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Nanošenje olova na ugljenični konstrukcioni čelik - poolovljavanje (homogeno)

Application of lead to carbon construction steel - lead coating (homogenous)

Stručni rad / Professional paper

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Rad je u izvornom obliku objavljen u Zborniku sa savetovanja „ZAVARIVANJE 2018" održanog u Beogradu 10-13. Oktobra 2018
Rad primljen / Paper received:
Jul 2018.

Ključne reči: olovari, olovo, homogena voda, poolovljavanje, cink-hlorid, kalaisanje.

Key words: *lead producers, lead, homogenous water, load coating, zinc chloride, tinning.*

Izvod

Razvojem hemijske industrije nakon II svetskog rata razvijala se i proizvodnja novih poliplasta koji su sve više zamenjivali primenu olova u raznim hemijskim procesima, ali još uvek postoje elementi i postrojenja gde je olovo nezamenljivo.

Pošto se upotreba olova znatno smanjila, uveliko se smanjio i broj radnika koji su radili sa olovom, tako da su olovari postali zanatlije u nestajanju, a literatura o radu s olovom je vrlo oskudna, skoro da ne postoji.

U ovom članku daje se praktična primena nanošenja olova radi zaštite vacuum breaker pumpe metodom homogenizacije – poolovljavanje radi zaštite od dejstva razblažene sumporne kiseline.

Poseban deo rada sa olovom odnosio bi se na zavarivanje, odnosno, na olovarenje, ali u ovom članku o tome neće biti reči ovog puta.

Uvod

Olovo je odavno u upotrebi (par hiljada godina p.n.e.) jer se dobija relativno lako iz sulfidnih ruda (galenit PbS) pošto je temperatura topljenja ovog metala vrlo niska. Olovom su pokrivani krovovi crkava, učvršćivali se stubovi ograda na mostovima, izrađivale cevi i kanali za dovod i odvod vode, izrađivala municija, radili klizni ležaji (babiti), rade se meki lemovi...

Razvojem hemijske industrije olovo je postalo vrlo važan metal za zaštitu od agresivnih medija, naročito tamo gde se upotrebljava razblažena sumporna kiselina. Najveća primena olova u industriji bila je u drugoj polovini dvadesetog veka, a onda je sve više zamenjivano raznim poliplastima. Međutim, postoje još uvek pogoni koji rade, a u kojima je zastupljeno olovo, koje iz raznih razloga nije moguće da se zameni plastikom, pa je neophodna reparacija postojećih pogona ili pak

Abstract

With the development of chemical industry after the Second World War, new poly-plastics have been developed and they have changed the application of lead in various chemical processes, but there still are the elements and plants where lead is irreplaceable. Since the use of lead has been significantly reduced, the number of workers who worked with lead has been considerably reduced, so the lead processors have become the craftsmen who are disappearing, and the literature about the work with lead is very deficient, it hardly exists.

In this article, it is given the practical use of lead application for the purpose of vacuum breaker pump protection by the method of homogenization-lead coating for the purpose of protection from the effects of diluted sulfuric acid. A special part of working with lead would be related to welding i.e. welding leads, but this article will not deal with this subject

Introduction

Lead has been used for a long time (since a couple of thousand years B.C) because it is produced relatively easily from sulfide ores (galena PbS) since the melting temperature of this metal is very low. Lead was used for covering roofs of churches, firming the pillars of the bridge fences, manufacturing pipes and canals for water supply and drainage, manufacturing ammunition, manufacturing sliding bearings (babits), producing soft soldering…

By the development of chemical industry lead has become very important metal for the protection from aggressive media, especially where diluted sulfuric acid is used. The widest spread use of lead in industry was in the second half of the twentieth century and since then it has been being replaced by various poly-plastics. However, there still are the plants which work, and in which lead is produced

zamena istrošenih delova novim. Te poslove sa olovom rade majstori OLOVARI. Nažalost, olovara je sve manje, a i stručnih ljudi, inženjera, koji bi trebalo da izvedu i proprate olovarske poslove.

U ovom radu dati su neki osnovni podaci o načinu rada pri nanošenju olova na površine ugljeničnog čelika, poolovljavanju.

