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Sprečavanje i uklanjanje termičkog oksida (heat tint)
Preventing and removing of heat tint

Originalni naučni rad / Original scientific paper
UDK / UDC: 669.14.018.8:620.193.4 ;
669.14.018.8:621.791.05
Rad primljen / Paper received:
Januar 2014.

Ključne reči: nerđajući čelici, zavarivanje, heat tint, korozija, nagrizanje

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Keywords: stainless steels, welding, heat tint, corrosion, pickling

Izvod

Obrazovanje heat tint-a predstavlja povećanje debljine prirodno formiranog oksidnog sloja na površini nerđajućih čelika, tokom zavarivanja. Debljina heat tint-a u neposrednoj blizini zavarenog spoja zavisi od temperature, vremena zagrevanja i koncentracije kiseonika u zaštitnom gasu. Kod nerđajućih čelika hromom bogat oksid formira se na površini metala, dok je podpovršinski sloj osiromašen hromom. Zavarivanje treba izvoditi u zaštitnom gasu da bi se sprečilo obrazovanje heat tint-a. Ukoliko se formira, ovaj oksid mora biti uklonjen da bi se sačuvala potpuna otpornost prema koroziji zavarenih delova. U ovom radu opisane su mehaničke i/ili hemijske metode za uklanjanje heat tint-a koje se obično primenjuju.

Abstract

Heat tinting is a thickening of the naturally occurring oxide layer on the surface of the stainless steels during welding. The thickness of the oxide layer next to the weld depends on the temperature, heating time, and oxygen concentration in the shielding gas. On stainless steels chromium is drawn from below the surface of the metal to form a chromium rich oxide surface layer. During welding, the shielding gas should be used to prevent hit tint formation. If formed, heat tint must be removed in order that the full corrosion resistance of the finished product is restored after welding. Mechanical and/or chemical methods of removing heat tint, that have been usually applied, are described in this article.

UVOD

U toku zavarivanja nerđajućih čelika dolazi do oksidacije i prirodno formiran zaštitni film na površini postaje deblji. Pri zagrevanju debljina oksida u neposrednoj blizini zavarenog spoja povećava se do 100 puta. Proces oksidacije odvija se na temperaturama iznad 300 ^{o}C. Debljina oksida neposredno uz zavareni spoj zavisi od temperature, vremena zagrevanja i koncentracije kiseonika u zaštitnom gasu. Boje obrazovanog oksida (heat tint) slične su bojama koje nastaju tokom termičke obrade i posledica su interferencije svetlosti. Oksid ima metalni sjaj ako je njegova debljina manja od 20 nm. Pri povećanju debljine oksida dolazi do promene boje od žute, braon, plave do crne. Kod nerđajućih čelika hromom bogat oksid formira se na površini metala, dok je podpovršinski sloj osiromašen hromom. U slučajevima eksploatacije zavarenih spojeva u vodenim sredinama lokalno smanjenje koncentracije hroma u podpovršinskom sloju može da utiče na otpornost čelika prema koroziji. Visok sadržaj kiseonika dovodi do dodatnog gubitka hroma iz oksidnog sloja ostavljajući oksidni sloj bogat gvožđem. Ovaj oksidni sloj počinje da rđa neposredno posle

INTRODUCTION

During welding oxidation will occur and the protective film will become thicker. As the zone next to the weld heats, the oxide-layer thickness will increase up to 100 times. The oxidation process is going on at a temperature above 300 °C. The thickness of the oxide layer next to the weld depends on the temperature, heating time, and oxygen concentration in the shielding gas. The colors formed are similar to 'temper colors' and are the result of 'light interference' effects. Up to a thickness of 20 nm the oxide shows a metallic shine. An increased thickness results in changes of heat tints ranging from yellow, brown, blue to black ones. As heat tint colors are formed on stainless steels chromium is drawn from below the surface of the metal to form a chromium rich oxide surface layer. This leaves the metal just below the surface with a lower chromium level. In cases where the application involves aqueous solutions the local reduction in sub-surface chromium can affect the corrosion resistance of the steel. During welding, high oxygen content will lead to an additional loss of chromium from the oxide surface leaving an iron rich oxide. This iron rich oxide is often seen rusting shortly

njegovog izlaganja vlažnoj atmosferi. Korozija na površini oksidnog sloja i u sloju osiromašenom hromom može da dovede do pojave pitinga ili korozije u zazorima, u uslovima gde je nerđajući čelik obično otporan prema koroziji [1-4].

