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Future Prospects for Foundry Technology

Povzetek

Nemška livarska industrija predstavlja okoli 5,5 milijona ton ulitih delov z vrednostjo skoraj 14 milijarde evrov. Približno 80 000 ljudi je zaposlenih v 600 podjetjih. Z veliko prednostjo je Nemčija vodilna država v Evropi, na svetu pa je četrta največja livarska proizvajalka za Kitajsko, ZDA in Indijo, skupaj z Japonsko. Da bi se lahko pojasnili izzivi v prihodnosti, je treba pogledati pomembna dejstva, zaslužna za uspeh nemške livarske industrije, ter tehnološki in organizacijski razvoj, ki je vplival na to. Predstavljeni bodo odgovori na vse glavne izzive. Začeli bomo s primeri uspešnega razvoja do sedaj:

- izboljšanje uspešnosti ulitkov v konkurenci izdelovalnih postopkov,
- izboljšanje okoljske varnosti izdelovalnih procesov in sonaravno obnašanje ulitkov v celem življenjskem ciklu,
- širjenje razvojnega partnerstva med livarji in konstruktorji za optimiranje stroškov v začetni fazi.

  To po logičnem zaporedju zahteva:

- vlaganje v razvoj in raziskave kot tudi v akademsko izobraževanje/usposabljanje ter stalno nadaljnje usposabljanje.

Summary

The German foundry industry represents approx. 5,5 Mio tons of cast components with a defined production value of almost 14 milliards €. Approximately 80.000 people are employed in 600 companies. With a big distance Germany is the leading Foundry nation within Europe and acts worldwide as the fourth-biggest nation following China, USA and India and equal with Japan. For an explanation of questions concerning future challenges it should be allowed to take a look at the important factors of success of the German Foundry Industry and which technological and organizational developments have affected these positive developments.

In the following we will respond to all main challenges, starting with examples of successful development until now.

- Improve the performance of castings in the competition of manufacturing processes.
- Improve environmental safety of manufacturing processes and sustainability of castings for the whole lifecycle.
- Expand development partnership of foundrymen and design engineers to optimize frontloading.

  In logical consequences it demands:

- investment in research and development as well as in academic studies/training and a continuous further training.

1. Izboljšanje uspešnosti ulitkov v konkurenci izdelovalnih postopkov

Ena od glavnih značilnosti je konkurenca na prostem trgu v okviru tržne ekonomije. Konkurirajo si ne samo podjetja, države, območja in delavci, ampak tudi posamezni proizvodni postopki pri izdelavi izdelkov.

Ulitki glede na svojo maso, funkcionalne značilnosti in cene stalno tekmujejo z različnimi proizvodnjami in materiali.

V primerjavi z deli, ki jih izdeluje kovinsko-predelovalna industrija, ulitki ohranjajo svoje mesto in celo večajo svoj pomen. V bitki za zmanjšanje mase izdelka prihaja do izraza tendenca prehajanja z ulitkov iz železove litine na ulitke iz lahkih kovin. Kovinske dele zamenjujejo deli iz sodobnih visoko trdnih kompozitnih materialov in polimernih materialov. Vendar lahko visoko trdne železove litine znova pridobijo izgubljeno področje uporabe.

Zaradi izboljšanja mehanskih lastnosti pri uporabi visoko trdnih železovih litin se

1. Improve the performance of castings in the competition of manufacturing processes

One main characterization is the free market competition within the market economy. Competition does not only take place between companies, countries and regions and among acting persons, but also between single production processes for manufacturing of product-parts.

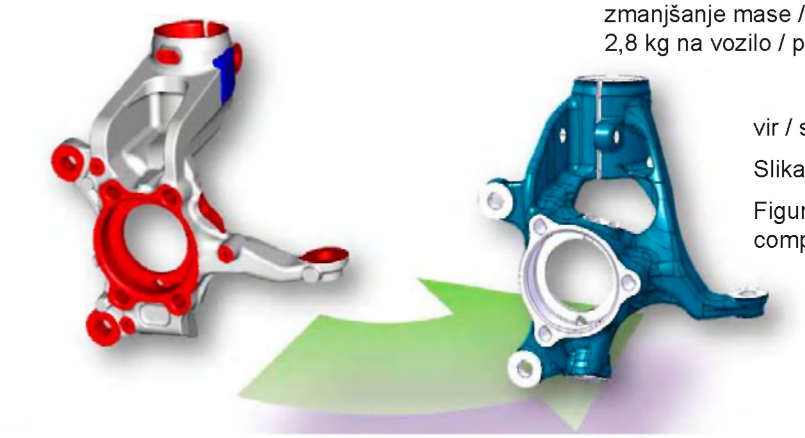
Castings are due to their weight, their functional characteristics and their prices constantly in competition with various productions and materials.