Osnovni podaci o olovu

Olovo se dobija uglavnom na dva načina:
iz rude olova (galenit PbS) i reciklažom starog olova.
U oba slučaja cena olova i njegovih legura je relativno niska jer su procesi jednostavni i odvijaju se na niskim temperaturama.
Olovo spada u grupu teških i lakotopivih obojenih metala. Kristališe u kubnu, površinski centriranu rešetku. Olovo je nemagnetično i vrlo duktilno (lat. ductilis – mek), može se lako oblikovati i istegljivo je, dobro je kovljivo. Na preseku je blago plavičasto – sjajno, ali se brzo presvlači pasiviziranim, oksidnim slojem mat sive boje koji ga štiti od daljeg nagrizanja.
specifična gustina $\rho = 11{,}34$ g/cm^3
temperatura topljenja $T = 327{,}4^oC$
prekidna čvrstoća $\sigma_m = 10\text{-}13$ MPa (N/mm^2)
izduženje $\delta = 30\text{-}40\%$
tvrdoća HB = 3,2-4,5 (na Mosovoj skali 1-1,5)
brzina zvuka N = 1260m/s (značajno za spajanje eksplozijom)
specifična toplota $C = 131$ J/kg^{o}C
toplotna provodljivost $\lambda = 35$ W/m^{o}C
modul elastičnosti $E = 17000$ MPa

Olovo ne otvrdnjava plastičnom deformacijom na hladno. U zavisnosti od smera izduženja kristalnog zrna (smera valjanja) različite su mehaničke osobine, ali već na sobnoj temperaturi, posle relativno kratko vremena, olovo rekristalizira i dolazi u prvobitno stanje. Primese u olovu (legirajući elementi) utiču na povećanje mehaničkih osobina i menjaju otpornost olova na agresivne medije. Primese koje prate olovo su: bakar, antimon, arsen, bizmut, cink, sumpor, kalaj, srebro, zlato.
U olovarskoj praksi olovo se deli uglavnom na meko, čistoće > 99% i tvrdo, legirano najčešće antimonom (sa 13% Sb i 87% Pb dobija se eutektička legura, Te=216^{o}C).

and which, because of various reasons, is not possible to be replaced with plastics, so it is necessary the reparation of the existing plants or replacement of used parts by new ones. These works are mostly done by the craftsmen LEAD PRODUCERS. Unfortunately, there are less and less lead producers and also the appropriate professionals, engineers, who would do and monitor the works of lead producers. In this project, there are some basic data about the way of work when applying lead on the surface of carbon steel, i.e. lead coating.

Basic data about lead

Lead is obtained mostly in two ways:
From the lead ore (galena PbS) and by recycling old lead.
In both cases the price of the lead and its alloys is relatively low because the processes are simple and are done at low temperatures.
Lead is classified in the group of heavy and easily melted ferrous metals. It is crystallized in a cube grid, centered on the surface. Lead is non-magnetic and very ductile (lat. ductilis- soft), it can be easily shaped and is elastic, it can be well wrought. On the cross section it is slightly bluish – lustrous, but it is immediately coated with passive, oxide layer of matt grey color which protects it from further corrosion.
Specific density $\rho = 11{,}34$ g/cm^3
Melting point $T = 327{,}4^oC$
Tensile strength $\sigma_m = 10\text{-}13$ MPa (N/mm^2)
Elongation $\delta = 30\text{-}40\%$
Hardness HB = 3,2-4,5 (on the Moss' scale 1-1,5)
Speed of sound N =1260m/s(significant for merging with explosion)
Specific heat $C = 131$ J/kg^{o}C
Thermal conductivity $\lambda = 35$ W/m^{o}C
Modulus of elasticity $E = 17000$ MPa
Lead does not harden by cold plastic deformation. Depending on the direction of elongation of crystal grain (direction of rolling) there are various mechanical properties, but on the room temperature, after relatively short time, lead re-crystallizes and comes to the previous condition. The primes in lead (alloying elements) influence to mechanical properties and change the resistance of lead to aggressive media. The primes which follow lead are: copper, antimony, arsenic, bismuth, zinc, sulfur, tin, silver, gold.
In the lead producing practice lead is divided mostly to: soft lead, of the purity > 99% and hard, alloyed mostly with antimony (with 13% Sb and 87% Pb it is obtained eutectic alloy, Te=216^{o}C).

Legura kalaj-olovo Pb 61.9% i Sn 38.1%, Te = 183°C. Adheziona moć lema se povećava sa povećanjem Sn u leguri sve do eutektičke tačke, a posle opada.
Olovo je vrlo postojano na dejstvo sumporne, fluorovodonične i hlorovodonične (sone) kiseline, hlora, vode, vazduha, sumpor dioksida, sumporvodonika… Hemijska otporonost olova potiče od pasiviziranog sloja koji se brzo stvara na površini u obliku olovo-oksida ili olovo-oksidno-karbonatnog sloja. U dodiru sa sumpornom kiselinom stvara se olovo sulfat ($PbSO_4$.)
Razblažena sumporna kiselina na povišenim temperaturama stvara na površini olova nestabilno jedinjenje koje nije dovoljno otporno na agresivne uslove, stvara se rastvorna so. Zbog toga se čisto olovo legira bakrom.
Destilovana voda polako nagriza olovo ako u njoj ima rastvorenog kiseonika.
Olovo nije postojano u azotnoj i sirćetnoj kiselini jer se na površini stvaraju lakotopive soli.
Prisutnost bizmuta i cinka smanjuje korozionu otpornost olova zbog velike razlike u elektro-potencijalu.
Korozionu otpornost poboljšavaju: srebro, nikal i bakar ako se nalaze u manjim količinama (ispod 0,1%). U većim količinama snižavaju otpornost olova na koroziju.