Mada neki autori smatraju da uklanjanje heat tint-a nije uvek neophodno, od velikog je značaja da se heat tint ukloni kako bi se sačuvala potpuna otpornost prema koroziji posle zavarivanja. Ovo omogućava da se izbegne pojava korozije tokom eksploatacije zavarenih konstrukcija. Da bi se obezbedila optimalna otpornost prema koroziji zavarenih spojeva nerđajućih čelika, moraju se ukloniti zazori, nečistoće i heat tint čija je boja tamnija od svetlo-žute, primenom mehaničkih postupaka, uz naknadno nagrizanje kiselinom.

after being exposed to humidity. Corrosion attack in the oxide surface and in the chromium depleted layer may initiate pitting or crevice corrosion at conditions where the alloy would normally be resistant [1-4].

Although some sources suggest that the removal of heat tint is not always essential, it is vitally important that weld heat tint is removed so that the full corrosion resistance of the finished product is restored after welding. This will help avoid service corrosion problems in fabrication weld areas. In order to achieve the optimum corrosion performance of stainless steel welded joints, crevice features, contamination and at least all weld heat tints deeper in color than a pale yellow shall be removed by mechanical dressing followed by acid pickling of the joint.

Figure 1. Heat tint in welded joints of a stainless steel.
Slika 1. Heat tint u zavarenim spojevima nerđajućeg čelika.

Heat tint sa površine nerđajućih čelika se može ukloniti pomoću paste, gela, spreja ili uranjanjem u rastvor za nagrizanje ili primenom elektrolitičkih postupaka. Usled korišćenja azotne kiseline u ovim postupcima površina čelika ostaje u pasivnom stanju. Tretman samo azotnom kiselinom nije dovoljan da se u potpunosti ukloni heat tint, pa je neophodno koristiti kombinovane postupke za uklanjanje ovog oksida. Ovo obuhvata mehaničke postupke (brušenje) uz naknadni tretman u azotnoj kiselini (pasivacija).

Sprečavanje obrazovanja heat tint-a

Tokom zavarivanja, štetan uticaj kiseonika u zaštitnom gasu može se svesti na minimum ukoliko se doda vodonik zaštitnom gasu. Vodonik veže kiseonik i nastaje vodena para na temperaturama iznad 500 ^{o}C. Zato se u praksi najčešće koristi argon sa 10 % H_2 [5].

The removal of heat tint from stainless steel fabrications using brush-on pastes or gels, spray or immersion acid pickling or electrolytic methods will normally be satisfactory. The nitric acid used in these treatments will also leave the steel surface in the passive condition. A combination of finishing techniques may be needed, especially as nitric acid treatments alone cannot be relied on to remove sufficient metal from the surface. This may include mechanical treatments (grinding or abrading) followed by nitric acid cleaning (passivation).

Preventing of heat tint

During welding, the harmful effect of oxygen in the shielding gas shall be minimized by an addition of hydrogen that will bond with oxygen to make water steam at a temperature above 500 °C. Therefore, in practical applications argon with the addition of 10% H_2 are mostly used [5].

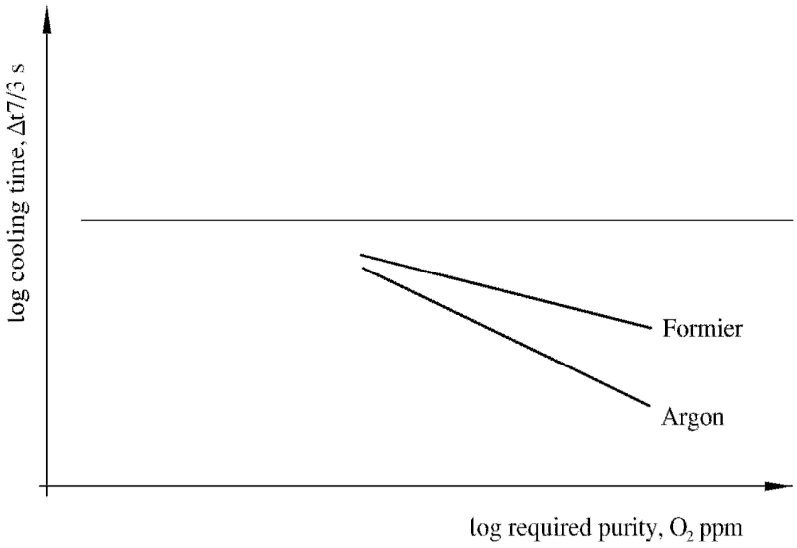

Figure 2. Application of formier gas or argon during welding of stainless steels.

Slika 2. Primena „formier“ gasa ili argona tokom zavarivanja nerđajućih čelika.

