



Cladding-Technology-Shanxi-Co.,-Ltd- CLADDING-MPS-001-Cladding-Flange- MPS

制造过程控制程序

Manufacturing Process Control Procedure

文件编号 Document No.	CLADDING-MPS-001
版本号 Version	A/0
生效日期 Effective Date	2024-01-01
编制 Prepared by	工艺工程部
审核 Reviewed by	质量部
批准 Approved by	总经理

1. 目的 Purpose

本程序规定了科雷丁技术（山西）有限公司堆焊法兰的完整制造工艺路线，明确从原材料下料到成品检验的全过程控制要求，确保堆焊法兰产品符合设计图纸、技术协议及标准要求，满足客户对产品质量、性能及交付周期的要求。



This procedure defines the complete manufacturing process route for cladding flanges at Cladding-Technology-Shanxi-Co.,-Ltd, clarifying the control requirements throughout the entire process from raw material cutting to finished product inspection, ensuring that cladding flange products comply with design drawings, technical agreements and standards, and meet customer requirements for product quality, performance and delivery schedule.

2. 适用范围 Scope

本程序适用于公司承接的各类堆焊法兰产品，包括但不限于：

- 石油化工用堆焊法兰（Cr-Mo 钢法兰、不锈钢堆焊层法兰）
- 电力行业用堆焊法兰（电站管道法兰、高温高压法兰）
- 冶金行业用堆焊法兰（耐磨堆焊法兰、耐腐蚀堆焊法兰）
- 船舶及海洋工程用堆焊法兰（耐海水腐蚀法兰）
- 其他特殊工况用堆焊法兰

This procedure applies to various types of cladding flange products undertaken by the company, including but not limited to:

- Petrochemical cladding flanges (Cr-Mo steel flanges, stainless steel cladding layer flanges)
- Power industry cladding flanges (power station pipeline flanges, high temperature and high pressure flanges)
- Metallurgical industry cladding flanges (wear-resistant cladding flanges, corrosion-resistant cladding flanges)
- Marine and offshore engineering cladding flanges (seawater corrosion resistant flanges)
- Other special condition cladding flanges

3. 职责 Responsibilities

部门 Department	职责 Responsibilities
生产部 Production Department	负责堆焊法兰制造全过程的组织协调与进度控制，确保各工序按计划执行
工艺工程部 Process Engineering Department	负责制定工艺规程、焊接工艺评定（WPS/PQR）、工艺参数设定及技术支持
质量部 Quality Department	负责原材料检验、过程检验、成品检验及质量记录管理
设备部 Equipment Department	负责堆焊设备、热处理设备、机加工设备的维护保养及正常运行保障



仓储部 Warehouse Department

负责原材料、焊材的出入库管理及标识追溯

4. 管理内容与程序 Management Content and Procedure

4.1 下料工序 Cutting Process

4.1.1 原材料确认 Raw Material Confirmation

- 核对原材料材质证明书，确认基材牌号、规格、炉号与设计图纸一致
- 检查原材料外观质量，表面不得有裂纹、折叠、结疤等缺陷
- 对关键原材料进行光谱分析复验，确认化学成分符合要求
- Verify material certification documents, confirm that base material grade, specification, and heat number match design drawings
- Inspect raw material appearance quality, surface shall be free of cracks, laps, scabs and other defects
- Perform spectral analysis re-inspection on key raw materials to confirm chemical composition meets requirements

4.1.2 下料操作 Cutting Operation

- 根据图纸尺寸及加工余量确定下料尺寸，考虑坡口加工及机加工余量
- 采用等离子切割或火焰切割方式进行下料，切割面质量应符合 GB/T 19418 要求
- 切割后清除熔渣，检查切割面平面度，偏差控制在 $\pm 1\text{mm}$ 以内
- 对下料后的毛坯进行标识，记录炉号、规格、下料日期等信息
- Determine cutting dimensions based on drawing dimensions and machining allowances, considering bevel processing and machining allowances
- Use plasma cutting or flame cutting for material cutting, cutting surface quality shall comply with GB/T 19418 requirements
- Remove slag after cutting, check cutting surface flatness, deviation controlled within $\pm 1\text{mm}$
- Mark the blank after cutting, record heat number, specification, cutting date and other information

