | Arc Voltage | 14-18V | 保持电弧稳定 |

| 焊接速度 | Welding Speed | 50-120mm/min | 与电流匹配 |

| 保护气体流量 | Shielding Gas Flow | 12-20L/min | 氩气纯度≥99.99% |

| 钨极直径 | Tungsten Electrode Diameter | Φ2.4-Φ4.0mm | 根据电流选择 |

| 钨极伸出长度 | Electrode Extension | 3-5mm | 保持稳定 |

| 预热温度 | Preheating Temperature | 100-200℃ | 根据母材确定 |

4.1.2 MIG 堆焊工艺参数 MIG Cladding Process Parameters

MIG 堆焊适用于高效熔敷及自动化适配场合，主要应用于管件、钢管大面积堆焊及模具型腔打底。

MIG cladding is suitable for high-efficiency deposition and automation applications, mainly used for large-area cladding of pipe fittings and steel pipes, and mold cavity base layer.

| 参数项目 | Parameter Item | 推荐范围 | Recommended Range | 备注 | Remarks |

| 焊接电流 | Welding Current | 180-320A | 根据焊丝直径调整 |

| 电弧电压 | Arc Voltage | 22-30V | 与电流匹配 |

| 焊接速度 | Welding Speed | 200-500mm/min | 自动化设备适配 |

| 焊丝送进速度 | Wire Feed Speed | 4-8m/min | 与电流匹配 |

| 保护气体流量 | Shielding Gas Flow | 15-25L/min | 混合气体或纯氩 |

| 焊丝直径 | Wire Diameter | Φ1.2-Φ1.6mm | 根据工艺选择 |

| 干伸长 | Contact Tip to Work Distance | 10-15mm | 保持稳定 |

| 摆动宽度 | Oscillation Width | 8-20mm | 根据焊缝宽度确定 |

4.1.3 TIG/MIG 复合堆焊工艺 TIG/MIG Composite Cladding Process

复合堆焊工艺采用 TIG 打底、MIG 填充的复合模式，兼顾精密成型与高效熔敷。

The composite cladding process adopts TIG base layer and MIG filling composite mode, combining precision forming and high-efficiency deposition.

| 工序 | Process Step | 工艺方法 | Method | 层数 | Layers | 单道厚度 | Single Pass Thickness |

| 打底层 | Base Layer | TIG 堆焊 | TIG Cladding | 1-2 层 | 1-2 layers | 1.5-2.5mm |

| 填充层 | Filling Layer | MIG 堆焊 | MIG Cladding | 2-6 层 | 2-6 layers | 3-5mm |

| 盖面层 | Cap Layer | TIG 堆焊 | TIG Cladding | 1 层 | 1 layer | 2-3mm |

4.2 层间控制要求 Interlayer Control Requirements

4.2.1 层间温度控制 Interlayer Temperature Control

| 母材类型 | Base Material Type | 最高层间温度 | Maximum Interpass Temperature | 测量方法 | Measurement Method |

| 碳钢 | Carbon Steel | ≤250℃ | 红外测温仪 |

| 低合金钢 | Low Alloy Steel | ≤200℃ | 红外测温仪 |

| 不锈钢 | Stainless Steel | ≤150℃ | 红外测温仪 |

| 镍基合金 | Nickel-based Alloy | ≤100℃ | 热电偶测温 |

4.2.2 层间清理要求 Interlayer Cleaning Requirements

每层堆焊完成后，必须执行以下清理工序：

After each cladding layer is completed, the following cleaning procedures must be executed:

- 清除焊渣：使用钢丝刷或角磨机清除表面焊渣
- Slag removal: Use wire brush or angle grinder to remove surface slag
- 去除氧化皮：使用砂轮机或喷砂处理去除氧化皮
- Oxide scale removal: Use grinding wheel or shot blasting to remove oxide scale
- 表面检查：目视检查层间是否存在裂纹、气孔、夹渣等缺陷
- Surface inspection: Visually inspect interlayer for cracks, porosity, inclusions and other defects
- 清洁表面：使用丙酮或酒精擦拭表面油污
- Surface cleaning: Wipe surface oil with acetone or alcohol

