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Comparison and Study of Various Degreasing Test Methods for Monel Alloy

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Abstract

The primary purpose of alloy degreasing is to eliminate oil stains and impurities, enhance alloy purity, and ensure processing quality and alloy performance. This article mainly compares various degreasing processes for Monel alloy pipelines. By comparing the reaction results of degreasing fluorescent agents, the most effective degreasing process is selected to improve the coating quality of the alloy and provide a quality foundation for subsequent alloy applications.

Keywords

monel metal; degreasing process; high pressure gas supply pipeline

1. Introduction

Monel400 alloy exhibits excellent mechanical, physical, and chemical properties. It is widely used in energy development, chemical engineering, electronics, marine applications, and aerospace industries. The alloy demonstrates superior corrosion resistance, stress corrosion resistance, and excellent machinability [1-2].

Metal degreasing is a critical process in manufacturing. When metal surfaces undergo stamping or cutting operations, lubricants or rust-preventive oils are typically applied to prevent oxidation and ensure smooth processing. The degreasing process involves removing organic contaminants like fats and oils from metal surfaces, ensuring clean surfaces that provide optimal conditions for subsequent operations[3]. This essential procedure plays a vital role in metalworking, manufacturing, and coating applications.

2. Alloy degreasing

In metal degreasing processes, various methods such as solvent-based, alkaline, and acidic approaches are commonly employed. The solvent method remains the most widely used technique. This process utilizes appropriate solvents to dissolve surface fats and oils, followed by physical or chemical separation to achieve degreasing objectives. Common solvents include petroleum ether, chlorinated petroleum, and alcohol. The solvent-based degreasing process offers advantages like simple operation and effective degreasing performance, making it extensively applied in metal processing industries.

Another widely used metal degreasing method is the alkaline process. This technique employs alkaline solutions to convert surface fats and oils into saponified compounds, which are then removed through water washing. The alkaline degreasing process is suitable for environmentally friendly applications that require non-toxic and harmless conditions. However, it may cause corrosion to metal surfaces, necessitating strict operational controls during implementation.

The acid-based degreasing method is another widely used technique in metal surface treatment. This process converts grease and oil residues on metal surfaces into esters through acidic solutions, which are then removed by water washing. It is particularly suitable for applications requiring high corrosion resistance of metal surfaces. However, this method demands strict safety protocols from operators, as the acidic solutions pose significant health risks.

In addition to the above common metal degreasing processes, there are some other methods, such as ultrasonic degreasing, high-pressure water degreasing, etc. These methods have certain advantages in specific occasions, but also have certain limitations and application restrictions.

3. Alloy degreasing process

The pipeline specifications used in this degreasing validation are 6×1.5, 8×2, 10×2, and 16×3.

3.1. Preparation before fat removal

Prior to the test, wrap the pipe opening with a clean cloth (wear gloves) and purge the pipeline with 4-5 MPa nitrogen for approximately 40 seconds. After completion, observe the fluorescence intensity on the clean cloth surface using a UV lamp and document the results through multimedia recording. This process serves as the basis for comparing different degreasing durations. For anhydrous ethanol degreasing: Soak the four specified pipe specifications for 24 hours, then dry residual ethanol with nitrogen. Afterward, wrap the pipe opening with a clean cloth (wear gloves) and purge the pipeline with 4-5 MPa nitrogen for approximately 40 seconds. Observe the fluorescence intensity on the clean cloth surface using a UV lamp and record the results through multimedia. Regarding carbon tetrachloride degreasing: The supplier uses carbon tetrachloride for degreasing. After degreasing, wrap the pipe opening with a clean cloth and purge the pipeline with 4-5 MPa nitrogen for approximately 40 seconds. Observe the fluorescence intensity on the clean cloth surface using a UV lamp and document the results through multimedia. For alcohol cleaning: Clean the pipes with alcohol, then observe the fluorescence intensity on the clean cloth surface using a UV lamp and record the results through multimedia.

3.2. Fat removal process

After completing the above preparation work, begin the pipe degreasing work.
This section conducts a comparative study of four degreasing processes, analyzing their effectiveness. The surface of degreased parts is inspected using ultraviolet light, with no visible oil fluorescence indicating compliance. This establishes a foundation for subsequent degreasing processes.

- Ultrasonic cleaning → Use degreasing agent (carbon tetrachloride) for 4-5 cycles → Drying → Inspect catheter surface with UV lamp.
- Apply carbon tetrachloride for degreasing. After degreasing, clean with pure alcohol and inspect valve components for blue dot detection.
- Use degreasing agent (carbon tetrachloride) for 30-minute circulation cleaning (filter before and after tooling) → Clean with purified water (Wahaha brand) → Blow off excess with ultra-pure nitrogen (⩾99.999%, ⩽1MPa) at one end, collect residue with lint-free cloth at the other end → Inspect lint-free cloth with white and UV lamps in dark environment for oil contamination → Wrap catheter connectors securely and avoid manual contact. For instrument transition connectors and other contact-prone areas, soak in SK-410 degreasing agent, wrap with degreasing tape after evaporation, then re-soak before assembly.
- Use immersion method for Monel alloy tube degreasing with anhydrous ethanol (⩾99.7%).

