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# Nova siva litina za transport staljenih Al-zlitin

# New Cast Iron Alloy for a Transport of Molten Al-Alloys

#### lzvleček

V tej študiji smo razvili, izdelali in preskusili nov material z analizo želene obrabne trdnosti, večje toplotne prevodnosti in bistvenim znižanjem stroška enote glede na obstoječe in pogosto uporabljane materiale (vroče obdelana orodna jekla) za brizgalni tulec pri procesu visokotlačnega litja.

Preiskovana litoželezna zlitina je bila preizkušena in podvržena realnim proizvodnim pogojem, poznejša ocena obrabe je bila opravljena na kritičnih površinah pod vplivom triboloških lastnosti.

Skupni proizvodni strošek za tulec, proizveden iz novega naprednega materiala skupaj z drugačnim pristopim k proizvodnji, je obsegal eno tretjino predhodno obstoječega in najpogosteje uporabljanega postopka.

**Ključne besede:** litoželezna zlitina, odporna proti visokim temperaturam, določitev lastnosti, mikrozgradba

#### ABSTRACT

In this study, we have developed, manufactured and tested new material, perusing preferred wear resistance, superior heat conductivity and notable decreasing the cost of the unit towards existing widely used materials (hot working tool steels) for shot sleeve at HPDC process.

Investigated cast iron alloy was tested and submitted to a real production conditions, subsequently wear evaluation was performed on the critical tribologically effected surfaces.

Total production cost of the sleeve manufactured with a new advanced material, together with a different production approach has been reduced to only one third of an existing, most widely used one.

Key words: High temperature resistant cast iron alloy, characterization, microstructure

#### 1 Uvod

Ker ulitki iz zlitine na osnovi Al glede na prostornino in število proizvedenih enot močno vodijo pred ostalimi ulitki iz neželeznih zlitin, poteka zelo intenzivno raziskovanje, usmerjeno v sisteme visokotlačnega litija aluminija, ki pa ga je

#### 1 Introduction

Since AI based alloys castings are by volume and produced units leading significantly towards other nonferrous alloy castings, intense research efforts are focused towards AI HPDC systems and that is achievable mainly by the use of cold chambered HPDC machines.

mogoče izvajati predvsem z uporabo strojev za visokotlačno litje s hladnimi komorami.

Pri strojih za tlačno litje s hladnimi komorami vse od njihove uvedbe ni bilo pomembnejših prebojev v smislu oblike in delovanja. Omejitve omenjenega sistema in obstoječega materiala za livne komore (vroče kovano orodno jeklo, predvsem tipa H13) v proizvodnji litja na osnovi Al.

## 1.1 Novi material z izboljšanimi lastnostmi

V 70. letih prejšnjega stoletja so bile raziskovalne dejavnosti usmerjene v razvoj materiala, ki lahko prenese še višje temperature, do katerih večinoma prihaja v motorjih z notranjim zgorevanjem, izpušnih kolektorjih itn. Rezultat teh raziskovanj je danes zelo znana družina zlitin na osnovi SiMo in železa. Tip zlitina na osnovi SiMo je nodularna zlitina s feritno matrico in karbidno mrežo. Silicij (Si) zveča premensko temperaturo, pri kateri se avstenit pretvori v ferit in grafit, Mo delno združi in strdi medcelične regije s tvorjenjem karbidov, medtem ko med postopkom premene v trdnem stanju delci Mo precipitirajo okrog kristalnih meja<sup>3</sup>.

Za izboljšanje zlitine Si v smislu toplotne prevodnosti in lastnosti mehanskega stiskanja je namen tega dela razvoj zlitine z vermikularnim grafitom (Slika 1). Stiskalne sile, ki delujejo na livno komoro, so posledica širjenja livne komore, ko ta doseže delovno temperaturo, pri čemer orodje v enem delu in bat preprečujeta širjenje tulca. Strjeni grafit kot grafit v zlitini tipa SiMo bi moral blagodejno vplivati, saj bo med postopkom visokotlačnega litja deloval kot mazivo ter tako izboljšal stopnjo obrabe površine med livno komoro in batom. Po drugi strani bo prisotnost grafita izboljšala težave, vezane Cold chambered machine has not met any significant design and functional revolutions since its introduction. Limitations of the mentioned system and existing shot sleeve material (hot forged tool steels, mainly H13 type) in Al based casting production.

