



Cladding-Technology-Shanxi-Co.,-Ltd- CLADDING-MPS-014-Multi-Pass- Cladding-Layer-Process-Specification

科雷丁技术（山西）有限公司

Cladding-Technology-Shanxi-Co.,-Ltd

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Multi-Layer Multi-Pass Cladding Process Parameters and Operation Specification

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1. 目的 Purpose

中文:



为规范科雷丁技术（山西）有限公司在增材制造与精密堆焊业务中的多层多道堆焊作业流程，确保法兰、管件、钢管、轴套管及模具等工件在 TIG 堆焊与 MIG 堆焊过程中的成型质量、稀释率控制及层间结合性能，特制定本管理程序。本文件旨在通过标准化的道次安排、严格的层间清理及精确的温度控制，降低焊接缺陷率，提升再制造修复与表面强化工程的整体可靠性。

English:

To standardize the multi-layer multi-pass cladding operation process in the additive manufacturing and precision cladding business of Cladding-Technology-Shanxi-Co.,-Ltd, ensuring the forming quality, dilution rate control, and interlayer bonding performance of flanges, pipes, steel tubes, shaft sleeves, and molds during TIG cladding and MIG cladding processes, this management procedure is established. This document aims to reduce welding defect rates and improve the overall reliability of remanufacturing repair and surface strengthening engineering through standardized pass arrangement, strict interlayer cleaning, and precise temperature control.

2. 适用范围 Scope

中文:

本规范适用于公司所有涉及金属零部件表面强化、再制造修复及梯度材料制备的项目。具体涵盖但不限于以下业务场景：

1. 高压法兰密封面的 TIG 精密堆焊。
2. 长距离钢管及管件内壁的 MIG 自动化堆焊。
3. 大型轴套管及旋转部件的耐磨层增材制造。
4. 各类工业模具的 TIG/MIG 复合堆焊修复。
5. 基于电弧增材制造技术的近净成形零部件制备。

English:

This specification applies to all projects involving surface strengthening, remanufacturing repair, and gradient material preparation of metal components in the company. It specifically covers but is not limited to the following business scenarios:

6. TIG precision cladding on high-pressure flange sealing surfaces.
7. MIG automated cladding on the inner wall of long-distance steel pipes and pipe fittings.
8. Wear-resistant layer additive manufacturing for large shaft sleeves and rotating components.
9. TIG/MIG composite cladding repair for various industrial molds.
10. Near-net-shape component preparation based on arc additive manufacturing technology.



3. 职责 Responsibilities

中文:

11. **生产部 Production Department:** 负责依据本规范编制具体的焊接工艺指导书（WPS），监督现场操作人员严格执行道次安排与温度控制要求，并负责焊接设备的日常维护。
12. **质量部 Quality Department:** 负责制定层间清理验收标准，对堆焊过程中的层间温度进行抽检，并对成品进行无损检测及尺寸精度验证。
13. **技术部 Technology Department:** 负责根据工件材质及工况要求，确定堆焊材料匹配方案，优化多层多道焊接参数，解决生产过程中的技术难题。
14. **操作人员 Operators:** 负责按照工艺文件要求进行设备调试、道次焊接、层间清理及温度记录，确保作业过程可追溯。

English:

15. **Production Department:** Responsible for compiling specific Welding Procedure Specifications (WPS) based on this specification, supervising on-site operators to strictly execute pass arrangement and temperature control requirements, and responsible for daily maintenance of welding equipment.
16. **Quality Department:** Responsible for establishing interlayer cleaning acceptance standards, spot-checking interlayer temperature during the cladding process, and performing non-destructive testing and dimensional accuracy verification on finished products.
17. **Technology Department:** Responsible for determining cladding material matching schemes based on workpiece material and operating conditions, optimizing multi-layer multi-pass welding parameters, and solving technical problems during the production process.
18. **Operators:** Responsible for equipment debugging, pass welding, interlayer cleaning, and temperature recording according to process documents, ensuring traceability of the operation process.

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

4.1 焊前准备 Pre-weld Preparation

中文:

在进行多层多道堆焊作业前，操作人员必须对基体工件进行彻底检查。对于法兰、管件及轴套管等工件，需清除表面的油污、锈蚀及氧化皮。若基体表面存在严重缺陷，需先进行打磨处理。同时，根据工件材质选择合适的焊丝，TIG 堆焊通常选用纯度较高的填充金属以



保证低稀释率，MIG 堆焊则根据熔敷效率要求选择相应直径的焊丝。焊接设备需提前预热，确保送丝机构运行顺畅，保护气体流量稳定。

English:

Before performing multi-layer multi-pass cladding operations, operators must thoroughly inspect the base workpiece. For workpieces such as flanges, pipes, and shaft sleeves, surface oil, rust, and scale must be removed. If there are serious defects on the base surface, grinding treatment is required first. At the same time, select appropriate welding wire based on workpiece material. TIG cladding usually selects high-purity filler metal to ensure low dilution rate, while MIG cladding selects welding wire of corresponding diameter based on deposition efficiency requirements. Welding equipment must be preheated in advance to ensure smooth operation of the wire feeding mechanism and stable shielding gas flow.