4.2 坡口加工工序 Bevel Processing Process

4.2.1 坡口形式确定 Bevel Form Determination

- 根据基材厚度、堆焊层厚度及焊接工艺要求确定坡口形式
- 常用坡口形式包括：I 型坡口（薄壁法兰）、V 型坡口（中等厚度）、U 型坡口（厚壁法兰）



- 坡口角度一般为 30° - 45° ，钝边尺寸 1-3mm，间隙 2-4mm
- Determine bevel form based on base material thickness, cladding layer thickness and welding process requirements
- Common bevel forms include: I-bevel (thin wall flanges), V-bevel (medium thickness), U-bevel (thick wall flanges)
- Bevel angle generally 30° - 45° , root face 1-3mm, gap 2-4mm

4.2.2 坡口加工要求 *Bevel Processing Requirements*

- 采用机械加工或等离子切割方式加工坡口
- 坡口表面应光滑，不得有裂纹、毛刺、氧化皮等缺陷
- 坡口加工后检查坡口角度、钝边尺寸、间隙等参数，符合工艺文件要求
- 坡口加工完成后清除铁屑，保持坡口及附近区域清洁
- Use machining or plasma cutting to process bevel
- Bevel surface shall be smooth, free of cracks, burrs, scale and other defects
- After bevel processing, check bevel angle, root face dimension, gap and other parameters, comply with process document requirements
- After bevel processing, remove iron chips, keep bevel and surrounding area clean

4.3 预热工序 *Preheating Process*

4.3.1 预热温度确定 *Preheating Temperature Determination*

- 根据基材材质、厚度及焊接工艺评定结果确定预热温度
- Cr-Mo 钢法兰：预热温度 150 - 250°C
- 碳钢法兰：预热温度 100 - 150°C
- 不锈钢法兰：一般无需预热，特殊情况按工艺要求执行
- Determine preheating temperature based on base material, thickness and welding procedure qualification results
- Cr-Mo steel flanges: preheating temperature 150 - 250°C
- Carbon steel flanges: preheating temperature 100 - 150°C
- Stainless steel flanges: generally no preheating required, special cases follow process requirements

4.3.2 预热操作要求 *Preheating Operation Requirements*

- 采用电加热或火焰加热方式进行预热
- 加热区域为坡口两侧各不小于 100mm 范围
- 使用测温仪多点测量，确保预热温度均匀，温差控制在 $\pm 20^{\circ}\text{C}$ 以内
- 预热完成后保温 30 分钟以上，待温度均匀后开始堆焊
- 堆焊过程中保持层间温度不低于预热温度



- Use electric heating or flame heating for preheating
- Heating area shall be not less than 100mm on both sides of bevel
- Use thermometer for multi-point measurement, ensure uniform preheating temperature, temperature difference controlled within $\pm 20^{\circ}\text{C}$
- After preheating, keep warm for more than 30 minutes, start cladding after temperature is uniform
- During cladding, maintain interpass temperature not lower than preheating temperature

4.4 堆焊工序 Cladding Process

4.4.1 焊前准备 Pre-welding Preparation

- 确认焊接工艺规程（WPS）已审批，焊工持证上岗
- 检查焊材规格、型号与 WPS 一致，焊材烘干记录完整
- 不锈钢焊丝：烘干温度 150-200 $^{\circ}\text{C}$ ，保温时间 1-2 小时
- Cr-Mo 钢焊丝：烘干温度 300-350 $^{\circ}\text{C}$ ，保温时间 2-4 小时
- 清理坡口及附近区域，去除油污、锈迹、氧化皮等杂质
- Confirm welding procedure specification (WPS) has been approved, welders are certified
- Check welding material specification and model match WPS, welding material drying records complete
- Stainless steel welding wire: drying temperature 150-200 $^{\circ}\text{C}$, holding time 1-2 hours
- Cr-Mo steel welding wire: drying temperature 300-350 $^{\circ}\text{C}$, holding time 2-4 hours
- Clean bevel and surrounding area, remove oil, rust, scale and other impurities