## 1.1 New Material with Improved Properties

During the 70s of the past century, research activates were focused at developing a material which can withstand the even higher temperatures, mainly obtained in the combustion engines. exhaust manifolds etc. Mentioned work resulted in a nowadays well-known SiMo family of iron based alloys. SiMo type of alloy is a ductile iron with a ferrite matrix and carbide network. Silicon (Si) increases the transformation temperature where austenite transforms to ferrite and graphite. Mo partly segregates and solidifies in intercellular regions, promoting carbides while during the solid-state transformation Mo particles precipitate around grain boundeies<sup>3</sup>.

To improve the SiMo alloy in terms of thermal conductivity and compression mechanical properties, the aim in this work was to develop alloy with vermicular type of the graphite (Fig. 1). Compression forces which acts on shot sleeve are the result of shot sleeve expanding after it reaches working temperature, where the tool in one part and plunger preventing the sleeve expansion. Carbon solidified as graphite in SiMo type alloy should be a beneficial, since it will act as a solid lubricant during the HPDC operation and will thus improve ware on the surface Shot sleeve-plunger. On the other hand, presence of graphite is going to improve issues related with dissolving Fe,

Sestava / Composition	Trdota / Hardness	Raztezek / Elongation	Uporaba / Applications
4-5 % Si	240 BHN max.	5 – 18 %	Toplotna odpornost do temperature 750 °C / Heat resistance up to 750 °C.
4 - 5 % Si, 0.5 - 2 % Mo	200 – 260 BHN	5 – 15 %	Toplotna odpornost do temperature 880 °C. Visoka temperaturna odpornost. / Heat resistance up to 880 °C. High temperature resistance.
4 - 6 % Si do / up to 2 % Mo	240 – 320 BHN	Up to 5 %	Toplotna odpornost do temperature 950 °C. Zelo visoka temperaturna odpornost. / Heat resistance up to 950 °C. Very high temperature resistance.
4 - 6 % Si, 2 % Mo, V, Ni do / up to 2 % Cr	> 300 BHN	Zelo krhko / Very brittle	Dobra toplotna odpornost. Odpornost proti obrabi pri visoki temperaturi. / Good heat resistance. High temperature wear resistance.

Preglednica 1. Razne sestave zlitine SiMo in njihove mehanske lastnosti glede na uporabo<sup>4</sup>

Table 1. Various compositions of Si-Mo alloy and its mechanical properties versus application<sup>4</sup>



**SI. 1.** Toplotna prevodnost grafita vzporedno z osnovno ravnino je večja kot pri pravokotni postavitvi. Nižja toplotna prevodnost je pri matrici izželezne kovine (Hasse, 1996).

**Fig. 1.** The thermal conductivity of graphite parallel to basal plane is higher than perpendicular. Lower thermal conductivity has a steel metal matrix (Hasse, 1996)

na topljenje Fe vsaj pri frakciji površine, kjer je grafit v stiku s staljenim Al.

V spodnji Preglednici so prikazane različne toplotne prevodnosti med različnimi metalografskimi sestavnimi elementi pri sobni in višji temperaturi. Ferit pri temperaturi 500 °C izgubi prednost toplotne prevodnosti glede na perlit, ta pa ohrani prednost tudi pri višjih temperaturah. Ker je naša uporaba omejena na temperaturo 500 °C, se zdi, da je ferit, obogaten s Se, ciljna at least in a surface fraction where graphite is in contact with molten Al.

In the table below, thermal conductivities between different metallographic constituents during room and elevated temperatures can be observed. At 500°C ferrite loses advantage in terms of thermal conductivity towards ferrite and takes over even at higher temperatures. Since our application is limited to 500°C, ferrite saturated with Si seems like a target

Metalografski sestavni del /	Toplotna prevodnost / Thermal Conductivity, W m <sup>-1</sup> °C <sup>-1</sup>			
Metallographic constituent	0 – 100 °C	500 °C	1000 °C	
Ferit / Ferrite	71 – 80	42	29	
Pearlit / Pearlite	50	44	40	
Cementit / Cementite	7 – 8	-	-	
Grafit / Graphite	-	-	-	
Vzporedno z osnovno ravnino / Parallel to basal plane	293 - 419	84 – 126	42 – 63	
Pravokotno na osnovno ravnino / Perpendicular to basal plane	84	-	-	

**Preglednica 2.** Toplotna prevodnost glavnih metalografskih faz železovih litin pri sobni temperaturi (Stefanescu, 2003)

**Table 2.** Thermal conductivity of main metallographic phases in cast irons at room temperature(Stefanescu, 2003)

sestavina za novo zlitino. Grafit znova igra vključno vlogo, ki je grafično opazna tudi na predhodni Sliki 1.