Compared with sheet forming parts casting parts have maintained their position and increased their significances. A trend from cast iron to light metal casting is being noticed due to fight on the light weight requirement section. Parts made of metal components had been replaced by modern high strength composite and plastic materials. Nevertheless, high strength

prej / before:
material / material: GJS 400
masa / weight: 4,4 kg

nato / afterwards:
material / material: SiboDur(R) 700
masa / weight: 3,0 kg

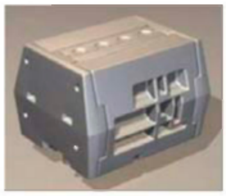
prednost / benefit
zmanjšanje mase / weight reduction: 32%
2,8 kg na vozilo / per vehicle



vir / source: GF Automotive

Slika 1. Teže komponent

Figure 1. Weight of component part

	klasična izvedba / conventional	lahka izvedba / lightweight	tankostenska izvedba / thin-wall
debelina stene / wallthickness	4.0 - 5.0 ±1	3.5+0,8	3.0 + 0.5
toleranca prereza / profile-tolerance	2,4	2	1,6
masa / weight	100%	85%	78%
material / material	GJL250/GJL270+	GJL250/GJL270+	GJL250/GJL270+/ GJV450
položaj vlivanja / pouring position	vodoravno / horizontal	vodoravno / horizontal	navpično / vertical
vstavljanje jeder / core assemby	ročno / manually	ročno / manually	paket jeder / corepackage
pokrovi forme / formcovers	4 zgibni / 4 fold	4 zgibni / 4 fold	4 zgibni / 4 fold
			

Vir : Železarna Brühl / source: Eisenwerke Brühl

Slika 2. Razvoj component

Figure 2. Development of a component part

lahko masa vrtljivega nosilca zmanjša za 32 %, kar pomeni 2,8 kg na vozilo (slika 1). S predelavo konstrukcije tega dela se lahko optimalno izrabijo vse izvrstne mehanske lastnosti novega materiala. Malo obremenjeni deli lahko postanejo tanjši.

Na sliki 2 se lahko vidi razvoj sestavnega dela ohišja zaganjalne ročice pri osebnem avtomobilu in razvoj postopka formanja ter ulivanja. Za klasično konstrukcijo s paketom jeder je bila v 70-tih letih značilna izdelava posameznih jeder in nato vstavljanje teh v formo, v 80-tih in 90-tih letih pa se je uporabljal že več ali manj popoln paket jeder. Končno so bila jedra zložena kot paket jeder, postavljen navpično v formo tako, da je bila forma kot enota pri transportu. Medtem ko se je s klasično konstrukcijo dosegala debelina sten 4-5 mm, se je z razvojem od klasične do lahke in tankostenske konstrukcije prešlo na debelino sten 3+0,5 mm. Masa sestavnega dela se je tako zmanjšala na manj kot 80 %.

casting materials could regain lost territory here.

(Fig. 1) Due to Improvement of the mechanical properties by usage of high-strength iron-cast alloys the weight of the component part of a swivel bearing could be reduced by 32% and therefore of 2,8 kg/vehicle. Reworking the design of the parts showed that all brilliant mechanical properties of the new material could be used in an optimal way. Weak stressed sections of the castings could be slimmed down.

In Fig. 2 you can see the development of a component part on a passenger-car crankcase und the development process of moulding- and casting. As the conventional core package design in the 70-ties was characterized by a single core production and by setting these single cores into the mould, the eighties and nineties showed a more or less complete core package. Finally cores are assembled to a core-package mould system with a vertically

prej / before:
material / material:
jeklena pločevina / steel sheet

nato / afterwards:
material / material:
aluminijev tlačni ulitek / aluminium die casting
masa / weight: 4,2 kg

prednost / benefit
zmanjšanje mase / weight reduction: 32%
14,5 kg na vozilo / per ve

vir / source: GF Automotive

Slika 3. Primer zamenjave jeklenega dela ploevine z aluminijevim tlačnim ulitkom kontrolneda

