JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

ANALYSIS THE EFFECT OF SMAW ELECTRODE COATING ON WELD SURFACE FINISH WITH DIFFERENT PROCESS PARAMETERS

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Abstract : Shielded Metal Arc Welding (SMAW), commonly known as stick welding, relies heavily on the characteristics of its electrode coating to achieve desired weld quality and performance. The electrode coating serves multiple critical functions, including arc stabilization, metal transfer control, slag formation, gas shielding, and alloying element addition. Depending on the coating composition and purpose, SMAW electrodes are classified into three main types: cellulosic, rutile, and basic (low hydrogen) coatings. Cellulosic coatings, rich in organic materials, produce deep penetration and are suitable for vertical and overhead positions. Rutile coatings based on titanium dioxide, offer smooth arc operation, easy slag removal and excellent bead appearance, making them ideal for general-purpose welding. Basic (low hydrogen) coatings, containing calcium carbonate and fluoride, minimize hydrogen content and provide superior mechanical properties and crack resistance, particularly for critical structural applications. Understanding the role and behavior of each coating type is essential for selecting the appropriate electrode to meet specific welding requirements and service conditions.

Key Words - SMAW, Shielded Metal Arc Welding, Electrode coating, Cellulosic electrode, Rutile electrode, Basic electrode, Low hydrogen electrode, Arc stability, Welding consumables, Coating composition.

Literature survey on Effect of Coating on Weldability

The type of electrode coating in Shielded Metal Arc Welding (SMAW) has a significant influence on weldability, determining factors such as arc stability, penetration, slag detachability, and mechanical properties of the weld. Cellulosic coatings, Rutile coatings, and Basic (low hydrogen) coated electrodes provides different mechanical properties and differently appeared clean welds, also the surface finish may be slightly different. If parameters are not properly optimized, as they require precise control of current, voltage, arc length and other process parameters. Therefore, the choice of coating type directly impacts weldability, efficiency, and the suitability of the process for different materials and service conditions [(6)].

1. Cellulosic Type Electrodes

Cellulosic electrodes contain a high percentage of cellulose in their coating. They produce a forceful, deeply penetrating arc and fast-freezing slag, ideal for vertical and overhead welding [(1)].

Electrode Designation	Current Type	Key Features	Typical Applications
E6010	DC+	Deep penetration, fast-freezing slag	Pipe welding, vertical and overhead welds
E7010-G	DC+	High-strength pipeline electrode with strong root penetration	Pipeline and structural welding
E8010-P1	DC+	High-strength cellulosic electrode for API-grade steels	Cross-country pipeline welding
E9010-G	DC+	Deep penetration, good for low-alloy steels	Pressure vessels and pipelines

2. Rutile Type Electrodes

Rutile electrodes contain titanium dioxide (rutile) in their coating, providing smooth arc operation, easy slag removal, and good bead appearance. Suitable for general fabrication and all position welding [3].

Electrode Designation	Current Type	Key Features	Typical Applications
E6012	AC/DC	Fast-freezing slag, shallow penetration	Thin sheet welding
E6013	AC/DC	Smooth arc, easy slag removal, moderate penetration	General fabrication, thin plates
E7014	AC/DC	Iron powder rutile, high deposition rate	Structural steel, fillet welds
E7024	AC/DC	High deposition rate, flat position only	Heavy fabrication, flat welds

3. Low Hydrogen (Basic) Type Electrodes

Low-hydrogen electrodes have coatings rich in calcium carbonate and calcium fluoride, reducing hydrogen content and minimizing cracking. They provide excellent mechanical properties and are used for critical applications [1].

Electrode Designation	Current Type	Key Features	Typical Applications
E7015	DC+	Deep penetration, high toughness	Heavy structures, pressure vessels
E7018	AC/DC+	Smooth, stable arc, low spatter, excellent mechanical strength	Structural steel, bridges, shipbuilding
E8018-C1	AC/DC+	Alloyed low-hydrogen electrode for higher strength	Boilers, high-strength steels
E10018	AC/DC+	High tensile strength, low hydrogen	Cranes, heavy structures

SMAW WELDING PARAMETERS CONSIDERED FOR ANALYSIS[2]

1. Electrode diameter: The diameter is plays vital role in welding work, its carries different current density with respect to different diameter.
2. Current: The mid-range of the current recommended for general work. Lower current for thin plates and higher current for thick plates or heavy deposition.
3. Voltage: SMAW voltage is generally not adjusted directly. Maintain correct arc length to achieve stable arc voltage.
4. Travel Speed: Faster travel reduces heat input, producing a narrower bead but may cause under fill or poor fusion. Slower travel increases reinforcement and can cause uneven bead shape.
5. Arc Length: Keep arc length short—about equal to the electrode diameter (in mm) for better surface finish and stable arc. Longer arcs increase spatter and reduce bead quality.
6. Polarity: DCEP (DC+) provides deeper penetration and is recommended for cellulosic and basic electrodes. Rutile electrodes work well with either AC or DCEP.

Effect of Coating on Weld Surface Finish of Mild Steel Plate with Different SMAW Parameters

The electrode coating type plays a crucial role in determining the surface finish quality of welds on mild steel plates under varying SMAW parameters such as current, voltage, welding speed, and electrode feed rate.

Cellulosic-coated electrodes tend to produce a more forceful arc and deeper penetration, which can lead to a rougher weld surface and higher spatter, especially at higher current settings [5].

Rutile-coated electrodes, due to their stable arc and smooth slag formation, generally yield a uniform bead appearance with minimal spatter and easy slag removal, even when welding parameters fluctuate [4].

