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-005-Cladding-Cap-MPS

科雷丁技术（山西）有限公司

Cladding-Technology-Shanxi-Co.,-Ltd

文件编号	文件名称	版本号	生效日期
CLADDING-MPS-005	堆焊管帽成形、堆焊、尺寸检验与压力试验工艺规程	A/0	2024-01-01

1 目的 Purpose

1.1 中文

本规程旨在规范科雷丁技术（山西）有限公司堆焊管帽产品的成形、堆焊、尺寸检验与压力试验工艺过程，确保产品质量符合设计要求及客户标准，实现增材制造与精密堆焊技术在管帽类产品中的标准化应用。

1.2 English

This procedure aims to standardize the forming, cladding, dimensional inspection and pressure testing processes for cladded pipe caps manufactured by Cladding-Technology-Shanxi-Co.,-Ltd,

ensuring product quality meets design requirements and customer specifications, and achieving standardized application of additive manufacturing and precision cladding technologies in pipe cap products.

2 适用范围 Scope

2.1 中文

本规程适用于公司生产的各类堆焊管帽产品，包括但不限于：

- 法兰堆焊管帽
- 管件堆焊管帽
- 钢管堆焊管帽
- 轴套管堆焊管帽
- 特殊工况用堆焊管帽

2.2 English

This procedure applies to all types of cladded pipe cap products manufactured by the company, including but not limited to:

- Flange cladded pipe caps
- Pipe fitting cladded pipe caps
- Steel pipe cladded pipe caps
- Shaft sleeve cladded pipe caps
- Cladded pipe caps for special operating conditions

3 职责 Responsibilities

3.1 中文

部门/岗位	职责内容
技术部	编制工艺文件，确定工艺参数，解决技术难题
生产部	组织生产，执行工艺规程，确保产品质量
质量部	过程检验与最终检验，出具检验报告
设备部	设备维护保养，确保设备正常运行
采购部	原材料采购，确保材料质量合格

3.2 English

Department/Position	Responsibilities
Technology Department	Prepare process documents, determine process parameters, resolve technical issues
Production Department	Organize production, execute process procedures, ensure product quality
Quality Department	Process inspection and final inspection, issue inspection reports
Equipment Department	Equipment maintenance, ensure normal equipment operation
Procurement Department	Raw material procurement, ensure material quality compliance

4 管理内容与程序 Management Content and Procedures

4.1 工艺准备 Process Preparation

4.1.1 中文

生产前，技术部应根据产品图纸和技术要求编制工艺卡，明确以下内容：

- 母材材质与规格
- 堆焊材料牌号与规格
- 堆焊层数与每层厚度
- 焊接工艺参数（电流、电压、焊接速度、气体流量等）
- 热处理要求
- 检验项目与验收标准

4.1.2 English

Before production, the Technology Department shall prepare process cards based on product drawings and technical requirements, specifying the following:

- Base material type and specification
- Cladding material grade and specification
- Number of cladding layers and thickness per layer
- Welding process parameters (current, voltage, welding speed, gas flow rate, etc.)
- Heat treatment requirements
- Inspection items and acceptance criteria

4.2 管帽成形工艺 Pipe Cap Forming Process

4.2.1 中文

管帽成形采用以下工艺路线：

下料工序

- 根据产品规格确定母材尺寸
- 采用等离子切割或锯切方式下料
- 下料尺寸公差控制在±2mm 以内

成形工序

- 采用冷成形或热成形工艺
- 冷成形适用于壁厚≤20mm 的管帽
- 热成形适用于壁厚>20mm 或高强度材料管帽
- 成形温度控制在材料规定范围内
- 成形后圆度偏差≤3mm

坡口加工

- 堆焊面坡口形式：V 型或 U 型
- 坡口角度：60°±5°（V 型）或 R3-R5（U 型）
- 坡口表面粗糙度 Ra≤12.5μm

4.2.2 English

Pipe cap forming adopts the following process route:

Cutting Operation

- Determine base material dimensions according to product specifications
- Use plasma cutting or sawing for material cutting
- Cutting dimensional tolerance controlled within ±2mm

Forming Operation

- Adopt cold forming or hot forming process
- Cold forming applicable for pipe caps with wall thickness ≤20mm
- Hot forming applicable for pipe caps with wall thickness >20mm or high-strength materials
- Forming temperature controlled within material specified range
- Roundness deviation after forming ≤3mm

Bevel Preparation

- Cladding surface bevel type: V-type or U-type
- Bevel angle: 60°±5° (V-type) or R3-R5 (U-type)
- Bevel surface roughness Ra≤12.5μm

4.3 堆焊工艺 Cladding Process

4.3.1 中文

TIG 堆焊工艺参数

参数项目	推荐范围	备注
焊接电流	80-160A	根据堆焊层数调整
焊接电压	12-18V	保持电弧稳定
焊接速度	100-200mm/min	确保熔敷质量
保护气体流量	8-12L/min	氩气纯度≥99.99%
焊丝直径	φ2.4-φ3.2mm	根据层厚选择
层间温度	≤150℃	防止过热
稀释率	≤15%	控制母材稀释