Obojenje heat tint-a u zavarenom spoju pokazuje da li je koren zavarenog spoja bio adekvatno zaštićen. Za kontrolu korena zavarenog spoja i eventualnog prisustva heat tint-a može se primeniti video kamera. Posmatranje treba vršiti iz različitih uglova. Boja heat tint-a može biti žuta, zelena, plava do sive i crne. Za određivanje nivoa prihvatljivosti heat tint-a koriste se etaloni sa odgovarajućim obojenjima tog oksida u zavarenom spoju [6]. Kriterijumi prihvatljivosti su manje oštri za prednju stranu zavarenog spoja nego za koren zavarenog spoja.

Uklanjanje heat tint-a

Heat tint se može ukloniti u tri stupnja. U prvom stupnju heat tint i sloj osiromašen hromom uklanjaju se brušenjem ili četkanjem. Zatim, u drugom stupnju površina se čisti pomoću rastvora kiselina ili paste za nagrizanje (smeša HNO_3 i HF u inertnoj pasti ili gelu), u cilju uklanjanja površinskih nečistoća i da se ubrza obnavljanje pasivnog sloja. U trećem stupnju rastvor kiseline ili paste za nagrizanje se temeljno ispira vodom, po mogućstvu demineralizovanom vodom. Brušenje ili četkanje nije dovoljno da se ukloni heat tint i obnovi pasivni sloj. Ti postupci mogu da dovedu do smanjenja debljine oksida, pri čemu se jedan deo oksida utisne u površinu metala. Takođe, može doći do toga da sloj osiromašen hromom bude izložen dejstvu spoljašnje sredine, kao i da se površina nerđajućeg čelika kontaminira česticama gvožđa. Površinu nerđajućeg čelika ne treba brusiti tocilom ili četkom koji su korišćeni za brušenje ugljeničnog ili nisko-legiranog čelika; takođe treba izbegavati primenu četki sa čekinjama koje nisu od nerđajućeg čelika sličnog sastava. Mehanički brušene površine nerđajućeg čelika imaju manju otpornost prema koroziji nego površine koje su nagrizane u kiselinama [7].

The heat tints in the heated zone of the weld indicate whether the root side was adequately shielded. The video-camera can be used for a good view of the weld root and the tinted area along the weld. The root side shall be inspected from various viewing angles. The heat tint colors vary from yellow, green, blue to grey and black. The color charts can be of great help in the determination of the acceptance level as well as in the control [6]. The acceptance criteria for the weld face are less stringent than for the weld root.

Removing of heat tint

The heat-tinted regions can be removed in three stages. First, the heat-tint oxide and chromium-depleted layer are removed by grinding or wire brushing. Second, the abraded surface is cleaned with an acid solution or a pickling paste (a mixture of HNO_3 and HF suspended in an inert paste or gel) to remove any surface contamination and to promote the reformation of a passive film. Third, after a sufficient contact time, the acid cleaning solution or pickling paste is thoroughly rinsed with water, preferably demineralized. Grinding or wire brushing might not be sufficient to repair a heat-tinted region. Such abrading operations may only smear the heat-tint oxide and embed the residual scale into the surface, expose the chromium-depleted layer beneath the heat-tint oxide, and contaminate the surface with ferrous particles that were picked up by the grinding wheel or wire brush. A stainless steel surface should never be abraded with a wheel or brush that has been used on a carbon or low-alloy steel; wire brushes with bristles that are not made of a stainless steel of similar composition should also be avoided. Mechanically ground surfaces generally have inferior corrosion resistance compared to properly acid-pickled surfaces [7].