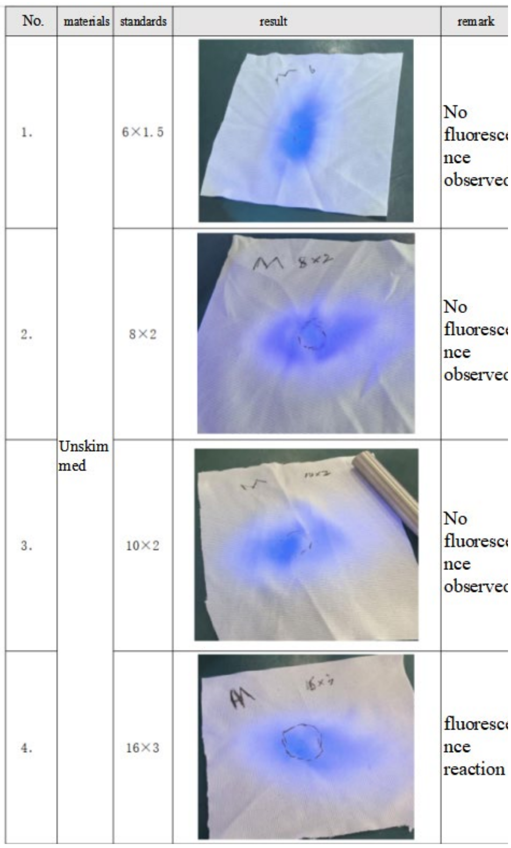
Prepare DN100 steel pipes with both ends sealed (using any method that prevents the release of degreasing agent). Form them into troughs and fill with anhydrous ethanol. Submerge all Monel alloy pipes completely and soak for over 24 hours. After soaking, first dry the pipes with nitrogen, then use a hot air blower to ensure no liquid remains inside.

Table 1. Statistical analysis of fat removal.

number	type specification	quantity	Fat removal method	Fat removal time	Nitrogen purging time	Fat removal effect	remarks
1	6×1.5	1	Unfat	/	40s	/	No fluorescence observed
2	8×2	1			40s		
3	10×2	1			40s		
4	16×2	1			40s		Weak fluorescence response
5	6×1.5	1	absolute ethyl alcohol	Soak the container for 24 hours	40s	No fluorescence observed	Attached diagram
6	8×2	1			40s		
7	10×2	1			40s		
8	16×2	1			40s		
9	6×1.5	2	carbon tetrachlo-	Ultrasonic clean-	40s	No fluorescence ob-	

10	8×2	2	ride	ing machine for 45 minutes	40s	served	
11	10×2	2			40s		
12	16×2	2			40s		
13	6×1.5	1	Metal Cleaner (SK-410)	Soak for 24 hours	40s	No fluorescence observed	Attached diagram
14	8×2	1			40s		
15	10×2	1			40s		
16	16×2	1			40s		

The degree of degreasing was determined by whether the inner and outer surfaces of the tube showed fluorescence under ultraviolet light. As shown in **Table 1**, the degreasing effect was good.



No.	materials	standards	result	remark
1.	Unskimmed	6×1.5		No fluorescence observed
2.		8×2		No fluorescence observed
3.		10×2		No fluorescence observed
4.		16×3		fluorescence reaction

Figure 1. Unblanched alloy pipe results for different sizes.

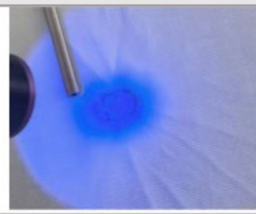
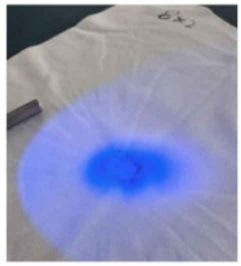
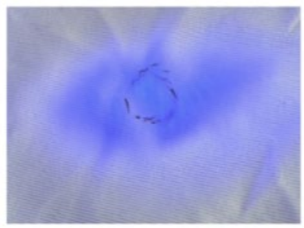
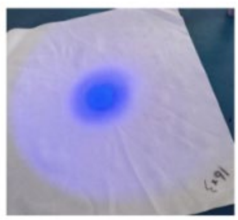
No.	materials	standards	result	remark
1.	Decontamination with anhydrous ethanol	6×1.5		No fluorescence observed
2.		8×2		No fluorescence observed
3.		10×2		No fluorescence observed
4.		16×3		No fluorescence observed

Figure 2. Deburring results of water-free ethanol on alloy pipes of different sizes.

