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PRIMJENSKO ISPITIVANJE BAZNE KLIZNE MASTI U BRODOGRADILIŠTIMA

Sažetak

Za uspješno porinuće brodova u brodogradilištu je kod pripreme navoza neophodna kvalitetna bazna klizna mast kao sredstvo pripreme saonika pred porinuće broda u more. Osnovna uloga te masti je izravnavanje površina saonika i saonica, preuzimanja opterećenja težinom broda, te davanje svojstva elastičnosti nosivim površinama. Na taj način naknadnim postavljanjem klizne masti između tarnih površina smanjujemo trenje i omogućujemo uspješno klizanje broda na saonicama po saoniku do porinuća u more.

Značaj kvalitete same masti, kao i pravilan postupak nanošenja bazne klizne masti na podlogu, uvažavajući uvjete pri kojima se taj postupak obavlja, značajni su i predstavljaju temelj uspješnosti porinuća broda. Moguća odstupanja od preporuka proizvođača bazne klizne masti i od iskustvenih preporuka dugogodišnjih stručnjaka u brodogradilištima, mogu rezultirati problemima kod porinuća brodova, posebno danas, kada se rapidno povećavaju opterećenja suhih navoza radi sve većih brodova. Posljednje novogradnje u hrvatskim brodogradilištima, pri kojima se pojavljuju opterećenja i do 50 tona po četvornom metru saonika, potakla su domaćeg proizvođača bazne klizne masti na primjenska ispitivanja o postupcima nanošenja i tretiranja bazne klizne masti u brodogradilištima.

Ovaj rad daje uvid u različitosti rada pri primjeni bazne klizne masti u brodogradilištima, uvid u promjene koje su uočene i izmjerene kod primjene masti pri različitim klimatskim uvjetima, donosi rezultate praćenja fizikalno-kemijskih svojstava masti, te u zaključku pokušava uputiti na bitne karakteristike kod postavljanja i općenito radu s baznom kliznom masti.

1. Uvod

Problem maziva kod porinuća brodova postavlja se kao vrlo ozbiljan problem kod gradnje sve većih jedinica na suhim navozima. Dok su do pedesetih godina prošlog stoljeća građeni lakši trupovi, porinuća su mogla biti izvršena uz dovoljnu sigurnost i uporabom prirodnih masti za podmazivanje saonika (prirodni loj). Danas se koriste specijalne mineralne masti za porinuća, pri čemu valja istaknuti da se razlikuju dva tipa mazivih masti u primjeni kod porinuća. Prvi sloj je bazna klizna mast, odgovarajuće ljepljivosti za drvo, s namjenom izravnavanja površina saonika (navoza) i saonica (nosača brodskog trupa), preuzimanja nošenja težine broda, te davanja svojstva elastičnosti „kliznim i tarnim površinama“. Drugi sloj je klizna mast koja smanjuje trenje i omogućava uspješno klizanje broda na saonicama po saoniku do prvog susreta broda s morem.

Uspješna gradnja brodova koji su po dužini i težini trupa već na granici mogućnosti suhih navoza, jer se najveći brodovi grade u suhim dokovima, svrstava hrvatska brodogradilišta u sam vrh svjetske brodogradnje. Tendencija je ugraditi u trup broda, dok je on još na navozu, što više opreme u unutrašnjosti, jer to poslije olakšava i ubrzava dovršenje broda u otpremnoj luci pred primopredaju novom vlasniku. Podaci govore da se u trenutku porinuća broda (ovisno o veličini) njegova težina penje na iznad 25000 tona (uračunavši i balast u krmenom dijelu broda radi potreba porinuća). Kod većih brodova u početku porinuća raspored opterećenja na navozu je od 10-ak tona/m^2 na pramčanom dijelu pa do 50 tona/m^2 na krmenom dijelu. Prilikom ulaska krmenog dijela u more zbog početka djelovanja uzgonske sile krma zaplovi. U tom trenutku sve opterećenje preuzima pramčani dio saonika – kolijevka, a sile koje djeluju na klizne površine se višestruko povećavaju, tako da se mogu postići kratkotrajna vršna opterećenja i do 200 tona/m^2.

Samo porinuće broda je najkritičniji trenutak u životu broda, odnosno u normalnoj eksploataciji brod nikada nije izložen takvim naprezanjima i rizicima. Brod je od trenutka kada krene niz stazu saonika pa do otplova potpuno prepušten samom sebi, na njega se više ne može djelovati niti njime upravljati. Toga radi, svi proračuni i pripremne radnje treba studiozno i kvalitetno predvidjeti i obaviti, kako bi se pokušalo izbjeći moguće neugodnosti, a koje za sobom povlače moguće vrlo velike i nepredvidljive financijske i druge štete. Da bi se rizik sveo na najmanju moguću mjeru, maziva moraju zadovoljavati stroge kriterije kvalitete i biti pažljivo primijenjena, uz tijesnu suradnju brodogradilišta s proizvođačem mazivih masti.

Pravilno odabrane masti, postupci i radnje kod nanošenja masti bitni su elementi u ukupnosti priprema pred porinuće broda. U tom smislu pred svako porinuće izrađuje se plan s točnim uputama i razrađenim postupcima o primjeni masti. Posebno se to odnosi na pripremu površina saonika i saonica, pripremu – topljenje bazne klizne masti, način nanošenja bazne klizne masti, temperature bazne klizne masti, debljinu sloja, kontrolu i tome slično. Također, valja istaknuti da ovisno o karakteristikama navoza (dužina, nagib, zakrivljenost, podloga navoza), kao i različitostima u

detaljima priprema i postupaka nanošenja masti postoje razlike između pojedinih hrvatskih brodogradilišta.

U toku 2003./2004. godine u jednom je hrvatskom brodogradilištu došlo do problema kod primjene mazivih masti za porinuće. Nakon porinuća izgled i stanje bazne klizne masti na navozu nije bio očekivan (slika 1), došlo je do ljuštenja i odvajanja slojeva bazne klizne masti, te se s pravom postavilo pitanje zašto je do toga došlo i što učiniti da bi se spriječile moguće teže posljedice, odnosno otklonilo opetovanje događaja?

U znaku dobrih poslovnih odnosa, kao i dosadašnjih dobrih iskustava u primjeni naših baznih kliznih masti, uz punu suradnju stručnjaka iz sva tri najveća hrvatska brodogradilišta odlučeno je aktivnije se uključiti u analiziranje opće problematike primjene mazivih masti u brodogradnji pri porinuću brodova.

Slika 1: Ljuštenje slojeva bazne klizne masti
Figure 1: Peeling of base launching grease layers

U daljnjem dijelu ovog rada razmatrat će se samo problematika primjene bazne klizne masti. Izložit će se značajke pripreme navoza, priprema i nanošenje bazne klizne masti, prikazati brojčane vrijednosti izmjerene u toku praćenja priprema nanošenja bazne klizne masti na klizne površine navoza u tri najveća hrvatska brodogradilišta, vrijednosti dobivene ispitivanjem fizikalno kemijskih svojstava

svježih i rabljenih baznih kliznih masti, kao i zaključci glede mogućih preporuka za daljnju uspješniju primjenu bazne klizne masti domaće proizvodnje.

2. Bazna klizna mast

Maziva iz kojih se daljnjim postupcima proizvode bazne klizne masti za porinuće proizvode se u rafinerijama, koje svojim tehnološkim postupkom omogućuju dobivanje više tipova smjesa parafinskih ugljikovodika. To su smjese kristaličnog ili amorfnog karaktera, visokog tališta (iznad sobne temperature), otporne na vodu i konzistentne u toj mjeri da mogu osigurati nosivi sloj masti. INA Bazna klizna mast odlikuje se odličnim svojstvima nosivosti, visokim talištem, vrlo dobrim svojstvom lijepljenja na drvenu podlogu, izvrsnom plastičnošću i otpornošću, te konzistentnošću. Preko 30-godišnje iskustvo u proizvodnji tog tipa masti, kao i uspješnost primjene u našim brodogradilištima, te veliko iskustvo brodograditelja potvrdili su kvalitetu i uspješnost primjene.