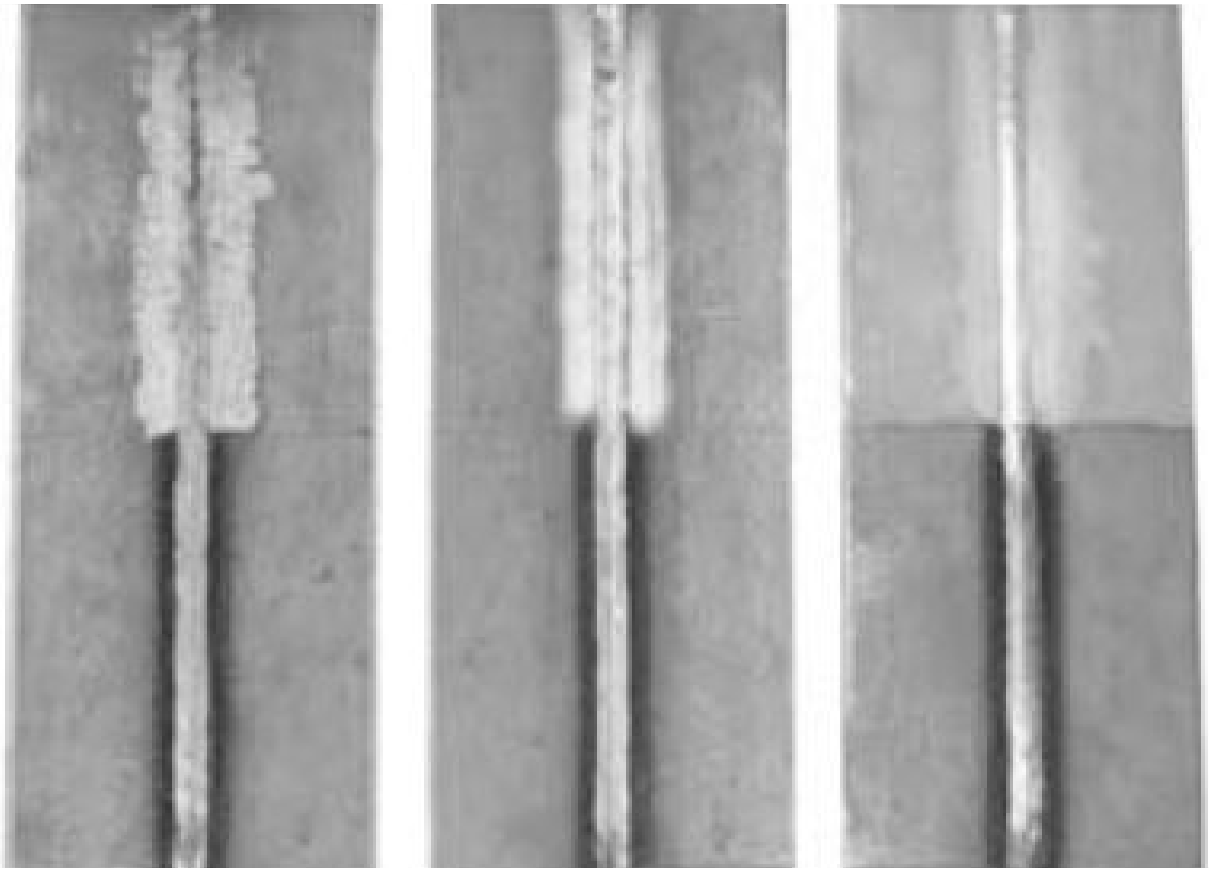

Figure 3. Pickling offers better results than grinding and polishing. a) ground, b) polished and c) pickled surface.

Slika 3. Nagrizanje daje bolje rezultate pri uklanjanju heat tint-a nego brušenje i poliranje. a) brušena, b) polirana i c) nagrižena površina.

Prednost mehaničkih postupaka za uklanjanje heat tint-a je što ne dovode do pojave interkristalne korozije, pitinga, vodonične krtosti i prslina. Brušenje je obično najefikasnije za uklanjanje heat tint-a koji je nastao pri zavarivanju. Nedostaci mehaničkih postupaka su visoka cena, kao i mogućnost da površinski defekti ostanu sakriveni, što otežava njihovu detekciju.

Nagrizanje u rastvorima kiselina najčešće koriste proizvođači opreme od nerđajućih čelika, jer se na taj način uklanjaju čestice metala, kao i heat tint i termički oksidi. Primena ovog postupka se ne preporučuje u slučaju senzibilizovanih austenitnih nerđajućih čelika ili ojačanih martenzitnih nerđajućih čelika ili kada nerđajući čelik može doći u kontakt sa delovima od ugljeničnog čelika. Rastvori azotne kiseline nisu dovoljno efikasni za uklanjanje debljih oksidnih slojeva. Posle nagrizanja u rastvorima kiselina, površina mora biti temeljno isprana da bi se uklonila zaostala kiselina; ponekad je potrebna neutralizacija pre završnog ispiranja.

U ASTM A 380 [8] navedena su tri rastvora za nagrizanje nerđajućih čelika (A, B, C). Za potrebe lokalnog nagrizanja ili u slučaju da su predmeti suviše velikih dimenzija mogu se koristiti komercijalne paste za nagrizanje koje sadrže HNO_3 i HF. U navedenom ASTM standardu je opisano osam postupaka za čišćenje i pasivaciju nerđajućih čelika.

Mechanical methods have the advantage that they do not produce intergranular attack, pitting, hydrogen embrittlement, cracks. Grinding is usually the most effective means of removing localized scale such as that which results from welding. Disadvantages of mechanical methods are cost, and the fact that surface defects may be obscured, making them difficult to detect.

Acid pickling is most widely used by fabricators of stainless steel equipment and removes both metallic contamination, and welding and heat-treating scales. Its use should be carefully controlled and is not recommended for descaling sensitized austenitic stainless steels or hardened martensitic stainless steels or where it can come into contact with carbon steel parts. Solutions of nitric acid alone are usually not effective for removing heavy oxide scale. After acid pickling, surfaces must be thoroughly rinsed to remove residual chemicals; a neutralization step is sometimes necessary before final rinsing.