4.2 道次安排规范 Pass Arrangement Specification

中文:

多层多道堆焊的核心在于合理的道次规划，以防止热输入过大导致基体稀释率超标或工件变形。

19. **底层堆焊 Base Layer Cladding:** 第一层堆焊对结合质量至关重要。对于 TIG 精密堆焊，应采用小电流、慢速度的参数设置，确保熔深适中，避免烧穿薄壁管件或法兰密封面。道宽应控制在焊丝直径的 1.5 至 2 倍之间。
20. **中间层堆焊 Intermediate Layer Cladding:** 中间层主要承担熔敷量任务。MIG 堆焊可采用较高的电流和电压以提高熔敷效率。道次排列应采用交错搭接方式，每道焊缝与相邻焊缝的重叠量应保持在道宽的 20%至 30%，以确保层间结合牢固，避免产生未熔合缺陷。
21. **盖面层堆焊 Capping Layer Cladding:** 最后一层堆焊主要影响表面成型质量。需严格控制道宽均匀性，特别是对于模具修复及轴套管表面强化项目，盖面层应平整光滑，无咬边及气孔。
22. **方向控制 Direction Control:** 对于长距离钢管内壁堆焊，应采用螺旋式或直线往复式的道次推进方式，确保熔池流动稳定。对于大型法兰，应采用分段对称焊接，以平衡焊接应力。

English:

The core of multi-layer multi-pass cladding lies in reasonable pass planning to prevent excessive heat input from causing excessive base dilution or workpiece deformation.

23. **Base Layer Cladding:** The first layer of cladding is crucial for bonding quality. For TIG precision cladding, small current and slow speed parameter settings should be adopted to ensure moderate penetration depth, avoiding burn-through of thin-walled pipes or flange sealing surfaces. The pass width should be controlled between 1.5 to 2 times the wire diameter.



24. **Intermediate Layer Cladding:** The intermediate layer mainly undertakes the deposition volume task. MIG cladding can use higher current and voltage to improve deposition efficiency. Pass arrangement should adopt a staggered overlapping method, and the overlap between each weld pass and adjacent passes should be maintained at 20% to 30% of the pass width to ensure firm interlayer bonding and avoid unfused defects.
25. **Capping Layer Cladding:** The last layer of cladding mainly affects surface forming quality. Uniformity of pass width must be strictly controlled, especially for mold repair and shaft sleeve surface strengthening projects. The capping layer should be flat and smooth, without undercutting or porosity.
26. **Direction Control:** For long-distance steel pipe inner wall cladding, a spiral or linear reciprocating pass advancement method should be adopted to ensure stable molten pool flow. For large flanges, segmented symmetrical welding should be adopted to balance welding stress.

4.3 层间清理规范 Interlayer Cleaning Specification

中文:

层间清理是保证多层堆焊质量的关键环节，必须严格执行以下标准：

27. **焊渣清除 Slag Removal:** 每完成一道或一层焊接后，必须立即清除焊缝表面的熔渣。对于 TIG 堆焊，主要使用钢丝刷清除氧化膜；对于 MIG 堆焊，需彻底清除熔渣及飞溅物。严禁使用砂轮机过度打磨导致前道焊缝被过度切削，影响层间结合。
28. **缺陷检查 Defect Inspection:** 清理后需目视检查焊缝表面是否存在气孔、裂纹、夹渣等缺陷。对于关键受力部件如高压法兰及轴套管，必要时需进行渗透检测（PT）或磁粉检测（MT）。发现缺陷必须彻底清除并补焊后方可进行下一道焊接。
29. **清洁度要求 Cleanliness Requirement:** 层间表面不得残留油污、水分及粉尘。在精密增材制造过程中，若发现基体表面有污染，需使用无水乙醇擦拭干净，防止气体保护失效导致焊缝氧化。

English:

Interlayer cleaning is a key link to ensure the quality of multi-layer cladding, and the following standards must be strictly executed:

30. **Slag Removal:** After completing each pass or layer of welding, the slag on the weld surface must be removed immediately. For TIG cladding, a wire brush is mainly used to remove the oxide film; for MIG cladding, slag and spatter must be thoroughly removed. It is strictly forbidden to over-grind with a grinder, which may cause excessive cutting of the previous weld pass and affect interlayer bonding.
31. **Defect Inspection:** After cleaning, the weld surface must be visually inspected for defects such as porosity, cracks, and inclusions. For critical load-bearing components such as high-pressure



flanges and shaft sleeves, penetrant testing (PT) or magnetic particle testing (MT) is required if necessary. Defects must be thoroughly removed and repaired before proceeding to the next pass.