# 1.2 Toplotnokemična zaščita površine livne komore

Površina livnih komor je bila toplotnokemično zaščitena postopkom plinskega s nitridiranja in strjevanja. Ta postopek je bil izrecno razvit za livne komore, ponaša se z večjo difuzijsko plastjo, rezultat katere pa je večja odpornost proti obrabi, torni obrabi, ki povzroča zajedanje, utrujenosti, torni obrabi, ki povzroča nastanek kraterjev, in prijemanju. Po drugi strani je količina bele plasti omejena v čim večji možni meri, da se prepreči prenašanje trdih in krhkih materialov s površine zaradi močne abrazije in obrabe, do katerih prihaja med delom, naprej v livno votlino. Proces nitridiranja se izvaja pri temperaturi 510 °C in traja 30 ur.

Uporabljene metode določitev za materialov lastnosti SO bile optična (Olympus BX61, mikroskopija vrstični elektronski mikroskop SEM), energijsko spektroskopija disperzivna rentgenska (EDS-Jeol 5610), toplotna kapaciteta, toplotna prevodnost, trganje, preskušanje trdote, toplotna analiza STA, kompresijska

constituent for a new alloy. Graphite again plays the key role, which can schematically be seen also in a previous picture 1.

# 1.2 Thermochemical Surface Protection of Shoots Sleeve

Shot sleeve was thermochemical surface protected with gas nitriding hardening process. This process was developed particularly for shot sleeves and is resulting with greater diffusion layer, which promotes high resistance to wear, scuffing, fatigue, galling and seizure. On the other hand, amount of white layer is taken to minimum in order to prevent hard and brittle material to be dispatched form the surface due to intensive abrasion and wear during the working operation and taken further to a casting cavity. Nitriding process is performed of temperature 510°C for prolonged time of 30 hours.

Applied methods for characterization of materials were Optical microscopy-Olympus BX61, scanning electron microscope SEM/ energy dispersive X-ray spectroscopy/EDS-Jeol 5610, heat capacity, heat conductivity, tensile testing, hardness testing, STA thermal analysis, Compression toughness, Optical temperature measurement-FLIR, Rotating Disk-heat transfer. trdnost, optično merjenje temperature (FLIR), prenos toplote z rotirajočimi koluti.

### 2 Ocena in določitev lastnosti novega materiala

#### 2.1 Določitev lastnosti mikrostukture

Kemijska analiza nove, izboljšane vermikularne zlitine SiMo je bila opravljena z optično spektrometrijo, inducirana z iskrenjem, na belem strjenem vzorcu, rezultati so prikazani v Preglednici 1.

Iz Slike 3 je razvidno, da je mikrostruktura oz. sestavine analizirane zlitine predstavljajo v glavnem vermikularni grafit in kovinsko matrico, ki je v večini ferit. Zaradi visoke vsebnosti Si, počasnega

# 2 Evaluation and Characterization of a New Material

#### 2.1 Characterization of Microstructure

Chemical analysis of the new, improved vermicular SiMo alloy was performed on optical spark spectroscopy on a white solidified sample token, results show in a Table 1.

As we can observe from Figure 3 that microstructure, ingredients of analyzed alloy consist with mainly vermicular graphite and metal matrix, which is mainly ferrite. Almost no perlite is present due to high Si content, slow cooling rates during the casting process and heat treatment. Strength of the alloy comes from near 1 area. % carbides incurred from metastable eutectic.

С	Si	Mn	S	Cr	Cu	Р	Mg
3,02	4,62	0,293	0,005	0,176	0,055	0,014	0,023
Ni	Мо	V	Ti	Sn	AI	Bi	Fe
0,024	0,529	0,007	0,01	0,019	0,02	0,001	90,9

Preglednica 1. Kemijska sestava novega, izboljšanega materiala

Table 1. Chemical composition of a new, improved material



SI. 2. Termodinamični izračun, sestava iz Preglednice 1

Fig. 2. Thermodynamical calculation, composition from Table1

ohlajanja med postopkom litja in toplotne obdelave perlita skorajda ni. Trdnost zlitine izvira iz bližine območja 1. % karbidov, nastalih iz metastabilne evtektike.