ASTM A 380 [8] lists three pickling solutions for stainless steels (A, B, C). For localized pickling or if the fabricated component is too large to be immersed, commercial HNO_3-HF pickle pastes can be just as effective. ASTM A 380 describes eight HNO_3-based cleaning/passivation treatments.

Tabela 1. Nagrizanje, čišćenje i pasivacija nerđajućih čelika

OZNAKA	Rastvor	T, °C	Vreme, min
A	H_2SO_4, posle čega se primenjuje postupak D ili F	66-82	5-45
B	HNO_3 + HF	21-60	5-30
C	HNO_3 + HF	21-60	5-30
Čišćenje nerđajućih čelika u rastvoru kiselina (HNO_3-HF)			
D	HNO_3 + HF	21-60	po potrebi
E	HNO_3 + HF	21-60	1-2
Čišćenje i pasivacija nerđajućih čelika u rastvoru HNO_3			
F	HNO_3	21-71	10-60
G	HNO_3 + $Na_2Cr_2O_7$	21-69	10-60
H	HNO_3	21-54	20-60
I	HNO_3 + $Na_2Cr_2O_7$	21-54	15-60
J	HNO_3 + $Na_2Cr_2O_7$	21-49	25-40
K	HNO_3 + $Na_2Cr_2O_7$	49-60	10
L	HNO_3 + $CuSO_4$	49-60	10
M	HNO_3 + $Na_2Cr_2O_7$	49-71	20-30

Table 1. Pickling, Cleaning and Passivation of Stainless Steels

CODE	Solution	T, °C	Time, min
A	H_2SO_4, followed by treatment D or F	66-82	5-45
B	HNO_3 + HF	21-60	5-30
C	HNO_3 + HF	21-60	5-30
Acid Cleaning of Stainless Steels with HNO_3-HF Solution			
D	HNO_3 + HF	21-60	As necessary
E	HNO_3 + HF	21-60	1-2
Cleaning-Passivation of Stainless Steels with HNO_3 Solution			
F	HNO_3	21-71	10-60
G	HNO_3 + $Na_2Cr_2O_7$	21-69	10-60
H	HNO_3	21-54	20-60
I	HNO_3 + $Na_2Cr_2O_7$	21-54	15-60
J	HNO_3 + $Na_2Cr_2O_7$	21-49	25-40
K	HNO_3 + $Na_2Cr_2O_7$	49-60	10
L	HNO_3 + $CuSO_4$	49-60	10
M	HNO_3 + $Na_2Cr_2O_7$	49-71	20-30

Kvalitet pasivacije se može oceniti primenom jedne ili više metoda: potapanje u vodu (ASTM A 967) [9], ispitivanje u vlažnoj atmosferi (ASTM A 380 i A 967) [8,9], ispitivanje u slanoj magli (ASTM B 117) [10], ispitivanje u rastvoru bakar sulfata (ASTM A 380 i A 967), modifikovani feroksil test za ispitivanje prisustva čestica gvožđa (ASTM A 380 i A 967) i metoda za ispitivanje prisustva slobodnog gvožđa (ASTM A 967).

Passivation shall be evaluated by one or more of the following test methods: water immersion test (Specification A 967) [9], humidity test (Practice A 380, Specification A 967) [8,9], salt spray test (Practice ASTM B 117) [10], copper sulfate test (Practice A 380, Specification A 967), modified “ferroxyl” test for free iron (Practice A 380, Specification A 967) and free iron test (Specification A 967).

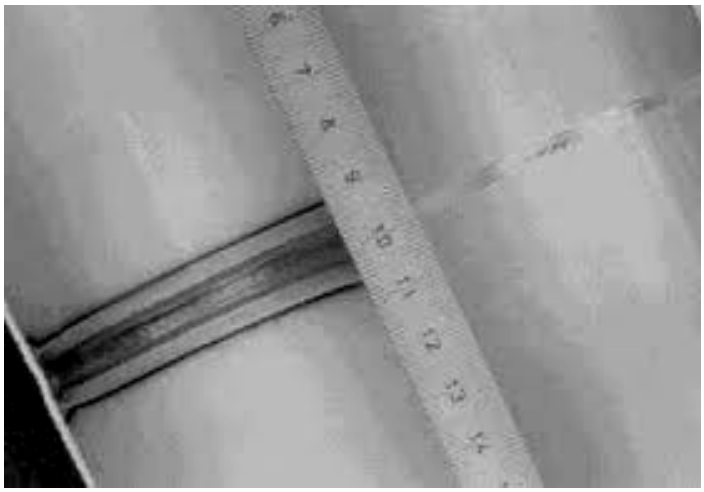

Figure 4. Welded joint with heat tint and after removing heat tint.