32. **Cleanliness Requirement:** No oil, water, or dust residues are allowed on the interlayer surface. In the process of precision additive manufacturing, if contamination is found on the base surface, it must be wiped clean with anhydrous ethanol to prevent shielding gas failure leading to weld oxidation.

4.4 层间温度控制 Interlayer Temperature Control

中文:

层间温度直接影响堆焊层的组织性能及稀释率。科雷丁技术针对不同材料制定了严格的温度控制标准:

33. **温度监测 Temperature Monitoring:** 操作人员必须使用红外测温仪或接触式热电偶对层间温度进行实时监测。每完成一层焊接, 需测量焊缝中心及两侧母材的温度。
34. **温度限值 Temperature Limits:**
- 对于不锈钢及合金钢法兰堆焊, 层间温度一般控制在 150°C至 250°C之间, 以防止晶间腐蚀及敏化现象。
 - 对于碳钢钢管及管件堆焊, 层间温度可控制在 200°C至 300°C之间, 以保证焊缝韧性。
 - 对于模具钢修复, 层间温度不得超过 350°C, 以防止基体硬度下降及回火软化。
 - 若层间温度超过规定上限, 必须暂停焊接, 自然冷却或采用强制风冷至规定范围内后方可继续施焊。
35. **预热与后热 Preheating and Post-heating:** 对于厚壁工件或低合金钢材料, 焊前需进行预热, 预热温度根据材料碳当量确定。焊后根据需要进行保温缓冷, 防止产生冷裂纹。

English:

Interlayer temperature directly affects the organizational properties and dilution rate of the cladding layer. Cladding-Technology-Shanxi-Co.,-Ltd has established strict temperature control standards for different materials:

36. **Temperature Monitoring:** Operators must use infrared thermometers or contact thermocouples to monitor interlayer temperature in real time. After completing each layer of welding, the temperature of the weld center and the base material on both sides must be measured.
37. **Temperature Limits:**
- For stainless steel and alloy steel flange cladding, the interlayer temperature is generally controlled between 150°C and 250°C to prevent intergranular corrosion and sensitization.
 - For carbon steel pipe and pipe fitting cladding, the interlayer temperature can be controlled between 200°C and 300°C to ensure weld toughness.



- For mold steel repair, the interlayer temperature must not exceed 350°C to prevent base hardness reduction and tempering softening.
 - If the interlayer temperature exceeds the specified upper limit, welding must be suspended, and natural cooling or forced air cooling to the specified range is required before continuing.
38. **Preheating and Post-heating:** For thick-walled workpieces or low-alloy steel materials, preheating is required before welding, and the preheating temperature is determined based on the material carbon equivalent. Post-weld insulation and slow cooling are required if necessary to prevent cold cracks.

5. 监督考核 Supervision and Assessment

中文:

39. 质量部每周对生产现场的层间清理及温度控制记录进行抽查，发现违规操作将依据公司绩效考核制度进行处理。
40. 对于因未执行本规范导致的产品质量事故，将追究相关操作人员及管理人員的责任。
41. 技术部每季度对本规范的有效性进行评估，根据行业技术发展及客户反馈进行修订。

English:

42. The Quality Department will spot-check the interlayer cleaning and temperature control records on the production site weekly. Violations will be handled in accordance with the company's performance assessment .
43. For product quality accidents caused by failure to implement this specification, the relevant operators and managers will be held accountable.
44. The Technology Department will evaluate the effectiveness of this specification quarterly and revise it based on industry technological development and customer feedback.

6. 附则 Supplementary Provisions

中文:

45. 本规范自发布之日起执行，原有相关作业指导书与本规范不一致的，以本规范为准。
46. 本规范由科雷丁技术（山西）有限公司技术部负责解释。
47. 本规范涉及的具体工艺参数应根据实际 WPS 文件执行，本规范为通用管理要求。

English:

48. This specification shall be implemented from the date of release. If any existing relevant work instructions are inconsistent with this specification, this specification shall prevail.



49. This specification is interpreted by the Technology Department of Cladding-Technology-Shanxi-Co.,-Ltd.
50. The specific process parameters involved in this specification shall be executed according to the actual WPS documents. This specification serves as general management requirements.

文件结束 **End of Document**