4.4.2 堆焊工艺参数 Cladding Process Parameters

工艺参数 Process Parameter	TIG 堆焊 TIG Cladding	MIG 堆焊 MIG Cladding
焊接电流 Welding Current	80-160A	180-350A
电弧电压 Arc Voltage	18-25V	24-32V
焊接速度 Welding Speed	50-120mm/min	200-500mm/min
焊丝直径 Wire Diameter	2.4-3.2mm	1.2-1.6mm
保护气体 Shielding Gas	Ar 100%	Ar+CO ₂ (80:20)
气体流量 Gas Flow Rate	10-15L/min	15-25L/min
稀释率 Dilution Rate	$\leq 15\%$	$\leq 25\%$



4.4.3 堆焊操作要求 *Cladding Operation Requirements*

- 采用多层多道焊方式，单层厚度控制在 3-5mm
- 每层堆焊前清理焊渣，检查层间质量，无气孔、夹渣、未熔合等缺陷
- 控制层间温度，Cr-Mo 钢不超过 300°C，碳钢不超过 400°C
- 堆焊顺序：先堆焊密封面，再堆焊法兰面，确保堆焊层均匀
- 堆焊层高度超出基材表面 2-3mm，为后续机加工留余量
- 每焊完一层记录焊接参数、层间温度、焊接时间等信息
- Use multi-layer multi-pass welding, single layer thickness controlled at 3-5mm
- Clean slag before each layer, check interpass quality, no porosity, slag inclusion, incomplete fusion and other defects
- Control interpass temperature, Cr-Mo steel not exceeding 300°C, carbon steel not exceeding 400°C
- Cladding sequence: first clad sealing surface, then clad flange face, ensure uniform cladding layer
- Cladding layer height exceeds base material surface by 2-3mm, leaving allowance for subsequent machining
- Record welding parameters, interpass temperature, welding time and other information after each layer

4.4.4 堆焊质量要求 *Cladding Quality Requirements*

- 堆焊层表面平整，波纹均匀，不得有咬边、焊瘤、飞溅等缺陷
- 堆焊层与基材熔合良好，无未熔合、裂纹等缺陷
- 堆焊层化学成分符合技术协议要求
- 堆焊层硬度符合设计要求，一般 HB 180-280
- 堆焊层厚度符合图纸要求，偏差控制在 $\pm 0.5\text{mm}$ 以内
- Cladding layer surface smooth, uniform ripples, no undercut, weld overflow, spatter and other defects
- Good fusion between cladding layer and base material, no incomplete fusion, cracks and other defects
- Cladding layer chemical composition meets technical agreement requirements
- Cladding layer hardness meets design requirements, generally HB 180-280
- Cladding layer thickness meets drawing requirements, deviation controlled within $\pm 0.5\text{mm}$

4.5 热处理工序 *Heat Treatment Process*

4.5.1 热处理目的 *Purpose of Heat Treatment*

- 消除堆焊过程中产生的焊接应力



- 改善堆焊层及热影响区的组织和性能
- 提高堆焊层的韧性和抗裂性能
- 消除氢致裂纹隐患
- Eliminate welding stress generated during cladding process
- Improve microstructure and properties of cladding layer and HAZ
- Improve toughness and crack resistance of cladding layer
- Eliminate hydrogen-induced cracking 隐患

4.5.2 热处理工艺参数 Heat Treatment Process Parameters

热处理类型 Heat Treatment Type	加热速率 Heating Rate	保温温度 Holding Temperature	保温时间 Holding Time	冷却速率 Cooling Rate
去应力退火 Stress Relief Annealing	$\leq 200^{\circ}\text{C/h}$	620-680 $^{\circ}\text{C}$	1h/mm 壁厚	$\leq 150^{\circ}\text{C/h}$
正火 Normalizing	$\leq 200^{\circ}\text{C/h}$	850-900 $^{\circ}\text{C}$	1h/mm 壁厚	空冷 Air Cooling
淬火+回火 Quenching+Tempering	$\leq 200^{\circ}\text{C/h}$	淬火 850-900 $^{\circ}\text{C}$ / 回火 580-620 $^{\circ}\text{C}$	1h/mm 壁厚	油冷/空冷