The alloy tin-lead Pb 61.9% and Sn 38.1%, Te = 183°C. The adhesion power of soldering is increased with the increasing of Sn in the alloy up to the eutectic point and then it is falling down.
Lead is very resistant to the effects of sulfuric, hydrofluoric acid, chlorine, water, air, sulfur dioxide, sulfur hydrogen… Chemical resistance of lead comes from the passive layer which is immediately created on the surface in the form of lead oxide or lead oxide carbon layer. In the contact with sulfuric acid it is created lead sulfate ($PbSO_4$.).
At higher temperatures diluted sulfuric acid creates on the surface of lead an unstable compound which is not resistant enough to aggressive conditions, dissolved salt is created. Because of this, pure lead alloys with copper.
Distilled water steadily erodes lead if there is dissolved oxygen.
Lead is not stable in nitric and acetic acid because easily dissolvable salts are created on the surface.
The presence of bismuth and zinc reduces corrosion resistance of lead because of the great variation in electro-potential.
Corrosion resistance is improved by: silver, nickel and copper if their presence is in small quantities (under 0,1%). In large quantities they lower the resistance of lead to corrosion.

DIN Pb 99,985 Standard DIN 1719	
Element	Težina u procentima %
Pb	99.985-99.999
Bi	0.01 – 0.01
Sb	0.001 – 0.002
Cu	0.001 – 0.001
Fe	0.001 – 0.001
Zn	0.001 – 0.001
Sn	0.001 – 0.001
As	0.001 – 0.001
Ag	0.001 – 0.001

Modul elastičnosti, E……17.00 GPa
Prekidna čvrstoća, R_m…..12.50 MPa
***Tabela br. 1** Hemijski sastav čistog olova*
***Table number 1** Chemical composition of pure lead*

DIN Pb 99,985 Cu Standard DIN 17640-1	
Element	Težina u procentima %
Pb	99.985-99.985
Cu	0.04 – 0.05
Bi	0.01 – 0.01
Ag	0.005 – 0.005
Sn	0.005 – 0.005
Sb	0.001 – 0.001
Fe	0.001 – 0.001
Zn	0.001 – 0.001
As	0.001 – 0.001

Modul elastičnosti, E……..17.00 GPa
Prekidna čvrstoća, Rm…….14.00 MPa
***Tabela br. 2** Hemijski sastav olova legiranog bakrom*
***Table number 2** Chemical composition of the lead alloyed with copper*

Zaštita ugljeničnog konstrukcionog čelika olovom

Zaštita se može izvesti rastavljivom i nerastavljivom vezom olova i čelika.

Rastavljiva veza se sastoji u oblaganju površina olovnim limom koji se pričvršćuje za čeličnu konstrukciju zavrtnjima. Preko glave zavrtnja stavlja se olovna obloga koja štiti zavrtanj od agresivnog medija. Olovni limovi se međusobno zavaruju po završenom oblaganju. Zavarivanje može biti sučeono ili ugaono preklapanjem limova.

Ovaj princip zaštite se primenjuje na posude koje su opterećene na pritisak koji dodatno priljubljuje olovo i lim na čelik. U slučajevima gde su opterećenja u posudama i cevima kombinovana: pritisak i vacuum ili samo vacuum, neophodno je da se ostvari prisna veza između čelika, koji daje čvrstoću i krutost konstrukciji i olova koje služi da zaštiti konstrukciju od hemijskog uticaja agresivnog medija.

Nerastavljivu vezu je moguće postići na više načina, a uvek se radi manje-više o postupku mekog lemljenja koje se naziva poolovljavanje.

Komercijalno poolovljavanje se može izvršiti:
-gasnim postupkom
-TIG-postupkom
-eksplozijom.

U ovom izlaganju razmotriće se samo primena gasnog postupka koji je najstariji, najrašireniji i univerzalni način poolovljavanja.

U principu se poolovljavanje vrši mekim, čistim olovom (najmanje 3 devetke), mada je tehnički izvodljivo poolovljavanje i tvrdim olovom, ali je ta primena ređa. Ono što je karakteristično za rad sa olovom je specifičan alat, odnosno upotreba olovarskih brenera koji su malih dimenzija, tanka i

Protection of carbon construction steel by lead

The protection can be performed by separable and inseparable connection of lead and steel.

The separable connection consists of coating the surfaces with lead tin which is fastened to a steel construction by screws. Over the head of a screw it is put lead coating which protects a screw from aggressive media. Lead tins are welded to each other after the completed coating. Welding can be frontal or corner by overlapping tins.