Pri tipu zlitin SiMo se v kompleksni karbidi radi tvorijo tako v medceličnih prostorih kot vzdolž kristalnih meja. Visoka vsebnost Si in Mo izboljšuje dimenzijsko stabilnost železovih litin z zagotovitvijo skeleta karbidov, ki se razširi po kovinski matrici.

Napodlagi izračunov termodinamičnega ravnovesja (SI. 2) izračunane sestavine mikrostrukture sovpadajo z optičnimi mikrografi (SI. 3). SiMo type of alloys are prone to form complex carbides in the intercellular areas and as well along the grain boundaries. High Si and Mo content improves the dimensional stability of casted irons by providing a skeleton of carbides dispersed through a metal matrix.

From equilibrium thermodynamic calculations from fig. 2, calculated microstructure ingredients coincide with optical micrographs on fig. 3.

With the help of corresponding software analyses on optical microscope, graphite surface fraction area was determined to be 11,3 area.%. This information is important



**SI. 3.** Svetlobni posnetek vermikularnega železa HiSi in razvrstitev, pridobljena s paketom programske opreme.

Fig. 3. Optical macrographs of HiSi vermicular iron and classification obtained by software package.

S pomočjo programske opreme za analiziranje z optičnim mikroskopom je bilo ugotovljeno, da območje frakcije površine grafita zaseda 11,3 % območja. Ta podatek je pomemben, ker ga je mogoče neposredno povezati s stopnjo razprševanja Fe v zlitini Al.

Vse sestavine mikrostukture so bile opazovane in pozneje analizirane s spektroskopijo EDS za določitev kemijske sestave. Rezultati so predstavljeni na Slikah 4 in 5.

since it can be directly correlated to decrees
dissolving of Fe in Al alloy.

All microstructure ingrediants were observed and later analyzed with EDS in order to determine chemical compositions. Results are presented in Fig. 4-5.



EI. / Elt.	Linija /	Intenzivnost	Napaka	Atomsk./	Območje /	2
	Line	/ Intensity	/ Error	Atomic %	Conc	-
		(c/s)	2-sig			
Si	Ka	123,64	2,486	7,619	3,964	wt.%
Cr	Ka	26,39	1,149	0,673	0,648	wt.%
Mn	Ka	9,18	0,677	0,386	0,393	wt.%
Fe	Ka	1.749,95	9,354	90,599	93,712	wt.%
Мо	La	25,37	1,126	0,722	1,283	wt.%
			Skupaj / Total	100,000	100,000	wt.%
kV			20,0			
Kot menja	ive / Take of	Angle	35,0°			
Pretečeni dei, čas. / Elapsed Livetime			80.0			

El. / Elt.	Linija / Line	Intenzivnost / Intensity (c/s)	Napaka / Error 2-sig	Atomsk./ Atomic %	Območje / Conc	4
Ca	Ка	411,43	4,536	98,683	94,155	
Fe	Ka	21,77	1,043	1,317	5,845	wt.%
			Skupaj / Total	100,000	100,000	wt.%
kV			20,0			
Kot menjave / Take of Angle			35,0°			
Pretečeni dej. čas. / Elapsed Livetime			80,0			

**SI. 4.** Posnetek SEM referenčne strukture – novi material, območja EDX, označeno 1–5

**Fig. 4.** SEM micrograph of a reference surface - new material, EDX areas marked from 1 - 5.

EI. / EIt.	Linija /	Intenzivnost	Napaka	Atomsk./	Območje /	1
	Line	/ Intensity	/ Error	Atomic %	Conc	•
		(c/s)	2-sig			
Si	Ka	139,44	2,640	8,463	4,435	wt.%
Cr	Ka	11,90	0,771	0,282	0,274	wt.%
Mn	Ka	5,12	0,506	0,209	0,214	wt.%
Fe	Ka	1.782,77	9,441	90,757	94,560	wt.%
Mo	La	10,38	0,721	0,289	0,518	wt.%
			Skupaj / Total	100,000	100,000	wt.%
kV			20,0			
Kot menjave / Take of Angle		35,0°				
Pretečeni dej. čas. / Elapsed Livetime			80,0			