Bazna klizna mast proizvodi se iz tri komponente različitih svojstava:

- makrokristalični parafin koji ima svojstvo nosivosti i visoko talište,
- mikrokristalična komponenta, koja osim nosivosti posjeduje i dobru ljepljivost za drvo i
- uljna komponenta, koja smanjuje krhkost maziva na nižim temperaturama i daje mu potrebnu elastičnost.

Posebnih specifikacija, koje bi određivale kvalitetnu razinu tih proizvoda, nema i osim interne norme ne postoji neki drugi definirani propis.

Tablica 1: Fizikalno-kemijska svojstva bazne klizne masti

Red.broj	Fizikalno-kemijska svojstva	Jedinica	Metoda ispitivanja	Vrijednost
1.	Kapljište	°C	DIN 51801/02	58 – 62
2.	Količina ulja, maks.	% m/m	ISO 2908, ASTM D 721	15,0
3.	Penetracija na 16 °C 21 °C 27 °C 32 °C 38 °C	mm 10^{-1}	ASTM D 1321	 16 – 20 20 – 30 30 – 40 ispod 80 ispod 200
4.	Plamište, min.	°C	EN 22592, ASTM D 92	200

3. Postupak pripreme i nanošenja bazne klizne masti

Priprema saonika navoza za porinuće u pravilu počinje otprilike jedan mjesec prije datuma porinuća, iako se može reći da već nakon prethodnog porinuća počinju pripreme za novo.

Slika 2: Izgled saonika nakon porinuća broda
Figure 2: Ground ways appearance after launching

Ovisno o godišnjem dobu i stanju klizne masti nakon prethodnog porinuća odlučuje se o skidanju, ili ostavljanju postojeće klizne masti. Ukoliko je stanje bazne klizne masti zadovoljavajuće, a naredno je porinuće u prihvatljivom vremenskom roku i klimatskim uvjetima, saonici se zaštite čeličnim limovima po cijeloj površini i tako zaštićeni čekaju novu uporabu. U nekim brodogradilištima, međutim, obvezno se nakon svakog porinuća skida upravo upotrijebljena bazna klizna mast i zatim se od mehaničkih oštećenja zaštićuje drvo saonika na isti način kao i kada je sačuvana za još koju uporabu stara klizna mast. Ne želeći riskirati svako porinuće dobiva, ako ne svu, a ono barem u najopterećenijem dijelu saonika, novu mast. Ta skinuta bazna klizna mast je pomiješana s dijelom zaostale i degradirane klizne masti, te se takva dalje rješava na dva načina. Prvo, sve ostrugano se baca kao otpad. Drugi način je ekonomski opravdaniji, iako s dozom rizika, a to je mogućnost ponovnog iskorištenja te masti uz prethodni postupak provjere kvalitete i korištenje za pripremu saonika u dijelu gdje nisu najveća opterećenja. Ovdje važnu ulogu imaju prateći laboratorij i prethodno iskustvo ljudi koji rade te poslove.

Uoči nanošenja bazne klizne masti saonik se pregleda i po potrebi poprave neispravnosti ili oštećenja drvene podloge. Podvodni dio saonika se u pravilu vadi iz mora i odlaže na zaštićeno mjesto radi sušenja i pripreme za novo porinuće. Nanošenje bazne klizne masti i klizne masti na taj dio saonika, te postavljanje na

mjesto u produžetku nadvodnog saonika obavlja se neposredno nekoliko dana pred porinuće. Za nadvodni dio saonika važno je obavljati sve radove nanošenja masti nakon završetka drugih radova na trupu broda, kako bi se izbjegla moguća oštećenja nanesenih masti. I sve to do dovršenja uvlačenja saonica i njihovog učvršćenja.

Slika 3: Skidanje rabljenih masti sa saonika odmah nakon porinuća broda
Figure 3: Used grease removal immediately after launching

Jedan od prevažnih preduvjeta uspješnog nanošenja bazne klizne masti je stanje površine saonika, prvenstveno čistoća i vlažnost drveta. Skidaju se nečistoća, ostaci stare klizne masti, neravnine, poželjno je utvrditi vlažnost i po potrebi sušiti drvo (plamenicima) i zatim ostrugati nagoreni dio. Ukoliko je vlažnost drveta previsoka, prema nekim izvorima ako je >15%, upitna je ispravna penetracija masti u drvo i sigurnost čvrstog prianjanja masti. Kod slučaja zadržavanja prethodno korištene bazne klizne masti na saoniku, pregled podrazumijeva provjeru stanja i utvrđivanje mogućih dodatnih zahtjeva glede pripreme površine za dodatnim slojem nove bazne klizne masti.

Pripremu - topljenje bazne klizne masti treba predvidjeti što bliže mjestu nanošenja. Topljenje masti izvodi se u posebno pripremljenim kotlovima. Bitno je postići

jednakomjernost u brzini grijanja ukupne mase i ne pregrijati mast. Poželjna temperatura otopljene masti u iskustvenim je granicama od 95 – 125 ^{o}C, no valja imati na umu kakve su klimatske prilike (ljeto/zima). Važno je to zbog održanja akumulirane toplinske energije u otopljenoj masti kao funkcije stvaranja kohezionih sila između drveta i masti, odnosno između slojeva masti pri nanošenju novog sloja. Padovi temperature mase otopljene masti od istakanja iz kotla do polijevanja na saonik moraju biti što manji. To je posebno značajno u zimskim uvjetima kada su inače temperature niske, kako okoliša, tako i saonika, a i hlađenje prethodnog sloja je brže. Postoji iskustvena donja granica temperature okoliša kod koje se još mogu vršiti poslovi nanošenja bazne klizne masti na saonik i to je oko +5 ^{o}C. Kod niskih temperatura opasnije su još niže noćne temperature nakon nanošenja bazne klizne masti, koje mogu prouzročiti naglija stezanja slojeva masti, pucanja i odvajanja slojeva. Toga radi, poželjno je zaštititi postavljenu baznu kliznu mast zaštitnim izolacijskim pokrovima (limovi, daske, platno i sl.). U slučaju ponovnog topljenja već upotrebljavane bazne klizne masti moramo znati da ta ostrugana mast sa saonika pomiješana s dijelom zaostale degradirane klizne masti predstavlja čimbenik pogoršanja ukupnih svojstava same bazne klizne masti. Prvenstveno gledano kroz sniženje tališta, ali i kroz unošenje prljavštine, pijeska i dr. u otopinu. Karakteristična je kod topljenja takve masti krosta, koju valja u što većoj mjeri ukloniti. Također i pijesak na dnu kotla koji direktno utječe na uvjete zagrijavanja i kasnije na nanošenje masti. Primjese zaostale klizne masti snizuju i tvrdoću i nosivot bazne klizne masti, te se ne preporuča uporaba takve masti u najopterećenijem dijelu saonika.

Organizacija nanošenja otopljene bazne klizne masti na saonik podrazumijeva timski rad grupe, zbog osiguranja brzine, kontinuiteta i jednakomjernosti polijevanja otopljene masti radi dobivanja kompaktnog i ispravnog sloja/eva. Ovisno o uzdužnom i poprečnim nagibima saonika kod polijevanja otopljene masti, radi sprječavanja gubitka na rubovima i razmazivanja po cijeloj širini saonika pomaže se mekanim četkama. U skladu s točno određenim uputama o debljini bazne klizne masti uzdužno po saoniku stalno se provjerava postignuta debljina. Ta debljina varira od vrha saonika pa do mjesta najvećeg opterećenja od 8 – 12 mm. Ako je ima više, ne smeta, ali je nepotreban trošak. Jasno je da se odmah, jednim polijevanjem, ne može postići potrebna debljina bazne klizne masti. Znači postupak podrazumijeva nalijevanje u više slojeva (4-5 slojeva).

Također, kod korištenja saonika s prethodno sačuvanom baznom kliznom masti, uz prethodno dobro čišćenje, valja dodatnim polijevanjem novo rastopljenom masti popuniti neravnine i dati saoniku ukupnu glatku površinu. Pri tome je važno ne dopustiti preveliku razliku u temperaturi prethodnog sloja i novog. Ako je novi sloj prevruć, dolazi do topljenja donjeg sloja, ili nedovoljnog povezivanja slojeva za slučaj ohlađene otopljene bazne klizne masti ispod 90-ak ^{o}C. Klizne površine saonica, kao i površine kolijevke također su premazane baznom kliznom masti, no površine se manje troše i rjeđe se, odnosno po potrebi, obnavlja bazna klizna mast.