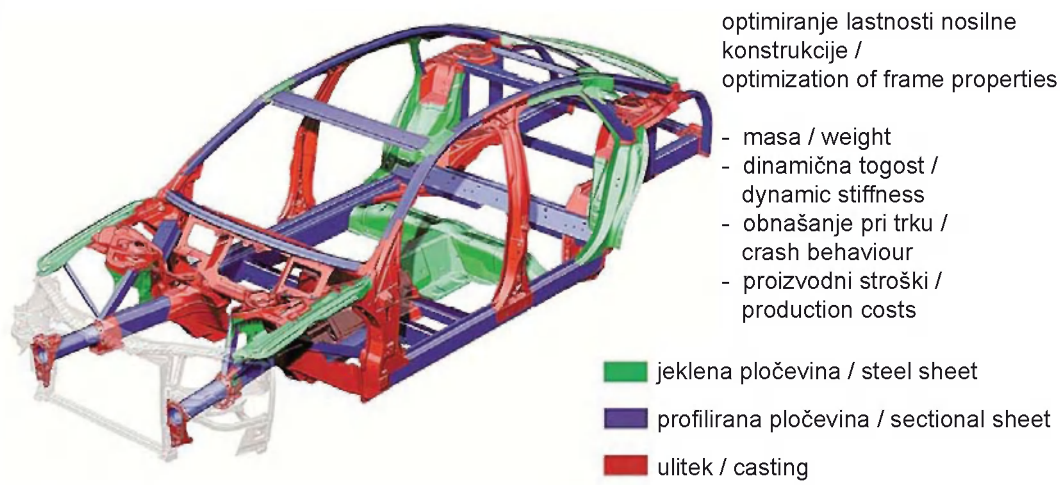
Figure 3. Example of substitution of a steel sheet part by an aluminium-die-casting of a control box

Istočasno je nadaljnji razvoj livnih zlitin od GJL 250 do GJV 450 v povezavi z manjšimi debelinami stene in manjšanjem mase omogočil povečanje moči motorja in končno zmanjšanje njegove velikosti.

Slika 3 kaže primer zamenjave dela stikalne omarice iz jeklene pločevine z aluminijevim tlačnim ulitkom. To je omogočilo zmanjšanje mase vozila za 14,5 kg in je lep primer prednosti ulivanja: ob primerni konstrukciji dela. Stalna debelina stene ni potrebna za ves del, kot pri izdelavi iz jeklene pločevine. Pri ulitku se lahko doseže okrepitev z debelino stene ali z rebri in niso potrebni dodatni dragi procesi sestavljanja. Vse te prednosti ulivanja zahtevajo prodorno oglaševanje na poslovnih tržiščih izdelovalnih postopkov. Postaviti pod vprašaj ustaljene rešitve naj bi bil izziv. Livarne so bolje pripravljene kot kdajkoli prej. Orodja za simulacijo (glej tč 3. tega prispevka) omogočajo ustvariti virtualne vizije in dajejo zanesljivost pri izbiri nadomestnih postopkov.

positioned core-package in the mould, reducing the mould to a transport unit. As with conventional design wall thicknesses of 4-5 mm could be reached, results of 3+/- 0,5 mm could be reached by these stages of development from conventional to lightweight towards the thin wall concept. The weight of the component part therefore reduced to below 80%. A simultaneously further development of casting alloys GJL-250 till GJV-450 in connection with less wall thicknesses and weight-reduction aimed in an increase of engine power, following the mainstream of downsizing.

Fig. 3 shows an example of substitution of a steel sheet part by an aluminum-die-casting of a control-box. This action enables a reduction of weight of 14,5 kg / vehicle. This shows a good example for the advantage of the casting method: an appropriate design of product parts. Constant wall thicknesses do not need to be carried along like metal sheet forming over the complete part. Stiffening and ribbings are produced in a single cast and do



vir / source: Audi

Slika 4. Primer ohišja vozila Audi A8

Figure 4. Example on a vehicle frame of an Audi A8

Slika 4 prikazuje primer nosilne konstrukcije avtomobila Audi A8. Uliti del (v rdeči barvi) je na mestu, kjer so posebne zahteve po mehanski odpornosti in togosti oz. duktilnosti, zamenjal druge izdelovalne procese. Prav tako se s ciljano uporabo ulitega dela zmanjša masa, izboljša obnašanje pri trku in zmanjšajo izdelovalni stroški. Ulivanje kaže svoje klasične prednosti glede svobode konstruiranja in primerne zasnove.