El. / Elt.	Linija / Line	Intenzivnost / Intensity	Napaka / Error	Atomsk./ Atomic %	Območje / Conc	3
		(c/s)	2-sig			
Si	Ka	230,26	3,393	14,031	6,116	wt.%
V	Ka	9,74	0,698	0,466	0,368	wt.%
Cr	Ka	36,04	1,342	1,778	1,435	wt.%
Mn	Ka	9,96	0,706	0,566	0,483	wt.%
Fe	Ka	819,13	6,400	51,794	44,893	wt.%
Мо	La	919,88	6,782	31,365	46,705	wt.%
			Skupaj / Total	100,000	100,000	wt.%
kV			20,0			
Kot menjave / Take of Angle			35,0°			
Pretečeni dej. čas. / Elapsed Livetime			80,0			

El. / Elt.	Linija / Line	Intenzivnost / Intensity (c/s)	Napaka / Error 2-sig	Atomsk./ Atomic %	Območje / Conc	5
Al	Ka	11,19	0,748	1,378	0,569	wt.%
Si	Ka	17,06	0,924	1,757	0,755	wt.%
Fe	Ка	260,60	3,610	18,439	15,766	wt.%
Co	Ka	835,95	6,465	69,751	62,937	wt.%
Srn	La	236,34	3,437	8,675	19,972	wt.%
			Skupaj / Total	100,000	100,000	wt.%
kV			20,0			
Kot menjave / Take of Angle			35,0°			
Pretečeni dej. čas. / Elapsed Livetime			80,0			



С





SI. 5. Posnetek SEM referenčne strukture - novi material, mapiranje EDX Fig. 5. SEM micrograph of a reference surface - new material, EDX maping

#### 2.2 Mehanske lastnosti

Preskusi napetosti in stiskanja ter meritve trdote so bili opravljeni na razsutem materialu, podatki o meritvah so predstavljeni v Preglednici 2. Ker glavno obremenitev in deformacijsko obremenitev pri livni komori predstavlja stiskanje, je bil opravljen preskus žilavosti za RT in visoke temperature do 600 °C. Rezultati so predstavljeni na SI. 10, vzorci so bili vzeti iz razsutega materiala od uporabljene livne komore in so imeli obliko valjev.

Iz meritev žilavosti pri stiskanju je mogoče sklepati, da nova zlitina ohranja zadovoljive kompresijske vrednosti do temperature 500 °C. Glede na to, da temperature v livni komori v delovnem okolju ne presežejo 400 °C, naj bi preučevani material zadovoljivo prenašal natezne obremenitve.



**SI. 6.** Tlačna trdnost novega materiala od RT do 600 °C v prirastih po 100 °C.

**Fig. 6.** Compression toughness of new material from RT to 600 °C, with 100 °C step

#### 2.3 Določitev toplotnih lastnosti

Meritve z diferenčno dinamično kalorimetrijo (DSC) so bile opravljene pri hitrosti segrevanja in ohlajanja 10 K/min. Iz

#### 2.2 Mechanical properties

Tensile, compression testing and hardness measurements were measured form the bulk material, data of the measurements is presented in table 2. Since the main stress and strain forces affecting the shot sleeve are compression in nature, compression thoughness test was performed for RT and elavated temperatures, ranging to 600 °C. Results are presented in Fig. 10, specimens were machined form bulk material of used shot sleeve and were in a shape of cylindres.

Rm [N/mm <sup>2</sup> ]	592
Rp <sub>0.2</sub> [N/mm <sup>2</sup> ]	466
A [%]	2,8
Trdota / Hardness [HB]	255

Preglednica 3. Mehanske lastnosti novega materiala

Table 3. Mechanical properties of new material

From compression toughness measurements it can be concluded that new alloy is maintaining satisfactory compression values till 500 °C. Since temperatures in shot sleeve during operational environment does not exceed 400 °C, it is expected that observed material should satisfactory withstand tensile loads.

## 2.3 Characterization of Thermal Properties

DSC measurement was performed with 10 K/min heating and cooling rate. From a thermograph on fig. 7, we can observe there are no phase and enthalpy changes appearing in a temperature range of shot sleeve working conditions; under 500 °C.



SI. 7. DSC krivulja s prikazom krivulje ohlajanja, 10 K/min

Fig. 7. DSC thermograph of a cooling curve, 10K/min

termografa na Sliki 7 je razvidno, da se pri delovni temperaturi livne komore do 500 °C ne pojavijo fazne in entalpične spremembe.