Slika 4. Zavareni spoj sa hit tint-om i posle uklanjanja heat tint-a.

Nagrizanje u rastvoru kiselina je uobičajen postupak za uklanjanje heat tin-a, ako postoji odgovarajuća oprema. Sastav smeše kiselina i temperatura rastvora bira se u zavisnosti od klase nerđajućeg čelika i tipa heat tint-a, odnosno termičkog oksida. Do suvišnog nagrizanja, koje za posledicu ima hrapavu površinu, može doći tokom nagrizanja nerđajućih čelika sa niskim sadržajem legirajućih elemenata na suviše visokim temperaturama (Dodatak 1 i 2) [11].

Pasta za nagrizanje nerđajućih čelika se sastoji od smeše kiselina (obično HF i HNO_3) sa dodatkom nekog vezivnog sredstva (punioca). Pasta je pogodna za nagrizanje lokalnih površina, npr. zavarenog spoja. Obično se nanosi pomoću četke koja je otporna na dejstvo kiselina. Rizik od suvišnog nagrizanja na visokim temperaturama je manji nego pri nagrizanju u rastvoru (Dodatak 1 i 2) [11].

Gel za nagrizanje u obliku spreja obično se sastoji od smeše HNO_3 i HF (fosforna kiselina se može upotrebiti da se dobije blaže sredstvo za nagrizanje) uz dodatak punioca (vezivno sredstvo) i površinski aktivnih materija. Pogodan je za korišćenje na velikim površinama, npr. kada je potrebno ukloniti zaostale čestice gvožđa (Dodatak 1 i 2) [11].

Dodatak 1. Primena paste, gela i rastvora za nagrizanje

Primena paste za nagrizanje

- Pre primene paste treba izvršiti mehaničko uklanjanje oksida, šljake i defekata u zavarenom spoju, najbolje dok je zavareni spoj još topao, a oksidi manje tvrdi.
- Površina koja se nagriza treba da bude ohlađena ispod 40 ^{o}C (posle zavarivanja).
- Treba izvršiti odmašćivanje u cilju uklanjanja organskih nečistoća.
- Pre upotrebe pastu treba promešati. Pastu treba naneti pomoću četke otporne na dejstvo kiselina. Nagrizanje ne treba vršiti u prisustvu direktne sunčeve svetlosti.

Pickling in a bath is a convenient method if suitable equipment is available. The composition of the acid mixture and the bath temperature are chosen with regard to the stainless steel grade and the type of heat oxide. Overpickling, resulting in a rough surface, may result when pickling the lowest alloyed stainless grades at excessive temperatures (Annex 1 and 2) [11].

Pickling paste for stainless steels consists of an acid mixture (normally HF/HNO_3) with added binding agents. It is suitable for pickling limited areas, e.g. weld-affected zones. It is normally applied using an acid-resistant brush. The risk of overpickling at high temperatures is less than when using bath pickling (Annex 1 and 2) [11].

Pickling solution (or pickling gel in spray form) normally consists of a mixture of nitric acid and hydrofluoric acids (phosphoric acid can be used to obtain mild pickling properties), with binding agents and surface-active agents. It is suitable for pickling large surfaces, e.g. when the removal of iron contamination is also desired (Annex 1 and 2) [11].

Annex 1. Application of Pickling Paste, Gel and Bath

Application of Pickling Paste

- Pre-treat oxides, slags and weld defects mechanically, preferably when the welds are still warm and the weld oxides less hard.
- Give the area to be pickled time to cool down to below 40ºC (after welding).
- Degrease using cleaner to remove organic contamination.
- Stir or shake the paste before use. Brush on the pickling paste using an acid-resistant brush. Do not pickle in direct sunlight.

- Ostaviti pastu dovoljno dugo vremena da reaguje.
- Izvršiti temeljno ispiranje čistom tekućom vodom, najbolje vodenim mlazom, tako da površina ostane potpuno čista. Za osetljive površine treba koristiti dejonizovanu vodu za završno ispiranje.
- Otpadnu vodu treba sakupiti i neutralisati.