Sedanje rešitve z ulivanjem za izboljšanje delovanja, zmanjšanje mase in izboljšanje vzdržljivosti po zahtevah kupca bodo izzivi za prihodnost. Dodatno je treba uspeti pri zamenjavi različnih izdelovalnih postopkov, da se doseže na pameten način podpora kombinaciji ulivanja in lahkih kompozitnih materialov, kadar se zahteva posebna konstrukcijska trdnost in kompleksnost sestavnih delov.

Materiali, katerih sestava in lastnosti se spreminjajo po prostornini, sestavljeni postopki ulivanja in tudi prodor predoblikovanih delov je le nekaj

not need to be produced with additional expensive assembly processes. All these advantages of casting production processes require an offensive advertising on the business marketplace of production processes. To question well established solutions should be the challenge. Foundries are well prepared as they had never been before. Simulation tools – see chapter 3 of this lecture – generate such visions virtually and give secureness in decision processes for substitution.

Fig. 4 shows a next descriptive example on a vehicle frame of an Audi A8. The casted part (presented in red color) is in the position to meet the special requirements on mechanical resistance and stiffness respectively ductility and to replace other production processes. As well as weight, crash behaviour and manufacturing costs can be improved by targeted use of casted structural parts. Casting processes show their classic advantages towards freedom of design and suitable lay-out.

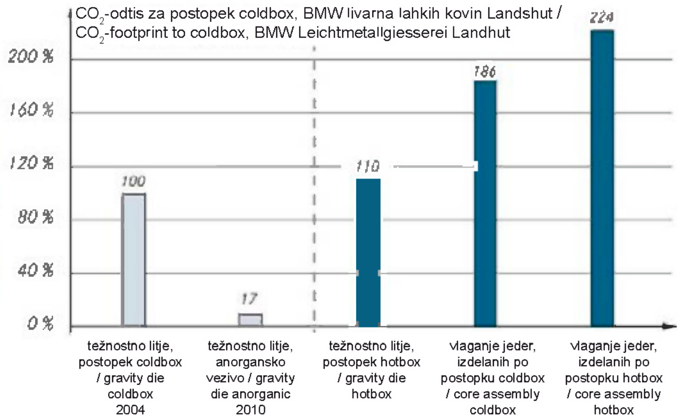
primerov, kam nas vodi razvoj, če moramo kombinirati lastnosti zapletenega dela, kot so temperaturna zanesljivost, trdnost, obrabna trdnost, trenjske lastnosti, dušilne sposobnosti in majhna masa.

2. Izboljšanje okoljske varnosti izdelovalnih postopkov in sonaravnost ulitkov v celotnem življenjskem ciklu

Naravne razmere pri litju, kot je uporaba sekundarnih surovin, veziv za jedra in forme ter tudi zelo velika poraba energije za taljenje ne prikazujejo litja kot vzor okolju in delovnemu okolju prijazne tehnologije. Kljub temu moderne livarne niso več kot nekdanje talilnice kovin, so čista podjetja, ki upoštevajo stroge delovne razmere in okoljevarstvene zakone. Moderne naprave za čiščenje zraka v delovnih prostorih

Future challenges will be now, to present casting solutions in improving performance, weight reduction and durability according to customer claims. Furthermore, we have to succeed in substituting in different production processes, to provide our support to combine casting technology with light composite materials in an intelligent way, if special structural strength and complexity of the components are required.

Gradient materials, compounded casting processes as well as infiltration of preforms are only a few examples of whereto the journey can go, if complex part properties like for instance temperature reliability, strength, wear resistance, friction properties, damping capability and low weight have to be combined.



- plini pri litju / casting gases
  produkti kondenzacije / condensation products
  količina odpadnih plinov / exhaust air quantity
  razvijanje smradu / odour emissions

- energija / energy

vir / source: ASK Chemicals, BMW Leichtmetllgiesserei Landshut

Slika 5. Pozitivni učinki pri uporabi anorganskih veziv v serijski izdelavi ulitkov v livarni lahkih kovin

Figure 5. Positive effects in usage of inorganic core binding materials

zmanjšujejo delovne obremenitve livarjev in vpliv na ljudi, ki živijo v bližini livarn. V spopadu z emisijami v sami livarni se je treba odreči organskim vezivom. V zadnjih letih je prišlo do več uspešnih poskusov pri razvijanju anorganskih veziv.