Toplotne meritve so bile opravljene na podlagi metode TPS, rezultati na podlagi različnih temperatur za novi materialu in kovano jeklo H13 ter rezultati na podlagi uporabljenih livnih komor in novega materiala so predstavljeni v Sliki 12. Očitno Thermal measurements were performed with hot disc method, results for various temperatures for new material and H13 forged steel and results form used shoot sleeve new material are presented in Fig. 12. It is obvious that new material has superior thermal conductivity properties at RT and elevated temperature. Increase is measured to be 2/3 higher in working



SI. 8. Meritve toplotne prevodnosti; novi, izboljšani material v primerjavi z jeklom H13.Fig. 8. Thermal conductivity measurements; new improved material-H13 steel

je, da ima novi material boljše lastnosti prevajanja toplote pri RT in višji temperaturi. Izmerjena razlika pri delavni temperaturi je za 2/3 višja pri novem materialu glede na orodno jeklo H13.

## 2.4 Nitridirana plast novega, izboljšanega materiala

Toplotno-kemični proces nitridiranja je bil izveden na livni komori, izdelanem iz novega materiala, saj je to standardni postopek pri livnih komorah.

Nitridirana plast je enakomerno razporejena po celotni površini ulitka, difuzijska dolžina pa sega v material pribl. 120 um globoko. Nekaj um bele plasti je tudi vidnih, plast pa je zaradi že omenjenih razlogov omejena na minimum.

Mikrotrdnost, povprečna vrednost treh meritev nitridirane plasti znaša 854,3 HVQ.5.

Koristi nitridirane plasti na novi zlitini niso očitne in ločeni prispevek bo obravnaval preskuse z izpostavljanjem nitridiranega in neobdelanega novega materiala visokim temperaturam in visokofrekvenčni toplotni utrujenosti. temperature ranges towards H13 tool steel material.

# 2.4 Nitrided Layer of a New Impoved Material

Thermochemical nitriding processes was applied on shot sleeve produced with new material since this is a standard procedure for shot sleeves. The nitrided layer is evenly distributed through all casting surface and diffusion length is extending to approx. 120 um deep into the material. Several um white layer is also visible and was limited to minimum due to already mentioned reasons.

Micro hardness, average of three measurements of the nitrided layer was  $854.3HV_{0.5}$ .

Benefices of nitride layer on new alloy are not clear and will be discussed on a separated paper, where nitrided and raw new material is going to be submitted to high temperature, high thermal frequency fatigue testing.



SI. 9: Površina nove livne komore po nidridiranjuFig. 9. Surface of the new shot sleeve, nitrided

# 3 Sklepi

Nov in napreden kompozitni litoželezni material je bil razvit in opredeljen z namenom poskusa nadomestitve kovanega orodnega jekla H13 vsaj v primerih, ko je potrebna manjša proizvodna količina.

Inovativen pristop k proizvodnji livne komore za zmanjšanje skupnih proizvodnih stroškov v čim večji možni meri in zvečanje izkoristka materialov smo dosegli s pomočjo proizvodne tehnologije ulitkov. Nadalje, smiselno je premisliti o uporabi litja v avtomatizirane livne stroje z uporabo jeder za zagotovitev votlin.

Livna komora. izdelan z drugim proizvodnim procesom in lit iz novorazvitih materialov, je bil preizkušen v proizvodnji z 20.000 cikli, pri čemer je bila določena tribološka obraba pri stiku. Novi materiali kažejo nižjo stopnjo topljenja Fe v topljenem temperaturah AI pri visokih (zaradi površinskega območja grafita), boljše lastnosti prevajanja toplote, enakomernejšo porazdelitev toplote in posledično manj deformacij zadovoljivimi elastičnih z mehanskimi lastnostmi glede na obstoječa kovana orodna jekla.

#### 3 Conslusions

New, advanced composite cast iron material has been developed and further characterized in order to try to replace a forged tool steel H13, at least where lower production quantities are needed.

Innovative approach to produce shot sleeve in order to minimize total production costs and increase material yield was taken by use of casting production technology. Further on, casting in automatic moulding machines with a use of cores to ensure cavities are worth considering.

Shot sleeve produced with alternative production process and casted with newly developed material was tested in a production at 20.000 cycles and tribological wear at contact was characterized. New material exhibits lower dissolution of Fe in molten Al at high temperatures (due to graphite surface area), superior thermal conductivity properties, more homogeneous thermal distribution and thus less elastic deformation with satisfactory mechanical properties towards existing forged tool steels.

# 4 Vliri / References

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