4.5.3 热处理操作要求 Heat Treatment Operation Requirements

- 堆焊完成后立即进行热处理，间隔时间不超过 24 小时
- 装炉前检查工件表面，清除焊渣、飞溅等杂物
- 工件在炉内摆放均匀，保证加热均匀性
- 使用热电偶监测炉温，多点测温，温差控制在 $\pm 10^{\circ}\text{C}$ 以内
- 保温时间从工件达到保温温度时开始计算
- 冷却过程中控制冷却速率，避免急冷产生新的应力
- 热处理完成后记录温度曲线、保温时间等参数
- Perform heat treatment immediately after cladding, interval not exceeding 24 hours
- Check workpiece surface before loading, remove slag, spatter and other debris
- Arrange workpieces evenly in furnace, ensure uniform heating
- Use thermocouple to monitor furnace temperature, multi-point temperature measurement, temperature difference controlled within $\pm 10^{\circ}\text{C}$
- Holding time calculated from when workpiece reaches holding temperature
- Control cooling rate during cooling, avoid rapid cooling generating new stress
- Record temperature curve, holding time and other parameters after heat treatment



4.6 机加工工序 Machining Process

4.6.1 机加工前准备 Pre-machining Preparation

- 确认热处理已完成，工件冷却至室温
- 检查堆焊层表面质量，确认无裂纹、气孔等缺陷
- 根据图纸要求确定机加工余量及加工基准
- 准备合格的刀具、量具，检查设备运行状态
- Confirm heat treatment completed, workpiece cooled to room temperature
- Check cladding layer surface quality, confirm no cracks, porosity and other defects
- Determine machining allowance and machining datum according to drawing requirements
- Prepare qualified tools and measuring instruments, check equipment operating status

4.6.2 机加工内容 Machining Content

- 堆焊层表面精加工：车削或铣削至图纸要求的尺寸和表面粗糙度
- 密封面加工：保证密封面平面度、粗糙度符合标准（ $Ra \leq 1.6\mu m$ ）
- 螺栓孔加工：保证孔位精度、孔径公差符合图纸要求
- 法兰端面加工：保证端面与密封面垂直度
- 倒角加工：按要求加工倒角，去除毛刺
- Cladding layer surface finishing: turning or milling to drawing required dimensions and surface roughness
- Sealing surface machining: ensure sealing surface flatness and roughness comply with standards ($Ra \leq 1.6\mu m$)
- Bolt hole machining: ensure hole position accuracy and hole diameter tolerance comply with drawing requirements
- Flange end face machining: ensure end face perpendicularity to sealing surface
- Chamfer machining: process chamfer as required, remove burrs

4.6.3 机加工参数 Machining Parameters

加工内容 Machining Content	切削速度 Cutting Speed	进给量 Feed Rate	切削深度 Depth of Cut	表面粗糙度 Surface Roughness
粗车 Rough Turning	80-120m/min	0.2-0.4mm/r	2-4mm	Ra 3.2-6.3 μm
精车 Finish Turning	120-180m/min	0.05-0.1mm/r	0.3-0.8mm	Ra 0.8-1.6 μm
精铣 Finish	100-150m/min	0.02-0.05mm/z	0.5-1.5mm	Ra 0.8-1.6 μm



Milling				
钻孔 Drilling	30-60m/min	0.1-0.3mm/r	分层加工	Ra 3.2μm

4.6.4 机加工注意事项 Machining Precautions

- 堆焊层硬度较高，选用硬质合金刀具或涂层刀具
- 切削过程中充分冷却，防止刀具过热磨损
- 加工密封面时避免振动，保证表面质量
- 加工过程中随时检测尺寸，防止过切
- 加工完成后清除铁屑，保持工件清洁
- Cladding layer has high hardness, use carbide tools or coated tools
- Fully cool during cutting to prevent tool overheating and wear
- Avoid vibration when machining sealing surface to ensure surface quality
- Measure dimensions at any time during machining to prevent over-cutting
- Clean iron chips after machining, keep workpiece clean