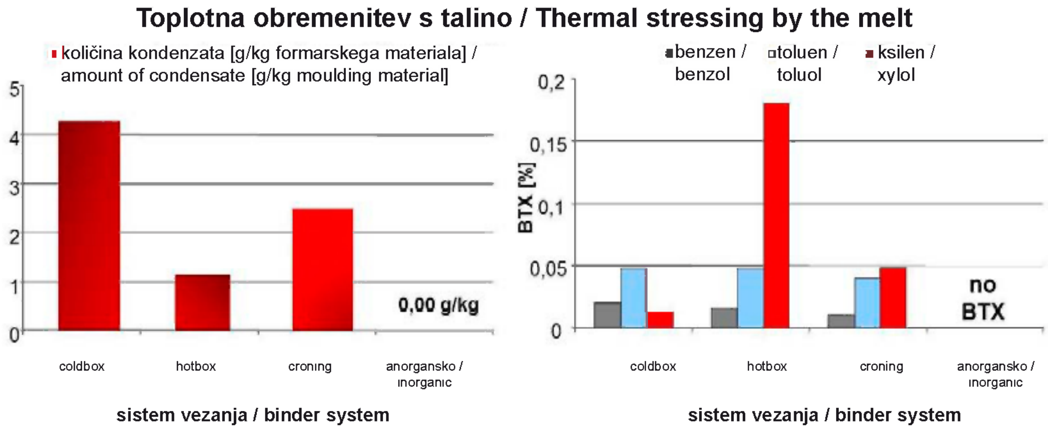
Slika 5 kaže pozitivne učinke pri uporabi anorganskih veziv v serijski izdelavi ulitkov v livarni lahkih kovin. Vidnih emisij plinov in dima ter sočasnega razvijanja smradu pri litju kot posledica uporabe jeder, izdelanih po postopku coldbox, ni več. CO_2-odtis celotne verige procesov skupaj s čiščenjem orodij in naknadne toplotne obdelave kaže izboljšanje v primerjavi s prejšnjim stanjem.

Slika 6 prikazuje zmanjševanje količine kondenzata v formarskih materialih s prehoda z organskih na anorganska veziva. Količina benzena, toluena in ksilena limitira proti nič.

Serijska vpeljava anorganskih veziv se je že začela. Izziv bo sedaj optimirati

2. Improve environmental safety of manufacturing processes and sustainability of castings for the whole lifecycle

The natural circumstances by casting like usage in scrap metal, core- and mould binding as well as extremely use of energy by melting do not place casting in a light of a workplace- and environmental friendly processing manner. Despite of this modern foundries are no archaic-seeming smelteries any more, however, they are clean companies which meet the strict working-conditions and laws of environment. Modern waste-air installations reduce the workplace-loads of foundrymen and reduce the impact to a minimum on persons living in the surrounding of a foundry. To combat the emissions of a foundry in the center, it requires a renunciation from organic binding materials. Many successful efforts had been



ni tvorbe kondenzata / no condensate build-up

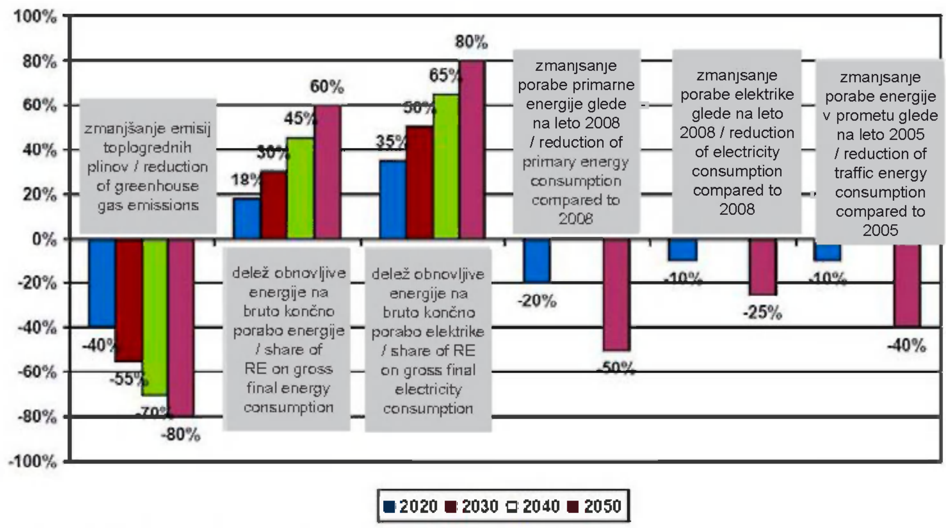
ni zaznavnih produktov pirolize anorganskega veziva za jedra / no detectible pyrolysis products of inorganic core binder

vir / source: Hüttenes-Albertus

Slika 6. Zmanjševanje količine kondenzata v formarskih materialih s prehoda z organskih na anorganska veziva