This principle of the protection is not applied to the vessels which are loaded to the pressure which additionally attach lead and tin to steel. In the cases where the loads in the vessels and pipes are combined: pressure and vacuum or only vacuum, it is necessary to create close connection between steels, the lead which gives firmness and inflexibility to the construction and the lead which serves to protect the construction from the chemical influence of aggressive media.

It is possible to obtain an inseparable joining in many ways, and it is always more or less about the procedure of soft soldering which is called lead coating.

Commercial lead coating can be done by:
-Gas procedure,
-TIG- procedure
-Explosion

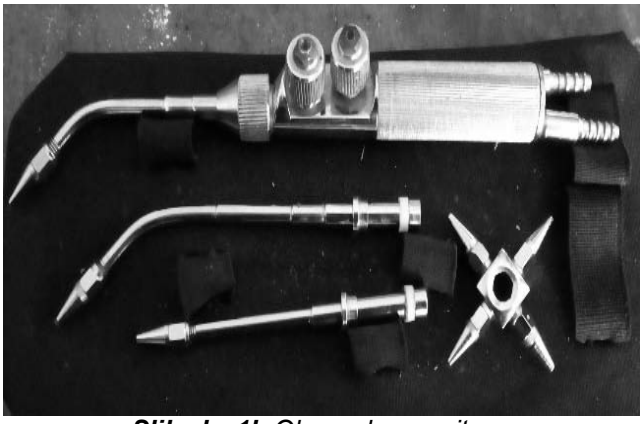
In this project only the use of gas procedure will be considered and it is the oldest, the widest spread and universal way of lead coating.

Generally, lead coating is done by soft, pure lead (at least 3 nines), although it is technically possible to do lead coating with hard lead, but that usage is rarer. The main feature of working with lead is specific tools, i.e. the use of lead producing brener tools which are of small dimensions, thin and

savitljiva creva, što sve skupa omogućava brzo reagovanje, manje zamaranje i dug rad olovara jer je postupak vrlo spor. Rad sa olovom zahteva posebnu veštinu koju olovari treba da savladaju jer je olovo tečljivo, ne menja boju pri zagrevanju i ima veliku specifičnu gustinu, što predstavlja poseban problem u radu kad su u pitanju prinudni položaji.

flexible hoses, which completely enable fast reaction, less fatigue and long work of lead producers because the procedure is very slow. The work with lead demands special skills which lead producers have to learn because lead is liquid, it does not change color while heated and has a specific density which represents special problem in working when it is about forced positions.

Slika br. 1a *Olovarski brener*
Picture number 1a. *Lead producing Brener Tool*



Slika br.1b *Olovarska garnitura*
Picture number 1b. *Lead producing equipment*

Gasnim postupkom je moguće poolovljavanje na dva načina: kalaisanjem površine čelika na koju se potom nanosi olovo i homogenizacijom, tj. primenom homogene vode.

Postupak kalaisanja

Osnovni preduslovi za uspešno kalaisanje su: čistoća, temperatura, dobar topitelj i lem.

Čistoća čelika se postiže ručnim brušenjem površine do metalnog sjaja, temperatura ne sme da bude ni preniska niti previsoka jer će "izgoreti" topitelj (doći će do pasivizacije i lem će da klizi sa površine u obliku kuglica. U tom slučaju jedino je rešenje da se izvrši ponovo prebrusivanje, zagrevanje, premazivanje topiteljem i nanošenje lema sa utrljavanjem istopljenog lema kudeljom, keramičkim vlaknom i sl.

Osnovna uloga topitelja je da spreči oksidaciju u toku zagrevanja i da smanji površinske napone između osnovnog materijala i rastopljenog lema. Topitelji mogu biti u obliku praška, paste ili tečnosti.

Kao topitelj upotrebljava se najčešće cink-hlorid ($ZnCl_2$) koji se dobija dodavanjem cinka u sonu kiselinu. Lem je legura kalaja i olova (najčešće 60/40). Sam proces treba izvesti brzo i zbog toga se zagrevanje vrši intenzivno. Na nakalaisanoj površini ne sme da bude debeo sloj lema niti zaostaci prljavštine (vlakna od kudelje, keramike i sl.). To se odstranjuje čeličnom četkom dok je lem

Lead coating by gas procedure is possible in two ways: by tinning the surface of steel on which then lead is applied, and homogenization i.e. use of homogenous water.

Tinning procedure

The basic preconditions for successful tinning are: purity, temperature, good smelter and solder.