Slika 4: Izgled slojeva bazne klizne masti i prikaz nevezanja masti na podlogu
Figure 4: Base launching grease layers appearance and example of inadequate sticking to launching ways

Završni dio priče oko primjene mazivih masti kod porinuća je uvlačenje saonica uz istodobno postavljanje klizne masti na klizne površine, fiksiranje saonica na trup broda i pred samo porinuće, skidanje potpornja trupa, nakon čega cijela težina broda biva oslonjena na saonice. Od tog trenutka, pa do časa otpuštanja stopera i zatim u vremenu klizanja broda prema moru do urona, masti su „glavni glumci“. A onda sve ispočetka za neki drugi brod !

4. Uočeni postupci i rezultati praćenja pripreme i nanošenja bazne klizne masti, rezultati ispitivanja uzoraka bazne klizne masti

Od rujna 2004. pa do ožujka 2005. praćenjem smo obuhvatili pripremu i nanošenje bazne klizne masti za ukupno 5 porinuća u tri najveća hrvatska brodogradilišta. Sva porinuća su bila uspješna bez ikakvih problema ili neugodnosti. U svim slučajevima uzimani su uzorci bazne klizne masti, kako svježe, tako i ponovno upotrijebljene (i nekoliko puta), s gornjeg dijela saonika i s donjeg opterećenijeg dijela. Pratili smo postignute debljine bazne klizne masti i utvrđivali eventualne promjene u debljini

nakon porinuća. Mjerili smo temperature u kotlovima i padove temperature kod prenošenja u kantama pred polijevanje na saonik. Kako su to pretežno bili hladniji mjeseci, i rezultate valja promatrati kroz prizmu temperature okoliša. No, mišljenja smo da su zimski mjeseci kritičniji te su podaci gledano općenito ipak dosta relevantni.

Udjel djelatnika laboratorija, odnosno službi kontrole i njihovo aktivno sudjelovanje u praćenju postupaka pripreme i nanošenja bazne klizne masti omogućuje sigurnost i kvalitetu u ukupnim postupcima rada. Dugogodišnje iskustvo ljudi, kao i potvrđena kvaliteta bazne klizne masti do sada su bili presudni u uspješnosti primjene. Nema negativnih konotacija glede dosadašnje primjene, a pokoja neočekivana pojava nenormalnosti nije plod nekvalitete bazne klizne masti. Ponajviše je u igri ljudski faktor i nepridržavanje preporuka iz korektno napisanih uputa koje prate svako porinuće.

Sama priprema – topljenje bazne klizne masti provodi se u otvorenim kotlovima, zagrijavanim drvima u kojima se teško postižu projektirane temperature topljenja, pogotovo ako se topi već korištena mast pomiješana s primjesama klizne masti. Topljenje masti u zatvorenim kotlovima primjenjuje se kod zagrijavanja električnim grijačima. Način topljenja masti tako da se cijele bačve (napravljeni otvori na limu bačve) ubacuju u kotao, a nema kontrole temperature i intenziteta grijanja, može prouzročiti pregrijanost masti i degradaciju svojstava. Uočeno je pregaranje boje bačava koje su bile u kotlu, što potvrđuje da je bilo pregrijanja. Kod postupka gdje se u kotao stavlja direktno mast izvađena iz bačve takav slučaj nije evidentiran.

Tablica 2. Primjer analize uzorkovanih smjesa bazne klizne masti i klizne masti uzetih iz kotla kod topljenja pred nanošenje na saonik

	Uzorak 1 Rabljena1x	Uzorak 2 Rabljena2x	Uzorak 3 Rabljena2 x	Bazna klizna mast (Norma)		
Svojstvo	Rezultat				Jedinica	Metoda
Kapljište	57.0	51.0	54.0	58-62	°C	DIN 51 801-2
Količina ulja	6.27	32.94	34.72	najviše 15.0	% m/m	ASTM D 721
Penetracija						
- kod 16 °C	27	89	93	16-20	x 0.1 mm	ASTM D 1321 (mod)
- kod 21 °C	35	99	104	20-30		
- kod 27 °C	51	117	123	30-40		
- kod 32 °C	93	127	147	ispod 80		
- kod 38 °C	221	213	221	ispod 200		
Plamište	224	228	230	najmanje 200	°C	ASTM D 92

Napomena: Prije ispitivanja u laboratoriju uklonjeni talog (5-8% v/v) i klizna mast (20% v/v-uzorak 3)

Kod topljenja već korištene bazne klizne masti vjerojatno sastojci kao što su kremeni pijesak i druge nečistoće, ali prvenstveno prisutnost ostataka klizne masti, onemogućavaju postizanje projektirane temperature otopine. Prisutna je pjena, a utvrđena je nakon nanošenja i smanjena tvrdoća sloja kod primjene rabljene masti.

Također, pretpostavljamo da je i pojava lošije povezanosti te rabljene bazne klizne masti s drvom saonika dijelom posljedica gubitaka adhezijskih svojstava masti.

Tablica 3. Primjer analiza uzorkovane smjesa bazne klizne masti i klizne masti nakon porinuća

	Uzorak 1 Rabljena1x	Uzorak 2 Rablj.1x	Uzorak 3 Rablj.3x	Uzorak 4 Rablj.3x	bazna klizna mast(norma)		
Svojstvo	Rezultat					Jedinica	Metoda
Kapljište	58.0	54.0	54.5	54.5	58-62	°C	DIN 51 801-2
Količina ulja	3.15	19.82	12.35	10.90	najviše 15.0	% m/m	ASTM D 721
Penetracija - kod 16 °C - kod 21 °C - kod 27 °C - kod 32 °C - kod 38 °C	 21 26 36 57 148	 51 62 81 110 306	 37 50 65 105 295	 35 45 61 102 282	 16-20 20-30 30-40 ispod 80 ispod 200	x 0.1 mm	ASTM D 1321 (mod)
Plamište	226	220	232	228	najmanje 200	°C	ASTM D 92

Napomena: Prije ispitivanja u laboratoriju odstranjeni talog (5% v/v) i klizna mast (2% v/v)

Uzorci bazne klizne masti uzimani su direktno iz kotlova za vrijeme topljenja, odnosno nakon nanošenja i stvrdnjavanja baznih kliznih masti na saoniku. Analizirani su u laboratoriju u INA Maziva Rijeka. Sva temperaturna mjerenja obavljena su direktno u brodogradilištima, pri pripremi i nanošenju otopljene bazne klizne masti na saonike. Mjerila se temperatura masti u kotlovima, kod istakanja u posude za prenošenje masti do polijevanja na saonik, mjerilo se temperature saonika prije nanošenja bazne klizne masti i nakon svakog sloja. U radu su prikazane tablice fizikalno-kemijskih svojstava bazne klizne masti, također i dijagrami proizašli iz karakterističnih vrijednosti temperatura u pojedinim slučajevima rada s baznom kliznom mašću.

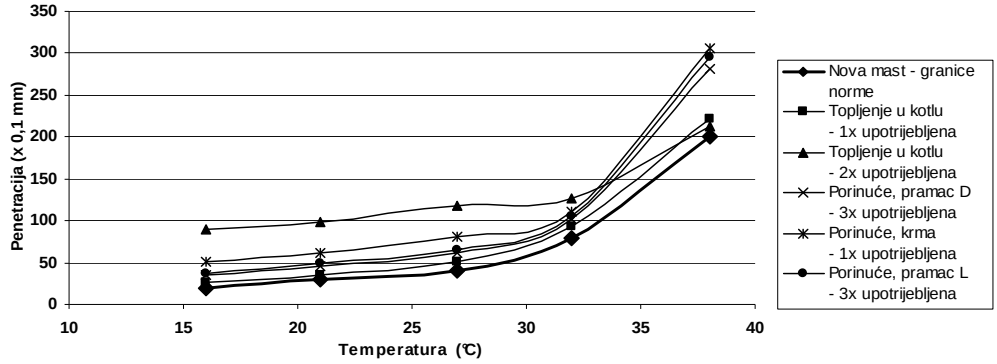
Tablica 4: Primjer analize uzorkovanih baznih kliznih masti uzetih sa saonika