MIG 堆焊工艺参数

参数项目	推荐范围	备注
焊接电流	180-280A	根据效率要求调整
焊接电压	22-28V	保持熔池稳定
焊接速度	200-400mm/min	高效熔敷
保护气体流量	12-18L/min	混合气体或纯氩
焊丝直径	φ1.2-φ1.6mm	连续送丝
层间温度	≤200℃	控制热输入
稀释率	≤20%	兼顾效率与质量

堆焊操作要求

- 堆焊前对坡口进行清理，去除油污、锈迹
- 采用多层多道堆焊，每层厚度 2-4mm
- 层间清理焊渣，检查有无缺陷
- 堆焊顺序：先堆焊内表面，再堆焊外表面
- 堆焊方向：沿圆周方向连续堆焊
- 起弧与收弧：在坡口外引弧，收弧填满弧坑

4.3.2 English

TIG Cladding Process Parameters

Parameter	Recommended Range	Remarks
Welding Current	80-160A	Adjust according to cladding layers
Welding Voltage	12-18V	Maintain arc stability
Welding Speed	100-200mm/min	Ensure deposition quality
Shielding Gas Flow	8-12L/min	Argon purity ≥99.99%
Wire Diameter	φ2.4-φ3.2mm	Select according to layer thickness
Interpass Temperature	≤150℃	Prevent overheating
Dilution Rate	≤15%	Control base material dilution

MIG Cladding Process Parameters

Parameter	Recommended Range	Remarks
Welding Current	180-280A	Adjust according to efficiency requirements
Welding Voltage	22-28V	Maintain molten pool stability
Welding Speed	200-400mm/min	High-efficiency deposition
Shielding Gas Flow	12-18L/min	Mixed gas or pure argon
Wire Diameter	φ1.2-φ1.6mm	Continuous wire feeding
Interpass Temperature	≤200℃	Control heat input
Dilution Rate	≤20%	Balance efficiency and quality

Cladding Operation Requirements

- Clean the bevel before cladding, remove oil and rust
- Adopt multi-layer multi-pass cladding, each layer thickness 2-4mm
- Clean slag between layers, inspect for defects
- Cladding sequence: clad inner surface first, then outer surface
- Cladding direction: continuous cladding along circumferential direction
- Arc starting and stopping: strike arc outside bevel, fill crater at arc stop

4.4 热处理工艺 Heat Treatment Process

4.4.1 中文

根据堆焊材料和母材要求，进行以下热处理：

热处理类型	温度范围	保温时间	冷却方式
去应力退火	600-650℃	1-2h/25mm	随炉冷却
固溶处理	1050-1150℃	0.5-1h	水淬或空冷
稳定化处理	850-900℃	2-4h	空冷

4.4.2 English

According to cladding material and base material requirements, perform the following heat treatment:

Heat Treatment Type	Temperature Range	Holding Time	Cooling Method
Stress Relief Annealing	600-650℃	1-2h/25mm	Furnace cooling
Solution Treatment	1050-1150℃	0.5-1h	Water quenching or air cooling
Stabilization Treatment	850-900℃	2-4h	Air cooling

4.5 尺寸检验工艺 Dimensional Inspection Process

4.5.1 中文

检验项目与公差要求

检验项目	公差要求	检验工具
外径尺寸	±1.0mm	卡尺/千分尺
内径尺寸	±1.0mm	卡尺/内径量表
总高度	±1.0mm	卡尺
堆焊层厚度	+0.5/-0mm	超声波测厚仪
圆度	≤2mm	圆度仪/卡尺
平面度	≤1mm	平板/塞尺
坡口角度	±3°	角度尺

表面粗糙度	Ra≤6.3μm	粗糙度仪

检验程序

1. 外观检查：目视检查堆焊层表面质量
2. 尺寸测量：按图纸要求测量各部位尺寸
3. 堆焊层厚度检测：多点测量，取平均值
4. 形位公差检测：圆度、平面度等
5. 记录检验数据，填写检验记录表

4.5.2 English

Inspection Items and Tolerance Requirements

Inspection Item	Tolerance	Inspection Tool
Outer Diameter	±1.0mm	Caliper/Micrometer
Inner Diameter	±1.0mm	Caliper/Internal Diameter Gauge
Total Height	±1.0mm	Caliper
Cladding Layer Thickness	+0.5/-0mm	Ultrasonic Thickness Gauge
Roundness	≤2mm	Roundness Tester/Caliper
Flatness	≤1mm	Platform/Feeler Gauge
Bevel Angle	±3°	Angle Gauge
Surface Roughness	Ra≤6.3μm	Roughness Tester

Inspection Procedure

6. Visual inspection: Visually inspect cladding surface quality
7. Dimensional measurement: Measure dimensions according to drawing requirements
8. Cladding layer thickness detection: Multi-point measurement, take average value
9. Geometric tolerance inspection: Roundness, flatness, etc.
10. Record inspection data, fill in inspection record form