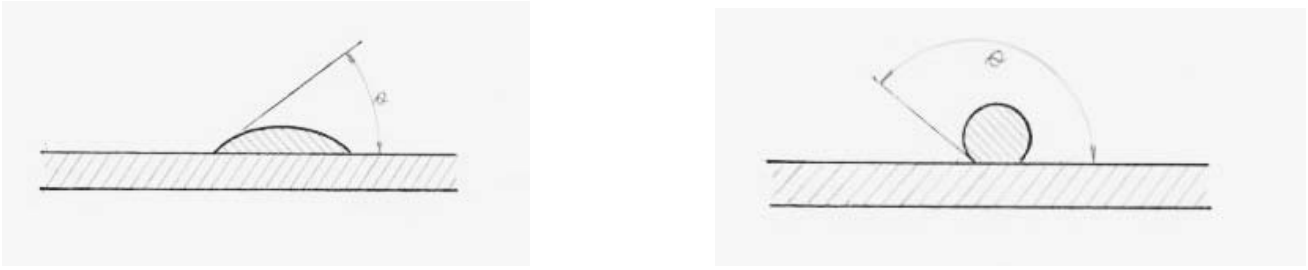
The purity of steel is obtained by manual grinding of the surface to metal shine, the temperature has to be neither too low nor too high because the smelter will "burn" (it will come to the passiveness and the solder will slide from the surface in the form of balls. In that case the only one solution is to redo grinding, heating, coating with smelter and applying solder with liniment of melted solder with hemp, ceramic fiber and so on.

The main role of the smelter is to prevent oxidation during the heating and to reduce surface voltages between the main material and melted solder. The smelters can be in the form of powder, paste or liquid.

The most frequently used smelter is zinc-chloride ($ZnCl_2$) which is obtained by adding zinc in hydrochloric acid. The solder is the alloy of tin and lead (the most frequently 60/40). The process itself has to be done fast and because of that heating is intensively done. On the tinned surface there must not be a thick layer of solder or remains of dirt još u

rastopljenom stanju. Debeli nanos lema bi dodatno legirao olovo, što bi bilo nepoželjno.
Kalaisanjem se aktivira površina za bolje kvašenje pri nanošenju prvog, kontaktnog sloja olova. Prionljivost nanetog sloja zavisi od kapilarnih sila, odnosno od ugla pod kojim je delić rastopljenog metala lema u interakciji sa čvrstom podlogom.

(hemp fibers, ceramics and so on). It is removed with steel brush while the solder is still in a melted form. A thick coat of solder would additionally alloy lead which would be undesirable. By tinning the surface is activated for better soaking while it is applied the first, contact layer of lead. The adhesion of the applied layer depends on capillary forces, i.e. on the angle under which there is the part of the melted metal of solder in the interaction with a firm base



a)Good or very good soaking
a)Dobro ili vrlo dobro kvašenje.

b)Bad soaking or there is no soaking at all
b)Loše kvašenje ili ga uopšte nema

***Picture number 2** (a,b)*
***Slika br.2** (a,b)*

Pri toplom kalaisanju uranjanjem u tečni Sn lem čeličnih elemenata, dolazi do stvaranja jedinjenja $FeSn_2$, koje pri zagrevanju u toku nanošenja olova ne menja sastav već samo tip kristalne rešetke. Ovo jedinjenje omogućava dobar spoj (bolje kvašenje površine i lakše vezivanje olova, bez grešaka neprionljivosti)

Nanošenje olova na kalaisanu površinu

Kalaisanu površinu na koju se nanosi olovo treba postaviti u horizontalan položaj, a ivice treba ograditi kako ne bi rastopljeno olovo curilo. Poštujući navedene principe moguće je izvršiti poolovljavanje površina svih oblika i veličina.

During the hot tinning by soaking to the liquid Sn solder of steel elements, there occurs the creation of the compound $FeSn_2$, which while heated during the applicaction of lead does not change the composition but only the type of the crystal grid. This compound enables a good joining (better soaking of the surface and easier connecting of lead, without the faults of not being adhesive).

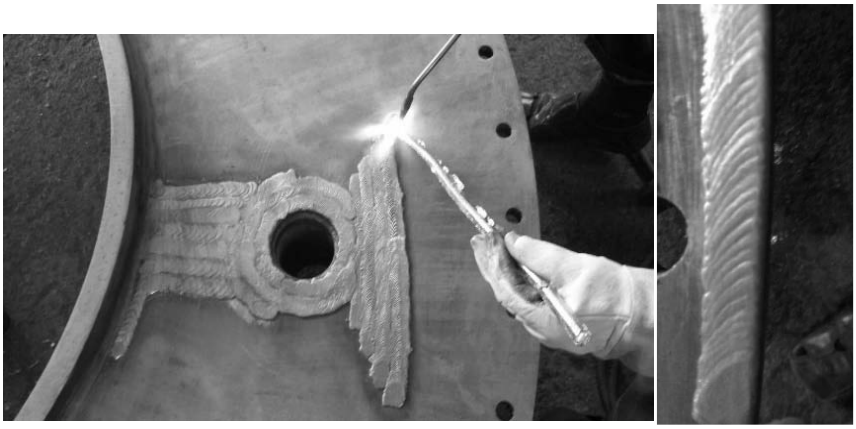
Application of lead to a tinned surface

The tinned surface on which lead is applied should be set to a horizontal position and the edges should be surrounded in order that the melted lead would not leak. Respecting the above principles it is possible to perform lead coating of the surfaces of all forms and sizes.