	Uzorak 1 rabljena mast (ostala na saoniku od prethodnog porinuća - krma)	Uzorak 2 rabljena mast (uzorak nakon porinuća - krma)	Uzorak 3 rabljena mast (uzorak nakon porinuća - pramac)	INA Bazna klizna mast (norma)		
Svojstvo	Rezultat				Jedinica	Metoda
Kapljište	58.5	56.5	55.5	58-62	°C	DIN 51 801-2
Količina ulja	5.6	3,96	12.03	najviše 15.0	% m/m	ASTM D 721
Penetracija - kod 16 °C - kod 21 °C - kod 27 °C - kod 32 °C - kod 38 °C	 26 34 48 76 198	 25 27 40 63 173	 36 45 60 95 247	 16-20 20-30 30-40 ispod 80 ispod 200	x 0.1 mm	ASTM D 1321 (mod)
Plamište	238	224	226	najmanje 200	°C	ASTM D 92

Vidljivo je iz tablica 2 i 3 da je nakon opetovane primjene bitno smanjena tvrdoća masti, kao i sadržaj ulja u odnosu na normu. Zanimljivo je da je sadržaj ulja viši kod masti u toku topljenja, kada je prisutnost ostataka klizne masti izraženija, kao i da tvrdoća masti nešto poraste nakon porinuća. Naime, kod topljenja masti pred nanošenje uklanja se koliko je to moguće ostatke klizne masti i pjena. Kapljište se snizuje no tek kod baznih kliznih masti koje se više od jedan puta ponovno koriste.

U tablici 4 vidljivo je dobro stanje ostavljene bazne klizne masti na saoniku i nakon 6 zimskih mjeseci, što je potvrda njezine stabilnosti pri pravilnom nanošenju i korektnoj zaštiti. U ljetnim mjesecima ostavljena bazna klizna mast moguće da bi pokazala drugačije rezulate?

Dijagram 1. Promjena tvrdoće (penetracija) bazne klizne masti – brodogradilište A

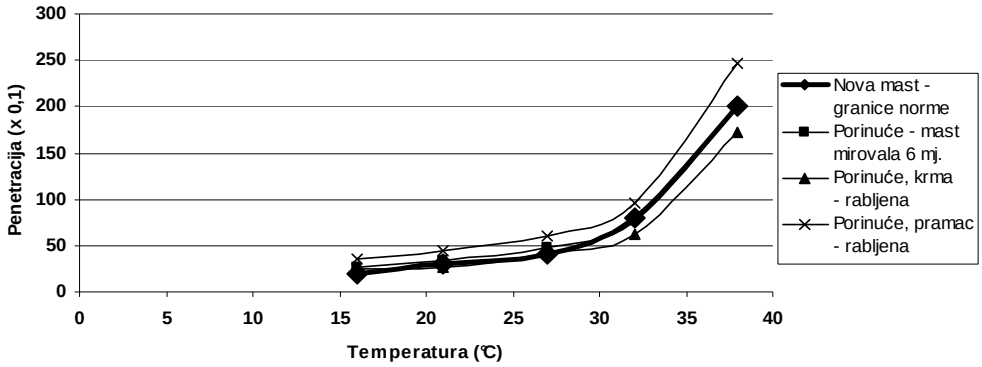


Moglo se očekivati da utjecaj zaostale klizne masti u smjesi s baznom kliznom masti, kod topljenja radi ponovnog iskorištenja, snizuje tvrdoću otopine. To je i vidljivo na dijagramu 1 (brodogradilište A), gdje je uočljiva i razlika ovisno o tome da li se radi sa smjesom koja je jednom ili dvaput korištena. Dvaput korištena mast kod nižih temperatura ispitivanja ima višu penetraciju, dok se kod viših ta razlika gubi. S druge pak strane rezultati provjere penetracije uzorkovane masti uzetih s krmenih, odnosno pramčanih dijelova saonika nakon porinuća, pokazuju pad tvrdoće upravo u području viših temperatura ispitivanja (metoda ASTM D 1321 – modificirana). Također, nema većih razlika u promjeni vrijednosti penetracije glede 1 ili 3 puta primijenjene masti?

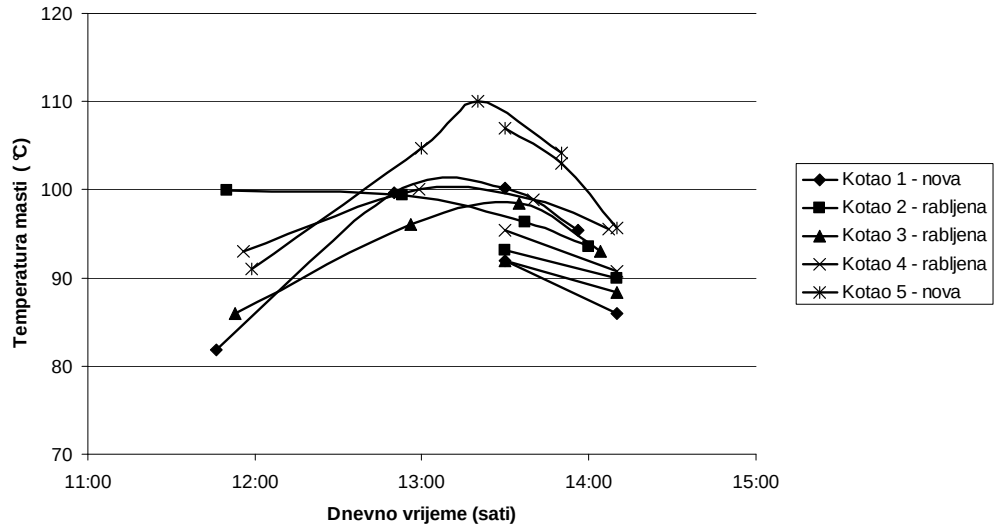
U dijagramu 2 za brodogradilište B imamo zanimljivost da se karakteristike penetracije kod rabljenih baznih kliznih masti ne mijenjaju mnogo i da su prihvatljivije u odnosu na vrijednosti uzoraka iz brodogradilišta A. Ima li to kakve veze s načinom topljenja (elektrogrijani kotlovi prema kotlovima grijanim otvorenom vatrom)? Ili možda o pomnosti uklanjanja klizne masti već kod struganja s navoza od prethodnog porinuća i kvalitetnijeg uklanjanja ostataka klizne masti, pjene, pijeska i sl. pri pripremi i samom topljenju smjese pred nanošenje na saonik?

Pretpostavljamo da ima utjecaj i kvalitetniji rad i angažiranost službe kontrole – laboratorija brodogradilišta pri kontroli i pripremi već upotrebljavane bazne klizne masti.

Dijagram 2. Promjena tvrdoće (penetracija) bazne klizne masti – brodogradilište B



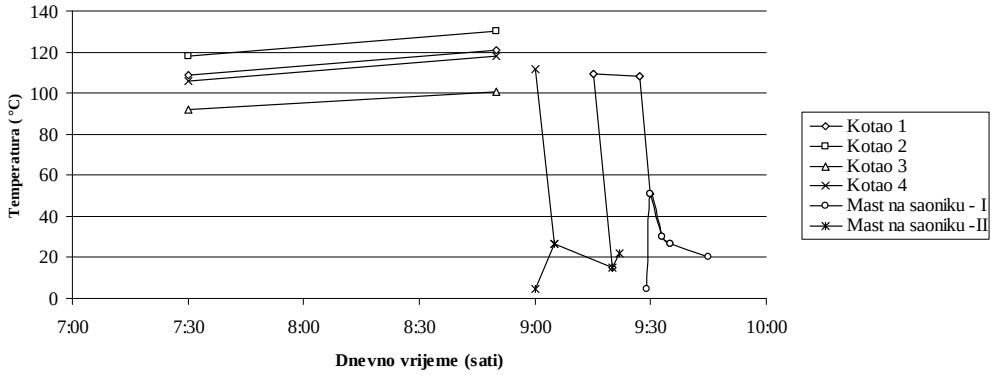
Dijagram 3: Promjena temperatura bazne klizne masti pri topljenju (nova i već rabljena bazna klizna mast) i uoči nanošenja na saonik (grijanje: otvorena vatra)