4.7 检验工序 Inspection Process

4.7.1 外观检验 Visual Inspection

- 堆焊层表面平整，无裂纹、气孔、夹渣、咬边等缺陷
- 堆焊层与基材过渡平滑，无未熔合、未焊透等缺陷
- 机加工表面粗糙度符合图纸要求
- 密封面平面度、粗糙度符合标准要求
- 法兰整体外观无变形、划伤等缺陷
- Cladding layer surface smooth, no cracks, porosity, slag inclusion, undercut and other defects
- Smooth transition between cladding layer and base material, no incomplete fusion, incomplete penetration and other defects
- Machined surface roughness meets drawing requirements
- Sealing surface flatness and roughness meet standard requirements
- Flange overall appearance no deformation, scratches and other defects

4.7.2 尺寸检验 Dimensional Inspection

检验项目 Inspection Item	检验工具 Inspection Tool	允许偏差 Allowable Deviation
法兰外径 Outer Diameter	卡尺/千分尺	±0.5mm
法兰内径 Inner Diameter	卡尺/内径千分尺	±0.3mm



法兰厚度 Thickness	卡尺/千分尺	±0.5mm
螺栓孔直径 Bolt Hole Diameter	塞规/卡尺	±0.2mm
螺栓孔间距 Bolt Hole Pitch	游标卡尺	±0.5mm
密封面平面度 Sealing Surface Flatness	平尺/塞尺	≤0.1mm
堆焊层厚度 Cladding Layer Thickness	超声波测厚仪	±0.5mm

4.7.3 无损检测 Non-Destructive Testing

- 射线检测（RT）：对堆焊层进行 100%射线检测，按 NB/T 47013 标准评定，不低于Ⅱ级合格
- 超声波检测（UT）：对堆焊层与基材结合面进行超声波检测，检测裂纹、未熔合等缺陷
- 磁粉检测（MT）：对堆焊层表面及近表面进行磁粉检测，检测表面裂纹
- 渗透检测（PT）：对堆焊层表面进行渗透检测，检测开口缺陷
- Radiographic Testing (RT): 100% radiographic testing on cladding layer, evaluate according to NB/T 47013 standard, not lower than Grade II qualified
- Ultrasonic Testing (UT): Ultrasonic testing on cladding layer and base material interface, detect cracks, incomplete fusion and other defects
- Magnetic Particle Testing (MT): Magnetic particle testing on cladding layer surface and near surface, detect surface cracks
- Penetrant Testing (PT): Penetrant testing on cladding layer surface, detect open defects

4.7.4 力学性能检验 Mechanical Property Testing

- 堆焊层硬度测试：按 HBW 标准测试，符合设计要求
- 堆焊层化学成分分析：光谱分析，符合技术协议要求
- 弯曲试验：对堆焊层进行弯曲试验，验证结合强度
- 冲击试验：对堆焊层进行冲击试验，验证韧性
- Cladding layer hardness test: test according to HBW standard, meet design requirements
- Cladding layer chemical composition analysis: spectral analysis, meet technical agreement requirements
- Bending test: perform bending test on cladding layer, verify bonding strength
- Impact test: perform impact test on cladding layer, verify toughness

4.7.5 水压试验 Hydrostatic Test

- 对成品法兰进行水压试验，试验压力为设计压力的 1.5 倍



- 保压时间不少于 30 分钟
- 试验过程中无渗漏、无变形为合格
- 试验完成后排放积水，干燥处理
- Perform hydrostatic test on finished flanges, test pressure is 1.5 times design pressure
- Holding time not less than 30 minutes
- No leakage, no deformation during test is qualified
- After test, drain water, dry treatment

5. 质量控制要点 Quality Control Points

5.1 关键控制点 Key Control Points

工序 Process	控制点 Control Point	控制方法 Control Method	记录要求 Record Requirement
下料	材质确认	光谱分析	材质复验报告
坡口	坡口尺寸	量具检测	坡口检验记录
预热	预热温度	测温仪测量	预热温度记录
堆焊	焊接参数	设备监控	焊接参数记录
堆焊	层间温度	测温仪测量	层间温度记录
热处理	保温温度/时间	热电偶监控	热处理曲线记录
机加工	尺寸精度	量具检测	机加工检验记录
检验	无损检测	RT/UT/MT/PT	无损检测报告