***Picture number 3.** The additional material are triangle bars (sides of the bar 6-10 mm) which are casted in a mould and immediately used in order not to come to the occurrence of surface oxidation of lead.*
***Slika br. 3** Dodatni materijal su trouglaste šipke (stranice šipke 6 – 10mm) koje se liju u kalupu i odmah upotrebljavaju kako ne bi došlo do površinske oksidacije olova*

Pre početka nanošenja prvog sloja potrebno je izrvršiti predgrevanje radnog komada na temperaturu 60-80°C (ispod 100 °C).
Debljina jednog nanetog sloja olova je 1,5-3mm. Uobičajeno se traže nešto veće debljine, pa je potrebno naneti bar dva sloja.
Pošto se nanošenje prvog sloja vrši bez rastapanja površine osnovnog materijala, ovaj postupak spada u meko lemljenje (temperatura ne prelazi 450°C), ali nanošenje drugog i sledećih slojeva vrši se rastapanjem osnove i dodavanjem Pb šipke, pa se dalji postupak naziva navarivanje olova ili olovarenje.
Pre nanošenja svakog sledećeg sloja neophodno je da se izvrši uklanjanje oksidisane i kontaminirane površine ručnim šaberovanjem (grebanjem) ili rotacionom čeličnom četkom. Takođe je neophodno da se olovna šipka ili žica očiste od oksida neposredno pre nanošenja topljenjem.
Kao gorivi gasovi upotrebljavaju se najčešće acetilen (disugas), vodonik i butan. Plamen treba da je neutralan i intenzivan (znatno jači nego pri zavarivanju). Čistiji i svetliji je navar ako se radi sa vodonikom, ali je teže kontrolisati kupku (ne vidi se jezgro plamena), pa je potrebna veća veština i iskustvo.
Nakon postizanja potrebne debljine površina olova se ravna širokim plamenom i ta operacija se naziva peglanje. Tako se ujednačava debljina plakature.
Nakon hlađenja potrebno je izvršiti kontrolu debljine, stanje površine i prionljivost.

Before the beginning of application of the first layer it is necessary to do the previous heating of a working piece, on the temperature 60-80°C (under 100°C). The thickness of one applied layer of lead is 1,5-3mm. Usually, thicker layers are usually demanded, so it is necessary to apply at least two layers. Since the application of the first layer is done without the melting of the surface of the basic material, this procedure is classified as soft soldering (the temperature does not exceed 450°C), but application of the second and other layers is done by melting the basis and adding Pb bar, so the further procedure is called welding of lead or lead coating. Before applying every other layer it is necessary to do the removing of the oxidized and contaminated surface by manual scraping (scratching) or rotational steel brush. It is also necessary for a lead bar or wire to be cleaned from oxides immediately before applying by smelting. As combustive gases the most frequently used are acetylene, hydrogen and butane. The flame should be neutral and intensive (much stronger than while welding). The weld is clearer and lighter if it is worked with hydrogen but it is more difficult to control the bath (the core of the flame cannot be seen), so that more skills and experience are necessary.After obtaining the necessary thickness the surface of lead is flattened with wide flame and that operation is called ironing. That is the way to unify the thickness of the coating. After cooling it is necessary to do the control of thickness, condition of the surfaces and adhesiveness.



Picture number 4a. *Application of lead to the tinned surface of the vacuum breaker pump*
Slika br. 4a *Nanošenje olova na kalaisanu površinu vacuum breaker pumpe*

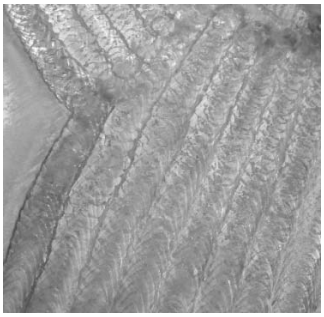


Figure 4b, *4c Welded detail*
Slika 4b, 4c *Navareni detalj*

Homogeno poolovljavanje

Princip rada ima sličnosti sa već opisanim postupkom poolovljavanja nakon kalaisanja. Osnovna je razlika što se na očišćenu, izbrušenu površinu premazuje homogena voda i potom se na tako nakvašeni deo direktno nanosi rastopljeno olovo bez prethodnog kalaisanja. Homogena voda je odličan topitelj a čini je rastvor cink-oksida (ZnO) i kalaj-hlorida (SnCl) u koncentrovanoj sonoj kiselini (HCl) i destilovanoj vodi (H_2O.
Homogena voda vrši dobro kvašenje lema i osnovnog materijala, podnosi veću temperaturu pri radu od cinkove soli sone kiseline ($ZnCl_2$). Primenjuje se za nanošenje olova direktno na ugljenični čelik, bez potrebe prethodnog kalaisanja. Homogena voda je znatno skuplja od $ZnCl_2$. Proces nanošenja prvog sloja je sporiji od nanošenja na kalaisanu površinu, a olovar je izložen većem uticaju isparenja kiseline i olova. Primenjuje se uvek tamo gde je nemoguće izvršiti pripremu kalaisanjem. Nedostatak je i to što postoji mogućnost pojave poroznosti usled zarobljavanja isparenja homogene tečnosti.
Sve ostalo, posle nanošenja prvog sloja, važi isto što je već opisano pri poolovljavanju nakon kalaisanja.