Dijagram 3 pokazuje, prvo, razliku u postignutim vršnim temperaturama otopljene masti ovisno o tome da li se radi o potpuno novoj masti, ili već upotrebljavanoj, i drugo, pad temperature (Δt) otopljene masti od prestanka grijanja do trenutka

ulijevanja u prenosnu posudu za nošenje do mjesta i trenutka polijevanja po saoniku. Utvrđeno je da rabljene bazne klizne masti s primjesama stare istrošene klizne masti i pijeskom u kotlu ne mogu kod topljenja postići temperature predviđene Uputama za porinuće. Stvarne temperature otopljene bazne klizne masti u trenutku nanošenja na saonik su ispod razine 95-100 ^{o}C. U toku našeg praćenja jedino se u jednom kotlu uspjelo postići temperaturu otopljene nove bazne klizne masti od 110 ^{o}C, pa su slijedom toga i ostali padovi temperatura viši. No, i te brojke su ispod predviđenih. Uzimajući u obzir u ovom slučaju i vanjske zimske temperature u vremenu topljenja i nanošenja bazne klizne masti od 4.4 ^{o}C (ujutro) do 11.5 ^{o}C (završetak nanošenja), moramo utvrditi da s postavljanjem bazne klizne masti nije bilo problema, slojevi i površine su bili uredni, a pregledom stanja saonika nakon porinuća (nakon 17 dana) nisu utvrđeni nikakvi posebni nepoželjni i neočekivani efekti.

Dijagram 4: Stanje temperatura bazne klizne masti pri topljenju (elektro grijanje, nova mast) i promjena temperature slojeva na saoniku pri nanošenju bazne klizne masti



U dijagramu 4 prikazane su promjene temperature kod topljenja samo nove bazne klizne masti, kotlovi su grijani elektrogrijačima, uz vanjsku temperaturu u sjeni od 3.7 ^{o}C (ujutro) pa do 5.1 ^{o}C (završetak nanošenja bazne klizne masti). Vidljivo je da su postignute predviđene temperature. Također su uočljivi padovi temperatura od kotla do trenutka izlijevanja otopljene bazne klizne masti na saonik. Ujedno dijagram prikazuje promjenu temperature bazne klizne masti od stanja u posudi do susreta s hladnijim saonikom, odnosno slojem na kojeg se nanosi sljedeći sloj, pa do postupnog daljnjeg hlađenja. Jasno, sve to ide dosta brzo, tako da od trenutka polijevanja vruće rastopljene bazne klizne masti do postizanja novog stvrdnutog sloja protekne manje od 5 minuta. Iz toga se nameće i zaključak o potrebi kontinuiranog i brzog nanošenja otopljene bazne klizne masti po cijeloj dužini jednog

saonika radi dobrog razlijevanja i međusobnog kvalitetnog kontakta i vezanja međuslojeva i prijelaznih mjesta po dužini.

Zaključci

1. Postupak pripreme saonika, topljenje bazne klizne masti i njezino nanošenje predviđeni su Uputama o pripremi za porinuće koje treba odgovorno i striktno primjenjivati.
2. Uporabom nove bazne klizne masti uz pravilan postupak primjene nisu uočeni bilo kakvi nepoželjni efekti na uspješnost porinuća brodova.
3. Preporučena temperatura otopljene bazne klizne masti u kotlovima prije neposrednog nanošenja na saonik je:

   - u zimskom razdoblju od 110 ℃ do 125 ℃
   - u ljetnom razdoblju od 100 ℃ do 115 ℃

4. Mjerenjem je utvrđeno da je kod temperature otopljene bazne klizne masti u posudi za polijevanje od 85 ^{o}C do 90 ^{o}C došlo do korektnog međusobnog povezivana bazne klizne masti s površinom pripremljenog saonika, odnosno s prethodnim slojem bazne klizne masti.
5. Postupak nanošenja bazne klizne masti na saonik treba biti kontinuiran i brz, tako da se otopljena bazna klizna mast po cijeloj dužini saonika jednoliko razlijeva i slojeve međusobno kvalitetno veže. Slojevi ne smiju biti lisnatog oblika i adhezijski nestopljeni.
6. Nije utvrđen nepoželjan efekt nespajanja slojeva bazne klizne masti kod nanošenja pri vanjskim zimskim temperaturama od 4 ^{o}C pa na više.
7. Fizikalno-kemijska svojstva višekratno rabljene bazne klizne masti odudaraju od normom zadanih parametara i takvu baznu kliznu mast treba obvezno laboratorijski kontrolirati prije eventualne ponovne primjene. Moguća preporučena uporaba je za manje opterećene površine saonika.

ZAHVALA

Autori zahvaljuju na pomoći i susretljivosti prilikom primjenskih ispitivanja bazne klizne masti u brodogradilištima stručnjacima i dugogodišnjim djelatnicima hrvatskih brodogradilišta:

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FIELD TESTING OF BASE LAUNCHING GREASE AT SHIPYARDS

Abstract

For a successful launching of ships at shipyards, while preparing the ground way, a good quality base launching grease is necessary to prepare the rail before launching the ship into the sea. The grease's basic role is to even the slipway surface, take over the ship transportation and provide elasticity to the hull cradle and sliding ways surfaces. The placing of launching grease between friction surfaces reduces friction and enables successful launching of the ship along the slipway until it is launched into the sea. The importance of the quality of grease, as well as of a correct procedure of its application onto the surface, taking into consideration the conditions under which the procedure is performed, are highly significant and fundamental for a successful ship launching. Not strictly abiding by the recommendations of the base launching grease manufacturer, as well as those by experienced shipyard experts, may cause problems at ship launching, especially today, when the load of dry sliding ways increases rapidly due to growingly large ships. The most recent ships built in Croatian shipyards, with loads of up to 50 tons per square meter on the slipway, came as an incentive to the local base launching grease manufacturer to perform field tests involving procedures of using and treating base launching grease at shipyards.

The present paper provides an insight into various operations while applying base launching grease at shipyards, as well as into changes observed and measured when applying the grease under different climatic conditions. It furtherly provides the results of monitoring the physico-chemical properties of the grease, and finally, in the conclusions, attempts to point out the important properties in the utilization and handling of base launching grease.

1. Introduction

The issue of lubricants is, when it comes to ship launching, a most serious issue as growingly large units are being built on dry ground ways. While, until the 50s of the past century, lighter hulls were being built, the launching was safe enough by using natural grease for ground ways lubrication (natural tallow). Today, two types of specialty mineral greases are used for launching. The first layer is the base launching grease with the capacity of sticking to the wood, for the purpose of

evening the ground way (slipway) and cradle (hull carrier) surface, taking over the ship's transportation, and providing elasticity to sliding and friction surfaces. The second layer is the launching grease, reducing friction and enabling a successful sliding of the ship on the hull carrier down the slipway until its first encounter with the sea.

Successful building of ships whose hull weight and length are on the very border of dry slipways' capacities – since the largest ships are built at dry docks – puts Croatian shipyards to the very top of the world's naval construction. The tendency is to build into the hull – while the ship is still on the slipway – as much interior equipment as possible, because it facilitates and speeds up the ship's completion in the port of shipment, before its delivery and acceptance to the new owner. According to the available data, at launching (depending on the actual size), the ship's weight is over 25,000 tons (including ballast in the stern necessary for launching). When it comes to larger ships, at the beginning of launching, load distribution on the slipway ranges from some 10 tons/m^2 in the bow to 50 tons/m^2 in the stern. When the stern reaches the sea, owing to the buoyancy, it starts floating. At that point, the entire load is taken over by the bow part of the slipway – the cradle, while the forces acting on launching surfaces multiply considerably, causing short-term peak loads of up to 200 tons/m^2.

The launching itself is the most critical part in a ship's life, since, in normal exploitation, it is never exposed to such stress or risk. From the moment it starts moving down the slipway until the moment it starts sailing, the ship is, as it were, on its own – it cannot be influenced or controlled in any way whatsoever. That is why all calculations and preparations need to be performed thoroughly and meticulously, in order to try and avoid any possible trouble causing enormous financial and other difficulties. In order to reduce the risk as much as possible, lubricants need to meet stringent quality criteria and be carefully prepared, with a close co-operation between shipyards and lubricant manufacturers.