Primena gela za nagrizanje u obliku spreja

- Pre primene gela treba izvršiti mehaničko uklanjanje oksida, šljake i defekata u zavarenom spoju, najbolje dok je zavareni spoj još topao, a oksidi manje tvrdi.
- Površina koja se nagriza treba da bude ohlađena ispod 40 ^{o}C (posle zavarivanja).
- Treba izvršiti odmašćivanje u cilju uklanjanja organskih nečistoća.
- Gel treba dobro promešati pre upotrebe.
- Raspršiti gel pomoću raspršivača napravljenog od materijala otpornog prema kiselinama. Ravnomeran sloj gela (kiseline) treba da pokriva celu površinu. Nagrizanje ne treba vršiti u prisustvu direktne sunčeve svetlosti.
- Ostaviti gel dovoljno dugo vremena da reaguje. Svetlo zeleno obojenje treba da se pojavi na površini kada je nagrizanje završeno. Pojava braon tačaka ukazuje da postoje zaostale nečistoće na čeliku koje mogu da reaguju sa gelom za nagrizanje. Ovo se može prevazići primenom veće količine gela. Kada se nagrizanje vrši na otvorenom prostoru ne treba dozvoliti da se gel osuši jer ovo može da prouzrokuje obezbojenje površine čelika. To znači da na visokim temperaturama i pri produženom vremenu nagrizanja može biti potrebno da se primeni veća količina gela posle nekog vremena.
- Izvršiti temeljno ispiranje čistom tekućom vodom, najbolje vodenim mlazom, tako da površina ostane potpuno čista. Za osetljive površine treba koristiti dejonizovanu vodu za završno ispiranje.
- Otpadnu vodu treba sakupiti i neutralisati.

Primena rastvora za nagrizanje

- Pre primene rastvora za nagrizanje treba izvršiti mehaničko uklanjanje oksida, šljake i defekata u zavarenom spoju.
- Površina koja se nagriza treba da bude ohlađena ispod 40 ^{o}C (posle zavarivanja).
- Treba izvršiti odmašćivanje u cilju uklanjanja organskih nečistoća.
- Pomešati koncentrovani rastvor za nagrizanje sa vodom pri čemu treba dodati kiselinu u vodu a ne obrnuto. Primenom pumpe treba obezbediti cirkulaciju rastvora, da bi se ostvarila homogena koncentracija rastvora.
- Proveriti temperaturu rastvora.
- Uroniti predmet u rastvor za nagrizanje. Izbegavati suvišno nagrizanje koje može da izazove hrapavljenje površine

- Give the product sufficient time to react.
- Rinse thoroughly with clean tap water, preferably using a high-pressure water jet. Ensure that no pickle residues are left on the surface. For sensitive surfaces, use deionised water for the final rinse.
- Collect the resulting waste water for neutralization.

Application of Spray Pickle Gel

- Pretreat oxides, slags and weld defects mechanically, preferably while the welds are still warm and the weld oxides less hard.
- Give the area to be pickled time to cool down to below 40ºC (after welding).
- Degrease using cleaner to remove organic contamination.
- Stir the spray gel well before use.
- Spray on the product using an acid resistant pump. Gently apply an even layer of acid that covers the whole surface. Do not pickle in direct sunlight!
- Allow the product sufficient pickling time. A light green color should appear on the surface when pickling is finished. The appearance of brown spots might indicate that there are some remaining contaminants on the steel that could have interfered with the pickling reaction. This can be compensated for by applying more solution onto these spots. When pickling outdoors, the solution should not be allowed to dry because this may cause discoloration of the steel surface. This means that at high temperatures and when prolonged pickling times are required, it may be necessary to apply more of the product after a while.
- Rinse thoroughly with clean tap water preferably using a high pressure water jet. Ensure that no pickle residues are left on the surface. For sensitive surfaces, use deionised water for the final rinse.
- Collect the resulting waste water for neutralization.

Application of Bath Pickling

- Pretreat oxides, slag and weld defects mechanically.
- Give the area to be pickled time to cool down to below 40°C (after welding).
- Degrease using cleaner to remove organic contamination.
- Mix the concentrated bath pickling solution with water. Remember to add the acid to the water, not the other way round! Set the batch solution circulating using a pump in order to obtain a homogenous acid concentration in the bath.
- Check the bath temperature.
- Immerse the object in the bath. Avoid overpickling, which will produce a rough surface.

- Prilikom uklanjanja predmeta iz rastvora za nagrizanje obezbediti da rastvor otkaplje sa površine predmeta u posudu sa rastvorom.
- Prvo ispiranje treba izvršiti potapanjem u posudu sa vodom. Zatim traba izvršiti temeljno ispiranje vodenim mlazom, tako da površina ostane potpuno čista. Za osetljive površine treba koristiti dejonizovanu vodu za završno ispiranje.
- Otpadnu vodu treba sakupiti i neutralisati.
- Neophodna je analiza sadržaja kiseline i slobodnih metalnih jona u kadi sa rastvorom za nagrizanje, jer postoji konstantna potrošnja rastvora za nagrizanje i istovremeno izdvajanje metalnih jona, što utiče na efikasnost rastvora za nagrizanje

- When removing the object, allow time for the bath solution to flow off above the bath.
- A first rinse should be performed by dipping into a rinsing vat containing water. Then rinse thoroughly using a high-pressure water jet. Ensure that no pickle residues are left on the surface. For sensitive surfaces, use deionised water for the final rinse.
- Collect the resulting waste water for neutralization.
- Analysis of the contents of bath acid and free metal ions is important since there will be a constant consumption of pickling acids and a simultaneous precipitation of metals in the bath, which will affect the pickling reaction.