Primer: poolovljavanje vacuum breaker pumpe koja radi u procesu dobijanja sumporne kiseline.
Dimenzije površina za poolovljavanje Ø 2185.Debljina nanetog olova……d = 5mm.
Olovo Pb 99,985 Cu
Uslovi rada:
- temperatura u toku procesa 61^oC
- vacuum u toku procesa -121,6 mbar
SO_2 10 – 11 %
SO_3 0 %
O_2 13 – 14 %
N_2 68 – 69 %
CO_2 0 %
koncentrovana sumporna kiselina – u tragovima

Kontrola
Ispitivanje debljine
a) Moguće je izvršiti kontrolu rastapanjem pojedinih mesta i merenjem kljunastim merilom (šublerom) ili dubinomerom, ili ubadanjem iglom i očitavanjem debljine, pa kontrolisana mesta navariti ponovo olovom. To su zastarele metode, a sada se primenjuju ultrazvučni instrumenti za merenje debljine koji se pre upotrebe baždare na etalonu koji se lako može da napravi za konkretan slučaj.

Homogenous lead coating

Principle of functioning is similar to the already described procedure of lead coating after tinning. The main difference is that homogenous water is smeared on the cleaned, sanded surface and then, on that soaked part, melted lead is directly applied without previous tinning. Homogenous water is excellent smelter and consists of the solution of zinc-oxide (ZnO), tin-chloride (SnCl) in the concentrated hydrochloric acid (HCl) and distilled water (H_2O). Homogenous water wets well solder and main material, tolerates higher temperature while working than the zinc salt of hydrochloric acid ($ZnCl_2$). It is applied for the lead coating directly to carbon steel, without the necessity for previous tinning. Homogenous water is much more expensive than ZnCl2. The process of applying the first layer is slower than applying to a tinned surface and a lead producer is exposed to greater influence of acid and lead evaporations. It is always applied where it is impossible to do the preparation by tinning. One of the deficiencies is also the one when there are no possibilities of occurrence of porosity for the reasons of capturing the evaporations of homogenous liquid. All others, after the application of the firs layer, is the same as it has been described, while lead coating after tinning.
Example: lead coating of the vacuum breaker pump which works in the process of obtaining sulfuric acid.
Dimensions of the surface for lead coating: Ø 2185.
Thickness of the applied lead ……d = 5mm.
Lead Pb 99,985 Cu
Conditions of work:
- temperature during the process - 61^oC
- vacuum during the process -121,6 mbar
SO_2 10 – 11 %
SO_3 0 %
O_2 13 – 14 %
N_2 68 – 69 %
CO_2 0 %
Concentrated sulfuric acid – in traces

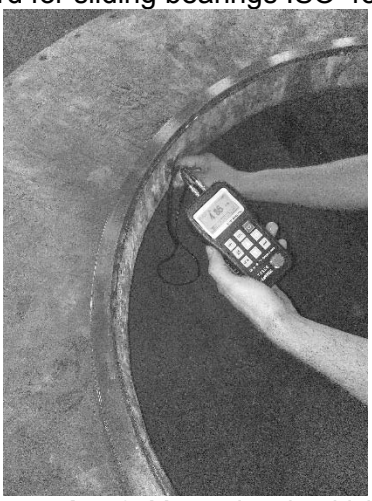
Control
Examination of the thickness
a) It is possible to do the control by melting individual places and measuring with a caliper (Schublehre) or sounder, or sticking a needle and reading the thickness and then again welding with lead the controlled spots. Those are outdated methods, nowadays we use ultrasound instruments for measuring thickness which are calibrated on the die which can be easily made for a specific case.

b) Opšta prionljivost se kontroliše ultrazvučnim aparatom uz primenu normalnih sondi (90°C). Princip kontrole treba da je kao kod svakog bimetala, a to je da spoj treba da omogući povratni eho od donje površine čelika. Ovo se lako izvodi ako su u pitanju ravne površine, a ako su u pitanju zakrivljene površine, onda se primenjuje tehnika gubitka energije ultrazvuka (Nema povratnog eha od kontakta čelik-olovo, već se isti gubi u čeliku).