5.2 不合格品控制 Non-conforming Product Control

- 发现不合格品立即标识隔离，填写不合格品报告
- 质量部组织评审，确定处置方案：返工、返修、让步接收或报废
- 返工返修后重新检验，合格后方可放行
- 不合格品处置记录存档，纳入质量统计分析
- Immediately mark and isolate non-conforming products, fill out non-conforming product report
- Quality department organizes review, determine disposal plan: rework, repair, concession acceptance or scrap
- Re-inspect after rework/repair, release only after qualified
- Non-conforming product disposal records archived, included in quality statistical analysis



6. 监督考核 Supervision and Assessment

6.1 过程监督 Process Supervision

- 质量部对堆焊法兰制造全过程进行监督检查
- 关键工序设置质量检验点，实行首件检验、巡检、终检制度
- 工艺工程部定期审核工艺执行情况，确保工艺纪律
- 生产部对生产进度进行跟踪，确保按期交付
- Quality department conducts supervision and inspection on the entire manufacturing process of cladding flanges
- Set quality inspection points at key processes, implement first article inspection, patrol inspection, final inspection
- Process engineering department regularly reviews process implementation, ensure process discipline
- Production department tracks production progress, ensure on-time delivery

6.2 考核指标 Assessment Indicators

考核项目 Assessment Item	目标值 Target Value	考核周期 Assessment Cycle
一次交检合格率	≥95%	月度
客户投诉率	≤1%	季度
工艺纪律执行率	≥98%	月度
设备完好率	≥95%	月度
产品交付及时率	≥95%	月度

7. 相关文件 Related Documents

文件编号 Document No.	文件名称 Document Name
CLADDING-WPS-001	焊接工艺规程 Welding Procedure Specification
CLADDING-QC-001	质量检验规程 Quality Inspection Procedure
CLADDING-HT-001	热处理工艺规程 Heat Treatment Procedure
CLADDING-NDE-001	无损检测规程 Non-Destructive Testing Procedure
CLADDING-MC-001	机加工工艺规程 Machining Process Procedure



8. 记录表格 Record Forms

表格编号 Form No.	表格名称 Form Name
CLADDING-FRM-001	原材料检验记录 Raw Material Inspection Record
CLADDING-FRM-002	坡口加工检验记录 Bevel Processing Inspection Record
CLADDING-FRM-003	预热温度记录 Preheating Temperature Record
CLADDING-FRM-004	焊接参数记录 Welding Parameter Record
CLADDING-FRM-005	层间温度记录 Interpass Temperature Record
CLADDING-FRM-006	热处理记录 Heat Treatment Record
CLADDING-FRM-007	机加工检验记录 Machining Inspection Record
CLADDING-FRM-008	无损检测报告 Non-Destructive Testing Report
CLADDING-FRM-009	成品检验记录 Finished Product Inspection Record
CLADDING-FRM-010	不合格品处置记录 Non-conforming Product Disposal Record

9. 附则 Supplementary Provisions

9.1 文件管理 Document Management

- 本程序由工艺工程部负责编制和修订
- 本程序每年评审一次，必要时进行修订
- 本程序经总经理批准后生效，修改需经审批程序
- This procedure is prepared and revised by Process Engineering Department
- This procedure is reviewed annually, revised when necessary
- This procedure takes effect after approval by General Manager, modifications require approval procedure

9.2 解释权 Interpretation

本程序由科雷丁技术（山西）有限公司工艺工程部负责解释。



This procedure is interpreted by Process Engineering Department of Cladding-Technology-Shanxi-Co.,-Ltd.

文件修订记录 Document Revision History

版本号 Version	修订日期 Revision Date	修订内容 Revision Content	修订人 Revised by
A/0	2024-01-01	首次发布 First Release	工艺工程部

本文件为受控文件，未经授权不得复制或外传

This document is a controlled document, reproduction or distribution without authorization is prohibited