4.2.3 层间变形控制 Interlayer Distortion Control

| 工件类型 | Workpiece Type | 变形控制要求 | Distortion Control Requirements |

| 法兰 | Flange | 密封面平面度≤0.1mm/m | Sealing surface flatness ≤0.1mm/m |

| 管件 | Pipe Fitting | 圆度偏差≤1%壁厚 | Roundness deviation ≤1% wall thickness |

| 轴套管 | Shaft Sleeve | 同轴度≤0.05mm | Coaxiality ≤0.05mm |

| 模具 | Mold | 型腔尺寸偏差≤±0.1mm | Cavity dimension deviation ≤±0.1mm |

4.3 质量要求 Quality Requirements

4.3.1 外观质量要求 Appearance Quality Requirements

| 检验项目 | Inspection Item | 质量要求 | Quality Requirements |

| 焊缝成形 | Weld Formation | 焊缝均匀，无咬边、未熔合 | Uniform weld, no undercut, no lack of fusion |

| 表面缺陷 | Surface Defects | 无裂纹、气孔、夹渣 | No cracks, porosity, inclusions |

| 焊缝尺寸 | Weld Dimension | 符合图纸及工艺要求 | Meet drawing and process requirements |

| 表面粗糙度 | Surface Roughness | Ra≤6.3μm（精修后） | Ra≤6.3μm (after finishing) |

4.3.2 无损检测要求 Non-destructive Testing Requirements

| 检测方法 | Testing Method | 检测比例 | Testing Ratio | 合格标准 | Acceptance Criteria |

| 磁粉检测 MT | Magnetic Particle Testing | 100% | 按 NB/T 47013.4 执行 |

| 渗透检测 PT | Penetrant Testing | 100% | 按 NB/T 47013.5 执行 |

| 超声波检测 UT | Ultrasonic Testing | 按客户要求 | 按 NB/T 47013.3 执行 |

| 射线检测 RT | Radiographic Testing | 按客户要求 | 按 NB/T 47013.2 执行 |

4.3.3 力学性能要求 Mechanical Properties Requirements

| 性能指标 | Property Index | 最低要求 | Minimum Requirements | 试验方法 | Test Method |

| 抗拉强度 | Tensile Strength | ≥母材标准值 | GB/T 2651 |

| 弯曲性能 | Bending Performance | 180°弯曲无裂纹 | GB/T 2653 |

| 硬度 | Hardness | 符合技术协议要求 | HBW/HRC |

| 冲击韧性 | Impact Toughness | 符合技术协议要求 | GB/T 229 |

4.4 工艺记录要求 Process Record Requirements

每批次堆焊作业必须填写以下记录：

The following records must be completed for each batch of cladding operations:

- 堆焊工艺参数记录表
- Cladding Process Parameter Record Sheet
- 层间温度记录表

- Interlayer Temperature Record Sheet
- 焊接工序流转卡
- Welding Process Routing Card
- 质量检验记录表
- Quality Inspection Record Sheet

5 监督考核 Supervision and Assessment

5.1 工艺纪律检查 Process Discipline Inspection

质量部每月对堆焊作业现场进行工艺纪律检查，检查内容包括：

The Quality Department conducts monthly process discipline inspections on cladding operation sites, including:

- 工艺参数执行符合性
- Compliance of process parameter execution
- 层间控制措施落实情况
- Implementation of interlayer control measures
- 工艺记录填写完整性
- Completeness of process record filling
- 设备状态维护情况
- Equipment status maintenance

5.2 质量考核指标 Quality Assessment Indicators

| 考核指标 | Assessment Indicator | 目标值 | Target Value | 考核周期 | Assessment Cycle |

| 一次合格率 | First Pass Rate | ≥95% | 月度 |

| 返工率 | Rework Rate | ≤3% | 月度 |

| 客户投诉率 | Customer Complaint Rate | ≤1% | 季度 |

| 工艺文件执行率 | Process Document Compliance Rate | 100% | 月度 |

6 附则 Supplementary Provisions

6.1 相关文件 Related Documents

- CLADDING-MPS-001 焊接工艺规程管理办法
- CLADDING-MPS-001 Welding Procedure Specification Management Method
- CLADDING-MPS-005 焊接设备维护保养规程
- CLADDING-MPS-005 Welding Equipment Maintenance Procedure

- CLADDING-MPS-008 焊接质量检验规程
- CLADDING-MPS-008 Welding Quality Inspection Procedure

6.2 记录表单 Record Forms

- CLADDING-FRM-013-01 堆焊工艺参数记录表
- CLADDING-FRM-013-01 Cladding Process Parameter Record Sheet
- CLADDING-FRM-013-02 层间温度记录表
- CLADDING-FRM-013-02 Interlayer Temperature Record Sheet
- CLADDING-FRM-013-03 堆焊质量检验记录表
- CLADDING-FRM-013-03 Cladding Quality Inspection Record Sheet

6.3 修订记录 Revision History

| 版本 | Version | 修订日期 | Revision Date | 修订内容 | Revision Content | 修订人 | Revised By |

| A/0 | A/0 | 2025-01-01 | 首次发布 | Initial Release | 工艺技术部 |

文件结束

END OF DOCUMENT