Figure 6. Reduction of quantity of condensate in moulding materials in comparison of procedures of organic to inorganic binding materials

Cilji boja proti podnebnim spremembam / Climate protection goals



Vir / source: IfG, Ecofys, Federal Environmental Agency

Slika 7. Cilji boja proti podnebnim spremembam

Figure 7. Climate protection goals

občutljivost za vlago in sprejemljivost za sisteme z mešanim in obnovljenim peskom ter spodbuditi preboj tega sistema tudi na litje železovih litin. Posebej pomembna je pri tem poraba energije. Stroški za energijo so glavni del stroškov livarskega procesa. Zaradi boja proti podnebnim spremembam, povezano s predpisi, to ni samo dodaten pritisk na prehod na energijsko intenzivne industrije, ampak predstavlja tudi bistveno odgovornost livarske industrije pri najpomembnejši nalogi, ki povezuje človeštvo, to je zaščiti življenja na tem planetu. Livarska industrija se ne bo izogibala tej odgovornosti.

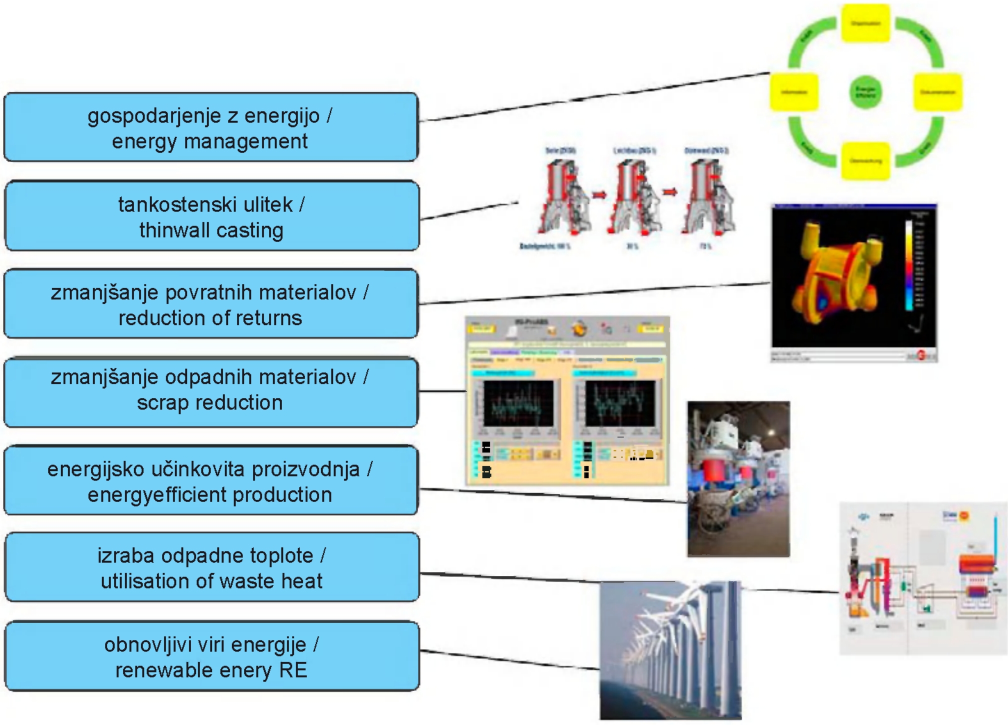
Slika 7 prikazuje cilje boja proti podnebnim spremembam v Nemčiji. Za izpolnitev teh ciljev ter zagotovitev varnega preživetja podjetja, so pripravljene številne interne akcije, katerih glavna in najpomembnejša naloga je uvajanje sistema gospodarjenja z energijo. Vsi

done within the last years by developing inorganic binding materials.