Correctly selected greases, as well as the manner of their application, are important elements in the totality of preparations preceding the ship launching itself. In this sense each launching is preceded by a plan with strict instructions and elaborate procedures on grease application. This refers in a special way to the preparation of the slipway and hull carrier surface; preparation – melting of the base launching grease, its manner of application, temperature, layer thickness, control, and the like. Also, depending on the slipway properties (length, inclination, curve, support), as well as various grease application details, there are differences among the respective Croatian shipyards.

In the course of 2003/2004, a Croatian shipyard was facing problems with the application of lubricating greases for launching. After launching, the appearance and condition of base launching grease on the slipway was not as expected (Figure 1). Layers of the base launching grease were chipping and separating, rightfully raising the issue why is this so and what can be done in order to prevent possible heavier consequences i.e. to prevent the incident from repeating?

In order to further our so far co-operation, as well as based on the so far positive experience in applying our base launching grease, with the involvment of experts from the all three Croatian largest naval yards, we have decided for a more active participation in resolving the issue.

In further text we shall be considering only issues regarding the application of base launching grease. We shall explain slipway preparation; preparation and application of base launching grease, as well as present the results of measurements performed during the observation of preparations in applying base launching grease on the slipway surfaces at Croatia's three largest shipyards; values obtained by testing the physico-chemical properties of both fresh and used base launching greases, and conclusions in terms of recommendations for a further, even more successful application of the locally produced base launching grease.

2. The base launching grease

Lubricants from which, through further procedures, base launching greases are produced for the launching of ships, are produced at refineries the technological procedures of which enable the obtaining of several types of paraffinic hydrocarbons. They are compounds of crystalline or amorphous nature, with high melting point (above room temperature), water-resistant and consistent in terms of being able to ensure the bearing layer of the grease. INA's Base launching grease has excellent bearing capacity, high melting point, very good adhesion to wooden surface, excellent plasticity and resistance, as w7ell as consistence. Over 30 years of experience in producing this particular type of grease, as well as its successful application in our shipyards, and the major experience of the naval constructors, have confirmed its good quality and efficient application.

Table 1: Physico-chemical properties of INA's base launching grease

No	Physico-chemical properties	Unit	Test Method	Value
1.	Dropping point	°C	DIN 51801/02	58 – 62
2.	Oil content, max	% m/m	ISO 2908, ASTM D 721	15,0
3.	Penetration - at 16 °C - at 21 °C - at 27 °C - at 32 °C - at 38 °C	mm 10^{-1}	ASTM D 1321	 16 – 20 20 – 30 30 – 40 below 80 below 200
4.	Flash point, min	°C	EN 22592, ASTM D 92	200

Base launching grease is produced from three components with different properties:

– macrocrystalline paraffin with bearing capacity and high melting point,

- microcrystalline component, having not only bearing capacity, but also good wood adhesion, and
- oily component, reducing lubricant fragility at low temperatures and providing it with the necessary elasticity.

There are no special specifications that would determine the quality level of these products – except for the internal standard, there are no other regulations.

3. Procedure of preparation and application of base launching grease on the hull carrier slipway prior to ship launcing

Preparation of the hull carrier slipway before launching as a rule begins ca. one month before the launching date, although it may be said that preparations for a new launching begin immediately after the previous one is completed.

Depending on the season and the condition of launching grease after the previous launching, the decision is made whether the grease will remain or be replaced by fresh one. If its condition is satisfactory, while the next launching follows shortly and still within the same season, the slipway is protected by steel sheets over its entire surface, thus waiting to be used again. However, in some shipyards, the just used base launching grease is removed, after which the slipway wood is protected against mechanical damage in the same way in which it is done when the grease is saved as well. In order to avoid any risks, each launching is performed with fresh grease – if not entirely, at least in the part of the slipway exposed to the most load. The removed base launching grease is mixed with a part of the left over, degraded grease, after which it is managed in one of the two following ways: it is either discarded as waste, or – which is perhaps riskier, but also more cost effective – it is reused, after its quality has been checked, in the part of the slipway where load is not the highest. The accompanying laboratory and the experts' experience play a significant role in this procedure.

Before the base launching grease is applied, the slipway is checked for any irregularities or damage to the wooden support. The underwater part of ground ways is usually taken out and placed to dry and undergo preparations for a new launching. The base launching grease and launching grease are applied on that part of the slipway and it is restored to its position adjacent to the part above the sea just (a few days) prior to the launching. As regards the part of the slipway above the water, it is important to apply the grease after all other works on the hull are completed, in order to avoid any damage to the grease coat – until the hull carrier is secured.

The condition of the slipway surface – especially the cleanliness and humidity of the wood – are extremely important for a successful coating. Impurities, remains of the used launching grease, and uneven parts of the surface are being removed. It is advisable to determine humidity and, if necessary, dry the wood (using burners), afterwards removing the burnt part. If the humidity of the wood is too high –

according to some sources, if it is >15%, the grase may not penetrate properly into the wood or adhere to it firmly. If the already used base launching grease is kept on the slipway, the inspection includes checking its condition and establishing possible additional requirements in terms of preparing the surface for an additional layer of fresh base launching grease.

The preparation – melting of the base launching grease - needs to be performed as close to the actual application spot as possible. Grease melting is performed in specially prepared grease melting pots. It is important to heat the entire volume evenly i.e. not overheat it. The temperature of the melted grease should, according to the experience, range from 95 to 125 ^{o}C, taking into account also climatic conditions (summer/winter). This is important in order to maintain the accumulated thermal energy in the melted grease as a function of cohesive forces creation between the wood and the grease i.e. between grease layers when introducing a new layer. Temperature losses of the melted grease from the moment it is poured out from the grease melting pot to the moment it is applied on the slipway have to be as low as possible. This is especially important in wintertime conditions when the temperature of both the air and the slipway is low, while the previous layer also cools faster. According to the experience, the bottom air temperature at which it is still possible to apply the grease onto the slipway is ca. +5 ^{o}C. As regards low temperatures, even more dangerous are night temperatures following the base launching grease application, capable of causing more abrupt hardening of grease layers, as well as their splitting and separation. That is why the already applied base launching grease needs to be covered by protective insulation (sheets, planks, canvas, and the like). If we re-melt the already used base launching grease, we must know that it was scraped off the slipway and mixed with a part of the left over degraded grease, which impairs its overall properties, primarily in terms of melting point reduction, but also the introduction of impurities, sand, and so on, into the solution. When such grease is melted, crust inevitably appears and needs to be removed as much as possible. The sand on the bottom of the grease melting pot directly impacting heating conditions and subsequent grease application also needs to be removed. The presence of left over grease lowers the firmness and bearing capacity of the grease, which is why its use is not recommended in the part of the slipway with the heaviest load.

The application of base launching grease onto the slipway requires team work, in order to achieve speed, continuity and evenness, to obtain a compact and appropriate layer. Depending on the slipway's transversal and lateral inclinations, in order to avoid losses on the edges and obtain an even layer throughout the entire surface, soft brushes are used. The layer thickness is constantly compared to the strict instructions. It varies from the slipway top to the highest load spot from 8 – 12 mm. Excess grease poses no problems, except for being an unnecessary expense. The required thickness, of course, cannot be obtained by a single application (spreading) – it usually requires 4-5 layers.

When using slipway with base launching grease to be reused, apart from proper cleaning, additional pouring of the freshly melted grease is also needed in order to achieve smooth surface. The temperature difference between the old and the new layer must not be too high: if the fresh layer is too hot, the bottom layer will melt. If the melted base launching grease is below some 90^{o}C, the layers will not bond properly. The shipway sliding surface, as well as that of the cradle, is also coated by base launching grease, but it is used less and the grease does not need to be renewed so often.

The story about applying base launching grease for launching ends when the slipway is pulled in and the grease applied to the sliding surfaces, the hull secured to the sliding ways and the hull support removed prior to the very launching, when the entire ship weight is on the carrier. From that moment on, until the stopper is released and the ship slides towards the sea only to plunge in it, the grease plays the key role. And then it starts all over again – for some other ship!