As shown in **Figure 1**, the 16×3 tube exhibited a faint fluorescence response without degreasing, while other sizes showed no fluorescence.

As shown in **Figure 2**, no fluorescence reaction occurred in the pipelines of all sizes after anhydrous ethanol defatting.

As shown in **Figure 3**, no fluorescence was detected in the pipelines of all sizes after degreasing with SK-410.

It is not difficult to see from the above experimental results that the three degreasing processes have good degreasing effect.

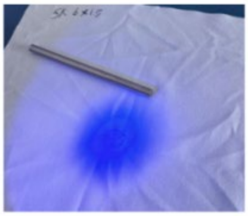
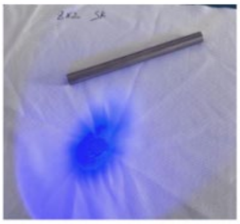
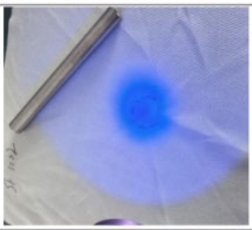
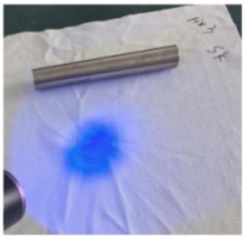
1.		6×1.5		No fluorescence observed
2.		8×2		No fluorescence observed
3.	SK-410	10×2		No fluorescence observed
4.		16×3		No fluorescence observed

Figure 3. Deburring results of water-free ethanol on alloy pipes of different sizes.

3. Alloy degreasing process

3.1. Pre-weld degreasing

Select stainless steel degreasing tanks based on catheter dimensions, ensuring complete immersion of all nickel-copper alloy catheters. Arrange the catheters neatly without collisions. Fill the degreasing tank with 99.7% anhydrous ethanol to fully submerge the catheters, then seal the tank and let it stand for 4 hours. After the initial degreasing, remove the catheters and purify them with 4-5 MPa 99.999% high-purity nitrogen. Simultaneously, drain the ethanol from the tank and clean it with 99.7% anhydrous ethanol before disposal. Reimpose the catheters in the degreasing tank with fresh 99.7% anhydrous ethanol, seal the tank, and let it stand for 20 hours. After the second degreasing, remove the catheters and purify them with 4-5 MPa 99.999% high-purity nitrogen. Drain the ethanol from the tank and clean it with 99.7% anhydrous ethanol before disposal. After degreasing and purifying, wrap both ends of the catheters with soft foam and secure them with rubber bands. Store them in a clean turnover box. Conduct 100% endoscopic inspections of all catheters to verify internal surface cleanliness, ensuring no oil stains or contaminants remain.

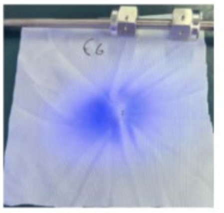
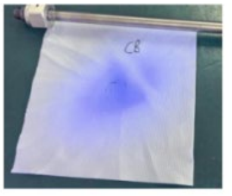
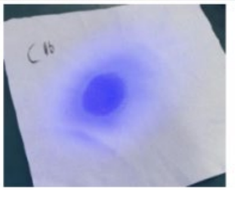
No.	materials	standards	result	remark
1.	carbon tetrachloride	6×1.5		No fluorescence observed
2.		8×2		No fluorescence observed
3.		10×2		No fluorescence observed
4.		16×3		No fluorescence observed

Figure 4. Deburring results of water-free ethanol on alloy pipes of different sizes.

3.2. Post-weld degreasing

Place the welded nickel-copper alloy tubes into the degreasing tank, add fresh 99.7% anhydrous ethanol to fully submerge them, then seal the tank and let them sit for 24 hours. After degreasing, remove the tubes and purify them with 35MPa 99.999% high-purity nitrogen. Wrap both ends of the degreased tubes with soft foam and secure them with rubber bands, then store them in a clean turnover box. Conduct residual material inspections on all tubes: purify one end with 35MPa 99.999% nitrogen, install a residual material collection fixture (with built-in non-woven fabric) on the other end, and purify for 20 seconds. Expose the non-woven fabric and both tube ends to ultraviolet light for inspection. No fluorescence reaction indicates compliance. Perform 100% endoscopic inspection of all tubes' inner surfaces to ensure complete removal of oil stains and residual materials.

4. Conclusion

This study conducted degreasing tests on pipelines of various sizes using four methods: anhydrous ethanol, carbon tetrachloride, and metal cleaner (SK-410). Fluorescence analysis of the degreased pipelines revealed no fluorescent reactions, confirming effective degreasing across all four methods.

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