Basic (low hydrogen) coated electrodes provide excellent mechanical properties and clean welds with low porosity, but the surface finish may be slightly uneven if parameters are not properly optimized, as they require precise control of current and arc length.

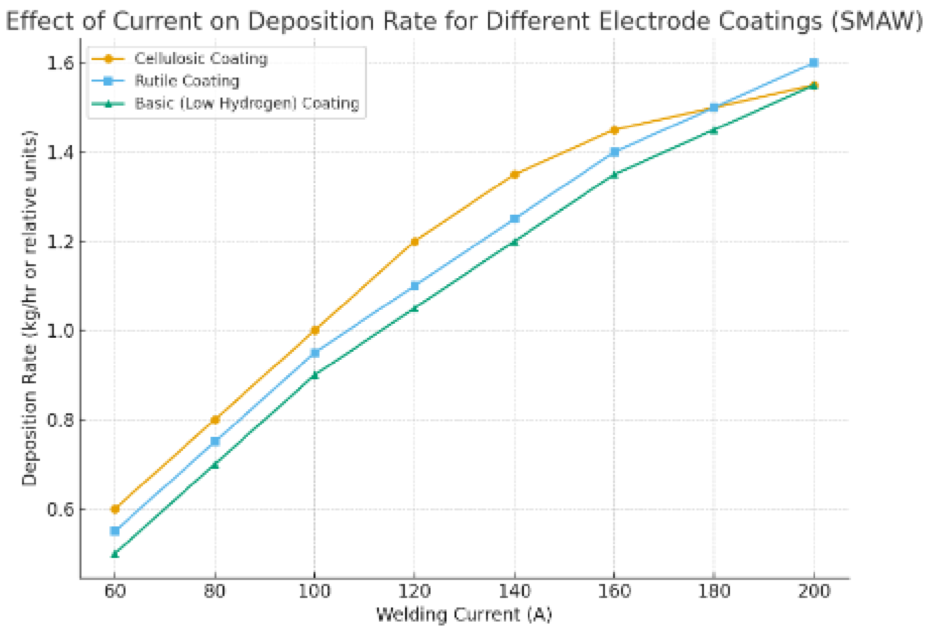
Increasing current and voltage generally improves penetration but can deteriorate surface smoothness due to excessive melting and spatter. Conversely, higher welding speeds may reduce heat input, leading to narrower beads and potential underfill, while controlled electrode feed ensures consistent metal deposition and bead uniformity.

Thus, the interaction between coating type and welding parameters strongly influences weld surface finish, requiring careful parameter optimization for achieving high-quality mild steel welds[7] .

Effect of Electrode Coating with different diameter for mild steel base plate welding by SMAW process parameters[(2)].

Coating Type	Electrode Dia (mm)	Current (A)	Voltage (V)	Travel Speed (mm/min)	Approx. Arc Length (mm)	Polarity	Weld Surface finish / Result
Cellulosic coated SMAW electrode E7010-G	2.5	50–85	18–25	300–600	1–2	DCEP	Deep penetration, high spatter, rougher surface finish
	3.15	75–120	21–27	250–500	1–2	DCEP	Maintain short arc length for smoother bead.
	4.0	120–160	22–30	200–450	1–2.5	DCEP	High gas generation requires skilled control. Average weld finish
Rutile coated SMAW electrode E-6013	2.5	60–90	20–26	350–700	1.5–3	DCEP	Smooth arc, low spatter, easy slag removal. Better weld finish in DCEP
	3.15	80–130	22–28	300–600	1.5–3	DCEP	Good bead appearance, stable arc.
	4.0	130–180	22–30	250–500	1.5–3.5	DCEP	Ideal for general-purpose welding.
Basic coated/ Low Hydrogen SMAW electrode E-7018	2.5	55–90	22–28	300–600	1–3	DCEP	Clean welds, low porosity, require dry electrodes.
	3.15	90–150	22–30	250–500	1–3	DCEP	Bake before use, avoid humidity exposure. Baked electrode produce better weld surface finish
	4.0	130–200	24–32	200–450	1–3.5	DCEP	Low hydrogen, high mechanical strength. Baked electrode produce better weld surface finish

The Effect of Electrode Coating on weld deposition rate[(2)]



The graph shows the weld deposition rate (kg/hr) vs. welding current for SMAW process, for different type of electrode used for weld deposit. The graph shows that there is marginal consistent difference in weld deposit.

Conclusion

The surface finish of welds in Shielded Metal Arc Welding (SMAW) is strongly influenced by both the type of electrode coating and the selected process parameters such as current, voltage, welding speed, and electrode feed rate.

Among the different coating types, rutile electrodes consistently produce the best surface finish due to their stable arc, smooth slag flow, and easy slag removal.

Cellulosic electrodes, while offering deeper penetration, tend to create a rougher surface with higher spatter, especially at elevated currents and slower travel speeds.

Basic (low hydrogen) electrodes provide clean and defect-free welds with low porosity, but achieving a smooth surface requires precise control of heat input and arc length.

There is some marginal difference seen in weld deposition rate with respect to coating type.

Process parameters also play a vital role: excessive current and voltage increase spatter and bead irregularities, whereas low welding speed can cause excessive reinforcement and poor bead contour. Conversely, optimal current, moderate voltage, and uniform travel speed result in better bead appearance and surface smoothness.

Therefore, obtaining a good weld surface finish on mild steel depends on selecting the appropriate electrode coating and maintaining balanced welding parameters suited to the electrode type and joint condition.

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