4. Procedures and results of monitoring the preparation and application of base launching grease, and results of testing base launching grease samples

From September 2004 to March 2005, we were monitoring the preparation and application of base launching grease for the total of 5 launchings at Croatia's three largest shipyards. All launchings were successful, without any problems or inconveniences. Samples of both fresh and (up to several times) reused base launching grease were taken from the upper part of the slipway, as well as its bottom - the more loaded part. We monitored the achieved thicknesses of base launching grease, and establised its possible changes after launching. We measured temperature in the grease melting pots and temperature losses during transportation in buckets before pouring onto the slipway. Since they were mostly colder, the results need to be considered taking into account the ambiance temperature. However, it is our opinion that the winter months are more critical, which is why the data obtained are after all quite relevant.

The presence of laboratory employees and control services, as well as their active participation in the monitoring process, enables safety and quality of overall operation. Long-term experience, as well as the confirmed quality of the base grease, have so far been crucial for successful application. There have been no negative connotations regarding the so far application, while an occasional abnormality is not due to the grease's poor quality, but mostly to the human factor and not abiding by the properly elaborated Instructions accompanying every launching.

The preparation itself – melting of the base launching grease - is performed in open grease melting pots, heated by wood on open fire, where projected melting temperatures are difficult to achieve, especially if the already used grease mixed

with launching grease is melted. The melting of grease in closed grease melting pots is applied for heating with electric heaters. Grease melting by putting entire barrels (with openings made) into grease melting pots, with no control of temperature or heating intensity, may cause overheating and degradation of properties. This has been known to happen and may be substantiated by the overheating of the barrel paint. However, when grease taken out of the barrel is placed directly into grease melting pots, such cases have not been recorded.

When melting the already used base launching grease, it is probable that ingredients such as flint sand and other impurities, but primarily the remnants of the launching grease, will impair achievement of the projected melting temperature. The presence of foam has been established after application, while layer firmness is also reduced when applying used grease. We also assume that a poorer bonding of the used base launching grease with slipway wood partially results from the loss of the grease's adhesion properties.

Table 2: An example of the analysis of sampled base launching grease and launching grease blends taken from the grease melting pot at melting before applying on the slipway

	Sample 1 Used 1 x	Sample 2 Used 2 x	Sample 3 Used 2 x	INA Base launching grease (Standard)		
Property	Result				Unit	Method
Dropping point	57.0	51.0	54.0	58-62	°C	DIN 51 801-2
Oil content	6.27	32.94	34.72	max. 15.0	% m/m	ASTM D 721
Penetration - at 16 °C - at 21 °C - at 27 °C - at 32 °C - at 38 °C	 27 35 51 93 221	 89 99 117 127 213	 93 104 123 147 221	 16-20 20-30 30-40 below 80 below 200	 x 0.1 mm	 ASTM D1321 (mod)
Flash point	224	228	230	at least 200	°C	ASTM D 92

Note: Sludge (5-8% v/v) and sliding gear (20% v/v-sample 3) removed prior to laboratory testing

Samples of the base launching grease were taken directly from grease melting pots during melting i.e. after application and solidification of the base launching grease on the slipway. They were analyzed at the laboratory of INA Maziva Rijeka. All temperature measurements were performed directly at shipyards, during the preparation and application of melted base launching grease on slipways. Grease temperature was measured in grease melting pots, and at pouring out into the buckets used for taking the grease to the slipway, while slipway temperature was measured before applying the base launching grease and after each layer. The paper presents tables of the base launching grease physico-chemical properties, as

well as diagrams resulting from characteristic temperature values in individual cases of handling the base launching grease.

Table 3: An example of the analysis of sampled base launching grease and launching grease blends taken after launching

	Sample 1 Used 1 x	Sample 2 Used 1 x	Sample 3 Used 3 x	Sample 4 used 3 x	Base launching grease (Standard)		
Property	Result					Unit	Method
Dropping point	58.0	54.0	54.5	54.5	58-62	°C	DIN 51 801-2
Oil content	3.15	19.82	12.35	10.90	max. 15.0	% m/m	ASTM D 721
Penetration - at 16 °C - at 21 °C - at 27 °C - at 32 °C - at 38 °C	 21 26 36 57 148	 51 62 81 110 306	 37 50 65 105 295	 35 45 61 102 282	 16-20 20-30 30-40 below 80 below 200	x 0.1 mm	ASTM D 1321 (mod)
Flash point	226	220	232	228	min. 200	°C	ASTM D 92

Note: Sludge (5% v/v) and sliding gear (2% v/v) removed prior to laboratory testing

Table 4: An example of the analysis of sampled base launching grease taken directly from the slipway

	Sample 1 Used grease (remained since previous launching - stern)	Sample 2 Used grease (Sample after launching - stern)	Sample 3 Used grease (Sample after launching - bow)	Base launching grease (Standard)		
Property	Result				Unit	Method
Dropping point	58.5	56.5	55.5	58-62	°C	DIN 51 801-2
Oil content	5.6	3,96	12.03	max. 15.0	% m/m	ASTM D 721
Penetration - at 16 °C - at 21 °C - at 27 °C - at 32 °C - at 38 °C	 26 34 48 76 198	 25 27 40 63 173	 36 45 60 95 247	 16-20 20-30 30-40 below 80 below 200	x0.1 mm	ASTM D 1321 (mod)
Flash point	238	224	226	min. 200	°C	ASTM D 92

It may be seen from Tables 2 and 3 that, after repeated application, the grease firmness, as well as the oil content, were considerably reduced with respect to the

standard. It is interesting that oil content is higher during melting, when the presence of the launching grease remnants is more pronounced, and that grease firmness increases slightly after launching. Namely, when melting grease before its application, the remains of launching grease and foam are removed to the extent possible. Drop point is lowered, but only with base launching greases reused more than once (1x).

Table 4. shows the good condition of base launching grease left on the slipway even after 6 winter months, confirming its stability if properly applied and protected. During summer months, the base launching grease would show different results?

Diagram 1: Change of penetration of base launching grease – Shipyard A

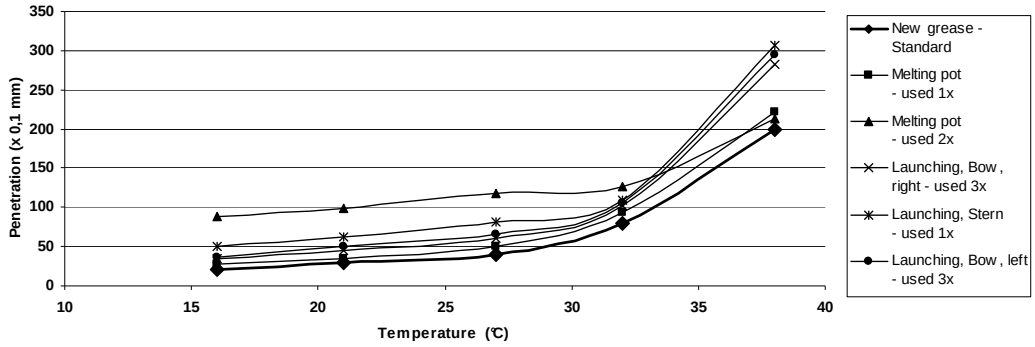
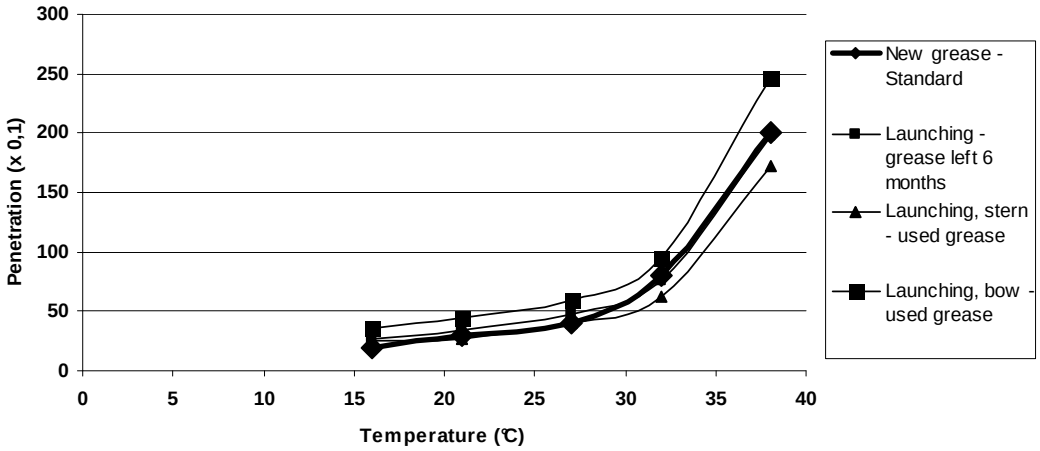


Diagram 2: Change of penetration of base launching grease – Shipyard B



It was to be expected that the impact of remaining launching grease in compound with base launching grease reduces solution firmness during melting for reuse. This is visible on diagram 1. (Shipyard A), where a difference may also be observed, depending on the fact whether the blend was (re)used once or twice. Twice used grease has higher penetration at lower testing temperatures, while, at higher temperatures, the difference is lost. On the other hand, the results of checking penetration of sampled grease taken from the stern i.e. bow of the slipway after launching, show firmness decrease, precisely in the area of higher testing temperatures (modified ASTM D 1321 method). Also, there are no major differences in the change of penetration value between grease used once or three times.