Fig. 5 shows the positive effects in usage of inorganic core binding materials in serial actions in alLight-metal foundry. Visible casting gas and smoke emissions and in connection with them combined odour pollution as a result of die casting with cold-box cores at working places do not adapt anymore. CO_2 Footprints of the total process chain including tool-cleaning and thermic follow-up treatment show the reached improvements of processes in comparison.

Fig. 6 shows the reduction of quantity of condensate in moulding materials in comparison of procedures of organic to inorganic binding materials. The quantity of benzene, toluene and xylene are regressing towards zero.

The serial introduction with inorganic binding materials has started. The challenge



vir / reference:IfG Ecofys, Umweltbundesamt

Slika 8. Uvajanje energetskega upravljalnega sistema

Figure 8. Implementation of an energy management system

naslednji omenjeni koraki bodo doseženi le z uspešnim uvajanjem te naloge (slika 8).

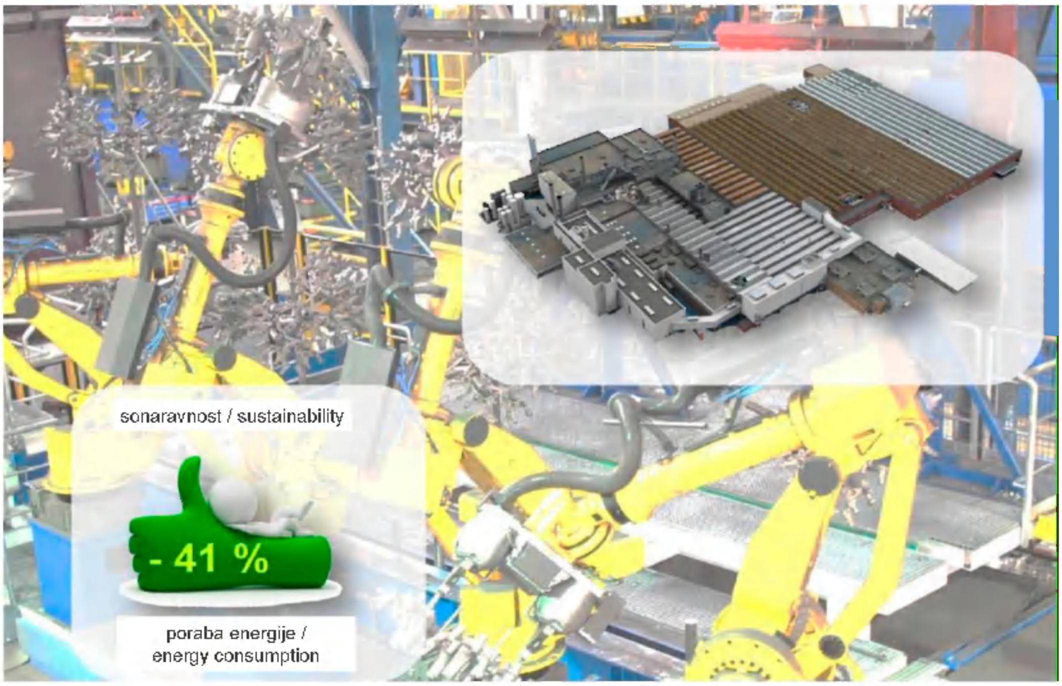
To kaže, da postaja posebna organiziranost livarjev, ki spominja že na rokodelstvo, posebno pomembna z vidika energijske učinkovitosti, tj. zmanjševanje povratnih materialov/povečanje učinka in zmanjšanje odpadkov.

Načrtovanje sodobnega izdelka, kot je tankostenski ulitek, dejavnosti za povečanje energijske učinkovitosti izdelovalne opreme in izraba odpadne toplote so cilji, ki bodo največ prispevali. Uporaba obnovljivih virov energije v livarnah je lahko le spremljajoč ukrep. Zgoraj omenjene mere za varčevanje z energijo je treba takoj intenzivirati.

Slika 9 kaže, da se je po uvedbi nove proizvodne linije za litje železove litine

now will be to optimize the moisture sensitivity and tolerability with mix sand and reclaimed sand systems and to encourage the breakthrough of this system also in iron-casting.

From particular importance for foundries is their energy consumption. Energy costs are a major factor in casting production costs. Due to the declared climate protection and therefore combined regulations there is not only an additional pressure of costs for this energy intensive industry, however, it implements the essential responsibility of the foundry industry for the most important task of the unity of humanity, the protection of life on this planet. The foundry industry will not withdraw this responsibility.