Dodatak 2. Površinski defekti i postupci korekcije

Površinski defekti	Uzrok	Postupak korekcije
Neuklonjeni oksidi	1. Nepotpuno čišćenje	1. Mehanička obrada/intenzivnije nagrizanje
Hrapava površina	1. Suvišno nagrizanje 2. Interkristalna korozija	1. Mehanička obrada/ponovno nagrizanje 2. Mehaničko poliranje
Neujednačen izgled	1. Organske nečistoće 2. Neravnomerna primena 3. Osetljiva površina 4. Interkristalna korozija	1. Odmašćivanje/ponovno nagrizanje 2. Ponovno nagrizanje 3. Mehaničko poliranje 4. Mehaničko poliranje
Obezbojenje	1. Osušeno sredstvo za nagrizanje (npr. sredstvo za nagrizanje u zazoru) 2. Površinske nečistoće (npr. čestice gvožđa) 3. Nepotpuno čišćenje 4. Zaprljana voda za ispiranje 5. Nepotpuno ispiranje	1. Ispiranje vodenim mlazom i ponovno nagrizanje 2. Pasivacija/uklanjanje nečistoća ili ponovno nagrizanje 3. Uklanjanje nečistoća 4. Pasivacija/uklanjanje nečistoća. Ispiranje vodenim mlazom 5. Uklanjanje nečistoća pomoću sredstvom za čišćenje. Upotreba dejonizovane vode za završno ispiranje
Mrlje posle ispiranja vodom	1. Zaprljana voda za ispiranje 2. Prašina	1. Upotreba čiste vode za ispiranjei/ili ponovno nagrizanje 2. Upotreba čiste vode za ispiranje i rad u čistim uslovima

Annex 2. Surface defects and corrective action

Surface defects	Caused by	Corrective action
Residual weld oxides	1. Insufficient cleaning	1. Mechanical pretreatment/more intensive pickling
Rough surface	3. Overpickling 4. Intergranular corrosion	3. Mechanical pretreatment / repickle 4. Mechanical polishing
Uneven finish (shading)	5. Organic contaminants 6. Uneven application 7. Sensitive surface 8. Intergranular corrosion	5. Degrease, repickle 6. Repickle 7. Mechanical polishing improves the result 8. Mechanical polishing improves the result
Discoloration	6. Dried-on pickling chemicals (e.g. pickling residues in crevice) 7. Surface contaminants (e.g. iron particles) 8. Insufficient cleaning 9. Contaminated rinse water 10. Poor rinsing	6. Rinse with high pressure water jet and repickle 7. Passivate/decontaminate or repickle 8. Remove spots 9. Passivate/decontaminate. Rinse with high pressure jet 10. Remove the spots with a cleaning agent. Use deionised water to final rinse
Water stains	3. Contaminated rinse water 4. Dust	3. Use clean rinse water and/or repickle 4. Use clean rinse water and work in dust-free environment

ZAKLJUČAK

Na osnovu gore navedenog može se zaključiti sledeće:

- Obrazovanje heat tint-a u zavarenim spojevima nerđajućih čelika utiče na otpornost prema koroziji ovih čelika. U prisustvu heat tint-a obično dolazi do pitinga i korozije u zazorima.
- Da bi se sprečilo obrazovanje heat tint-a treba primeniti zaštitni gas tokom zavarivanja.
- Obrazovani heat tint uklanja se mehaničkim i/ili hemijskim postupcima.
- U praksi se široko primenjuje nagrizanje u rastvoru ili nagrizanje pomoću paste ili gela.
- U slučaju pojave površinskih defekata tokom nagrizanja treba razmotriti mogućnost primene korektivnih postupaka.

Zahvalnica

Rad je finansiran od strane Ministarstva za prosvetu, nauku i tehnološki razvoj Republike Srbije, kroz projekte TR 34028 i TR 34016.

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CONCLUSION

Based on all above described, the following conclusions can be drawn:

- Heat tint formation in welded joints of stainless steels influences corrosion resistance of these steels. In the presence of hit tint layers pitting and crevice corrosion usually occur.
- The shielding gas must be applied during welding, in order to prevent heat tint formation.
- When formed, heat tint shall be removed by application of mechanical and/or chemical procedures.
- Pickling in bath, or using pickling pastes and gels have been widely applied in practice.
- In the case of surface defects during pickling corrective actions should be considered.

Acknowledgement

This work was co-financed from the Ministry of Education, Science and Technological Development of the Republic of Serbia through projects TR 34028 and TR 34016.

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