Diagram 2, for shipyard B, shows the interesting fact that penetration properties of used base launching greases do not change much and that they are more acceptable than the values of samples from shipyard A. Does it have anything to do with the way of melting (electrically heated grease melting pots versus those heated by open flame)? Or maybe with the thoroughness of removing launching grease from the previous launching already during scraping and better removal of the remains of launching grease, foam, sand and the like, during preparation and melting of the blend before its application on the slipway? We assume that there is also the influence of a better work and higher engagement of the control service – the shipyard laboratory - while controlling and preparing the already used base launching grease.

Diagram 3: Temperature change of base launching grease at melting (fresh and used base launching grease) and before application onto the slipway (heating: open flame)

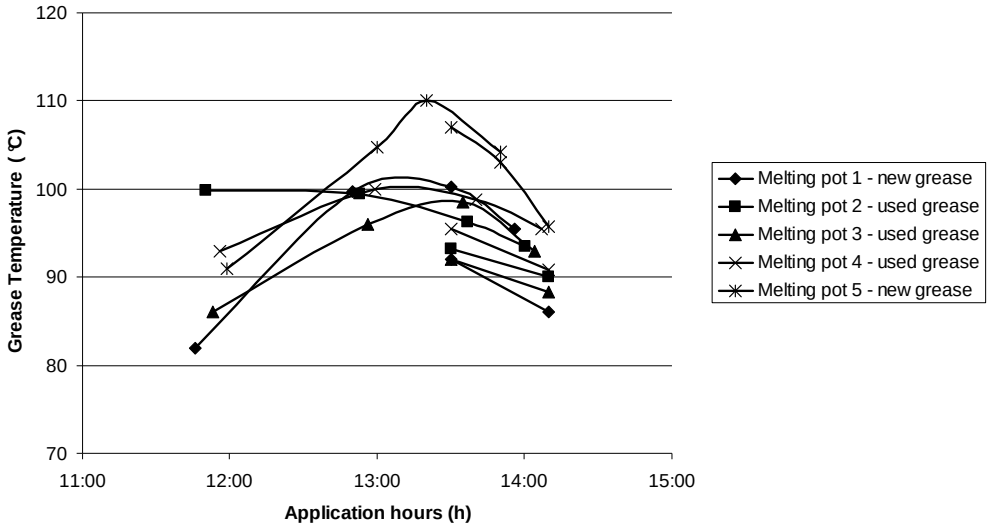


Diagram 3 shows primarily the difference in peak temperatures of the melted grease achieved, depending on whether it is fresh or used grease, and secondly, temperature decrease (Δt) of melted grease from heating completion to the moment when it is poured into the transporting receptacle and the moment of its application on the slipway. It has been established that used base launching greases with ingredients of used launching grease and sand in the grease melting pot cannot reach temperatures envisaged by Launching instructions at melting. Real temperatures of melted base launching grease at the moment of its application onto the slipway are below 95-100 ^{o}C. During our monitoring, only in one grease melting pot it was possible to achieve the temperature of melted fresh base launching grease of 110 ^{o}C, which means that other temperature losses are also higher. But even these numbers are below the envisaged ones. Taking into account in this case also the outside wintertime temperature during the melting and application of base launching grease of 4.4 ^{o}C (morning) to 11.5 ^{o}C (end of application), we must establish that there were no problems with the application of base launching grease: Layers and surfaces were correct, while slipway inspection after launching (after 17 days) discovered no undesirable or unexpected effects.

Diagram 4: Condition of base launching grease temperature at melting (electric heating, fresh grease) and layer temperature change on the slipway at application

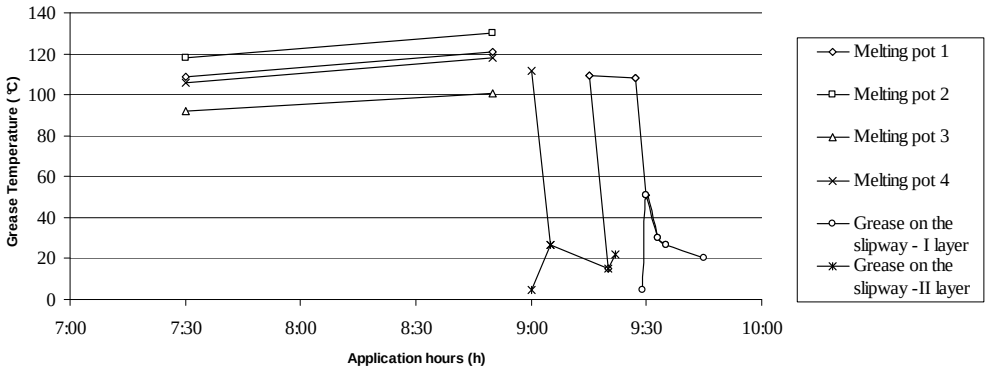


Diagram 4 shows temperature changes at melting of only the fresh base launching grease. Grease melting pots were heated by electric heaters, while outside temperature in the shadow was 3.7 ^{o}C (morning) to 5.1 ^{o}C (end of application of the base launching grease). It may be seen that the envisaged temperatures were indeed achieved. One may also observe temperature loss from the grease melting pot to the moment of pouring the melted base launching grease onto the slipway. The diagram also shows temperature change of the base launching grease in the receptacle until it reaches the colder slipway i.e. layer onto which the next layer is applied until further gradual cooling. Of course, everything happens quite fast, so

that it takes less than 5 minutes from pouring the hot melted base launching grease to achieving a new firm layer. This means that there is a need for a continuous and fast application of melted base launching grease over the entire slipway length for good pouring out and mutual good lateral contact and bonding of interlayers and transition spots.

Conclusions

1. The procedure of slipway preparation, melting of the base launching grease and its application, are stipulated by the Instructions for Launching Preparation which need to be abided by responsibly and strictly.
2. Using fresh base launching grease, with proper application procedure, did not reveal any undesirable effects on successful ship launching.
3. Recommended temperature of melted base launching grease in grease melting pots before immediate application on the slipway is:
   - in wintertime, from 110 ℃ to 125 ℃
   - in summertime, from 100 ℃ to 115 ℃
4. It has been established by measurement that at melted base launching grease temperature in the pouring receptacle of 85 ^{o}C to 90 ^{o}C there was a proper mutual bonding of the base launching grease with the prepared slipway surface i.e. with the previous base launching grease layer.
5. The procedure of applying base launching grease onto the slipway should be continuous and fast, so that the melted base launching grease is poured evenly onto the entire slipway length, establishing good quality bonds between the layers. The layers must not be “leafy” or not adhesive.
6. No undesirable effect of not connecting base launching grease layers was observed during the application at winter ambiance temperatures of 4 ^{o}C and more.
7. The physico-chemical properties of multiply used base launching grease deviate from the parameters set by the standard, which is why such base launching greases need to be controlled at a laboratory before their possible reuse. Recommended use in this case is for parts of the slipway with lighter loads.

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629.53.081.5	klizni premaz za porinuće broda	slip coat for ship launching
665.765.035.6	reološka svojstva mazivih masti	rheological properties of lubricanting grease
.004.58	praćenje stanja maziva tijekom upotrebe	condiotion monitoring
.004.58	održavanje prema praćenju stanja maziva	condition based maintenance
.004.86	gledište regeneracije za ponovnu upotrebu	regeneration for repeated use

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