4.6 压力试验工艺 Pressure Testing Process

4.6.1 中文

试验前准备

- 确认产品尺寸检验合格
- 检查堆焊层表面无裂纹、气孔等缺陷

- 准备试验设备和工装
- 确认试验介质（水或空气）

水压试验

试验项目	参数要求
试验压力	1.5 倍设计压力
保压时间	≥30min
试验介质	清洁水
水温	5-70℃
合格标准	无渗漏、无可见变形

气压试验

试验项目	参数要求
试验压力	1.15 倍设计压力
保压时间	≥10min
试验介质	干燥压缩空气
合格标准	无渗漏、压力降≤1%

试验程序

11. 安装试验工装，确保密封
12. 缓慢升压至试验压力
13. 保压规定时间
14. 检查焊缝及堆焊层有无渗漏
15. 记录试验数据
16. 缓慢降压，拆卸工装

4.6.2 English

Pre-test Preparation

- Confirm dimensional inspection qualified
- Check cladding surface for cracks, porosity and other defects
- Prepare test equipment and fixtures
- Confirm test medium (water or air)

Hydrostatic Test

Test Item	Parameter Requirements
Test Pressure	1.5 times design pressure
Holding Time	≥30min
Test Medium	Clean water
Water Temperature	5-70℃
Acceptance Criteria	No leakage, no visible deformation

Pneumatic Test

Test Item	Parameter Requirements
Test Pressure	1.15 times design pressure
Holding Time	≥10min
Test Medium	Dry compressed air
Acceptance Criteria	No leakage, pressure drop ≤1%

Test Procedure

17. Install test fixtures, ensure sealing
18. Slowly pressurize to test pressure
19. Hold pressure for specified time
20. Inspect welds and cladding layer for leakage
21. Record test data
22. Slowly depressurize, disassemble fixtures

5 质量控制与检验 Quality Control and Inspection

5.1 中文

过程质量控制

- 每层堆焊后进行外观检查
- 关键尺寸过程检验
- 层间温度监控
- 焊接参数记录

最终检验项目

- 外观检验：堆焊层表面质量、焊缝成型
- 尺寸检验：按 4.5 节要求执行
- 无损检测：必要时进行 MT/PT/UT 检测
- 压力试验：按 4.6 节要求执行
- 硬度测试：堆焊层及热影响区硬度

不合格品处理

- 发现不合格品立即标识隔离
- 分析不合格原因
- 制定返修方案
- 返修后重新检验

5.2 English

Process Quality Control

- Visual inspection after each cladding layer
- Critical dimension process inspection
- Interpass temperature monitoring
- Welding parameter recording

Final Inspection Items

- Visual inspection: Cladding surface quality, weld formation
- Dimensional inspection: Execute according to Section 4.5
- Non-destructive testing: MT/PT/UT testing when necessary
- Pressure testing: Execute according to Section 4.6
- Hardness test: Cladding layer and HAZ hardness

Non-conforming Product Handling

- Immediately identify and isolate non-conforming products
- Analyze causes of non-conformance
- Develop rework plan
- Re-inspect after rework

6 安全与环保要求 Safety and Environmental Requirements

6.1 中文

- 操作人员必须佩戴防护眼镜、焊接面罩、防护手套
- 焊接区域配备通风设施，确保有害气体排出
- 压力试验区域设置警戒线，非操作人员禁止入内

- 试验用水回收处理，不得随意排放
- 废焊丝、废渣分类收集，按环保要求处理

6.2 English

- Operators must wear protective glasses, welding masks, protective gloves
- Welding areas equipped with ventilation facilities to ensure harmful gas exhaust
- Pressure testing areas marked with warning lines, non-operators prohibited from entering
- Test water recycled and treated, not to be discharged arbitrarily
- Waste welding wire and slag collected separately, handled according to environmental requirements

7 监督考核 Supervision and Assessment

7.1 中文

- 质量部每月对工艺执行情况进行检查
- 对违反工艺规程的行为进行考核
- 定期组织工艺培训，提高员工技能
- 收集客户反馈，持续改进工艺

7.2 English

- Quality Department inspects process execution monthly
- Assess violations of process procedures
- Organize process training regularly to improve employee skills
- Collect customer feedback for continuous process improvement

8 附则 Supplementary Provisions

8.1 中文

- 本规程由技术部负责解释
- 本规程自发布之日起执行
- 本规程每年评审一次，必要时修订
- 相关记录表格随本规程附件发布

8.2 English

- This procedure shall be interpreted by the Technology Department
- This procedure shall be effective from the date of release

- This procedure shall be reviewed annually and revised when necessary
- Related record forms shall be released as appendices to this procedure

9 相关文件 Related Documents

文件编号	文件名称
CLADDING-QP-001	质量手册
CLADDING-WI-002	焊接工艺规程
CLADDING-WI-003	检验作业指导书
CLADDING-WI-004	设备操作规程

10 记录表格 Record Forms

表格编号	表格名称
CLADDING-FRM-001	工艺卡
CLADDING-FRM-002	焊接参数记录表
CLADDING-FRM-003	尺寸检验记录表
CLADDING-FRM-004	压力试验记录表
CLADDING-FRM-005	不合格品处理单

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