c) Stanje površine i ivična prionljivost se ispituju penetrantima. Kvalitet i strogost kontrole mogli bi da budu definisani prema dogovoru sa projektantom, naručiocem ili prema standardu za klizne ležajeve ISO 4386.

b) General adhesion is controlled by an ultrasound device with the application of normal probes (90oC). The principle of control should be as it is for every bimetal, and that is that a joining should enable a reverse echo from the bottom surface of steel. This can be done easily if it is about flat surfaces, but if it is about curved surfaces, then, it is applied the technique of losing ultrasound energy (there is not a reverse echo from the contact steel-lead, it is lost in steel).
c) The condition of the surface and edge adhesiveness are examined with penetrates. The quality and strictness of the control could be defined according to the agreement with the designer, ordering party or according to the standard for sliding bearings ISO 4386.

Picture number 5. *Presentation of the ultrasound control of vacuum breaker pump after ironing the lead surface*
Slika br. 5 *Prikaz ultrazvučne kontrole vacuum breaker pumpe nakon peglanja površine olova*



Picture number 6. *Measuring the thickness of the lead*
Slika br. 6 *Merenje debljine olova*

Zaštita na radu

Olovne pare su otrovne, utiču na zdravstveno stanje radnika i zato se moraju preduzeti odgovarajuće mere. Lica koja rade sa olovom ne smeju biti mlađa od 16 godina. Osnovna zaštita bila bi dobra ventilacija i lična higijena kao i primena osnovnih sredstava za zaštitu.
Olovo utiče na intelektualni razvoj, nervni sistem, povećanje krvnog pritiska, smanjuje funkciju bubrega, izaziva anemiju i reproduktivne probleme. Posebno treba voditi računa pri radu poolovljavanja jer pored olovnih para tu su i isparenja od topitelja (kiseline).

Lična higijena

Olovari moraju da nose odela koja se lako peru (keper). Potrebno je da se nosi kapa od kepera, zaštitne kožne rukavice od meke (jelenske, jareće) kože.

Protection at work

Lead evaporations are poisonous; they influence health conditions of the workers so appropriate measures have to be taken. The persons who work with lead must not be younger than 16. The basic protection would be good ventilation and personal hygiene as well as using the basic protection equipment.
Lead has the influence to intellectual development, nervous system, blood pressure increase, it reduces the function of kidneys, provokes anemia and reproductive problems. A special care should be taken while working on lead coating because besides lead evaporation there are also the evaporations of smelters (acids).

Personal hygiene

Lead producers have to wear clothes which are easy to be washed (twill). It is necessary for them

Olovari treba da imaju dvostruki radni ormar, jedan za radno a drugi za čisto odelo.
Pošto plamen nije intenzivne svetleće boje, a olovo ne menja boju pri topljenju, nisu potrebne zaštitne naočari kao za autogeno zavarivanje, čelika npr.
Poželjno je nositi zaštitnu papirnu masku za disanje, kao zaštitu od prašine ako su takvi uslovi u prostoriji.
Najvažnija zaštita disajnih organa čini se provetravanjem bilo prirodnim, bilo veštačkim putem.
Hrana ne sme da se unosi u prostoriju gde se radi sa olovom. Olovari moraju redovno da vrše lekarske preglede, najmanje jednom godišnje.
Ukoliko se radi u tesnim i zatvorenim prostorima, što je čest slučaj u toku raznih remontnih radova, onda treba voditi računa o mogućnosti zasićenja prostora zapaljivim gasovima. Naročito je opasno ako se olovarenje vrši vodonikom (H_2) u zatvorenom prostoru. Tada treba da radi jedan olovar uz stalni nadzor i merenje koncentracije gasova, uz češću zamenu sa drugim olovarom. Zamena je potrebna nakon svakih 45 minuta.Sve ostalo što važi za zaštitu pri radu gasnim zavarivanjem važi i za olovarske radove.

to wear a twill cap, protective leather gloves made of soft (deer and goat) leather. Lead producers should have double cabinet, one for working clothes and one for clean clothes. Since the flame is not of intensively shining color, and lead does not change color while melted, protection glasses are not necessary as it is the case with autogenous welding of, for example, steel. It is desirable to wear protection paper mask for breathing, as well as the protection form dust if the room has such conditions. The most important protection of respiratory organs is done by ventilation, whether in natural way or by air-conditioning. Food must not be taken to the room where it is worked with lead. Lead producer have to regularly go to medical examinations, at least once a year. If they work in small and close rooms, which is a usual case during various repair works, then, they should take care of the possibility of saturating the room with inflammable gases. It is especially dangerous if lead coating is done with hydrogen (H_2) indoors. Then, one lead producer should work with the constant supervision and measuring the concentration of gases, and frequent changing with another lead producer. The change is necessary every 45 minutes. All other measures which are taken while working with gas welding are applied to lead producing works.

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