Slika 9. Energetski prihranek

Figure 9. Energy savings

zmanjšala celotna poraba energije za 41 %. Jasno se vidi, kaj je možno doseči v okviru celote.

Slika 10 prikazuje tisti vidik prednosti lahke konstrukcije, ki se tiče bilance CO_2 za celotni življenjski cikel in ki se ga ne sme zanemariti. **Opomba:** okoljsko prijazna izvedba je dosežena takrat, ko je zmanjšanje CO_2-emisije v času uporabe večje, kot so izpusti pri energijsko intenzivni izdelavi. **Sklep:** Ta argument se lahko uporabi tudi v obratni smeri. Energijsko intenzivni proces izdelave sestavnega dela, kamor spada tudi livarski proces, je upravičen, če je njegov cilj pozitivna celotna ekološka bilanca življenjskega cikla dela. Vsekakor je treba upoštevati celotno ekološko bilanco, preden se vrednotijo energijsko zelo intenzivna področja. Ni treba posebej poudarjati, da je o tem vidiku treba razpravljati politično. Toda to ne odvezuje livarn, da ne uvedejo

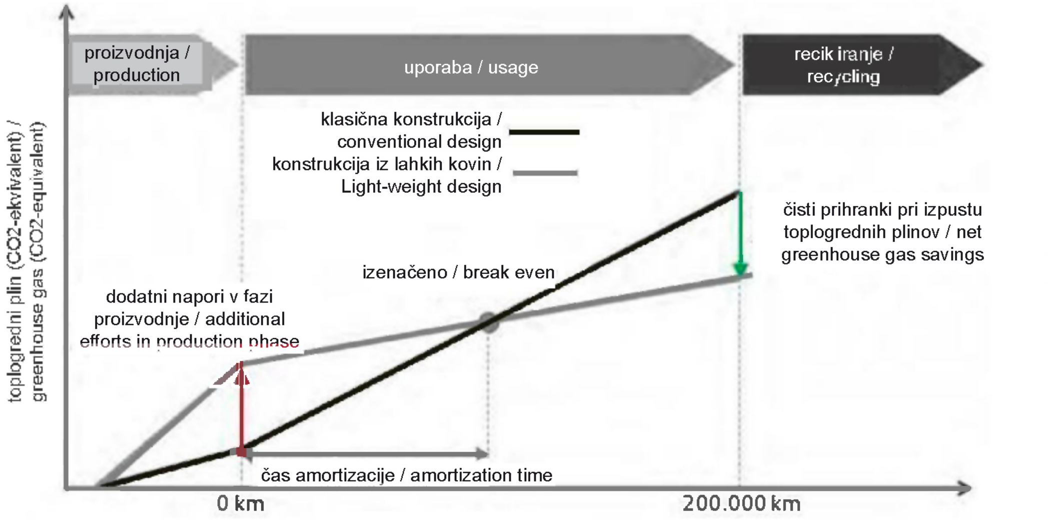
Fig. 7 reflects the climate protection targets in Germany. To fulfill these claims and to secure survivability of the company, many internal specific actions have been issued, which first and most important element is an implementation of an energy management system. All following mentioned steps will only be successfully implemented with its help (Fig. 8).

This shows, that special arrangements quasi the handcraft of the foundrymen, gets a more important meaning under the aspect of energy efficiency. I.e. reduction of returns / increase of output and scrap reduction.

Objectives out of modern product design like thin-wall casting, but even also actions to increase the energy efficiency of production equipments and utilization of waste heat will give a substantial contribution. Use of renewable energies in foundries is to be understood as

“Okolju prijaznejša konstrukcija se lahko doseže, če je izpust CO_2 v fazi uporabe manjši kot ekološka obremenitev energijsko intenzivne proizvodnje” /

“Environment lightweight design is only realised, if the saving of CO_2 in the usage phase ist higher than the ecological backpack of energyintensive production”



Vir / Source: Audi / VDI-lectires

Slika 10. Okolju prijaznejša konstrukcija ob upoštevanju CO2 bilance CO_2 za celotni življenjski cikel

Figure 10. Light-weight design concerning the issue „CO2-Balance Sheet of the total Life-Cycle

čim hitreje zgoraj omenjenih ukrepov za varčevanje z energijo.

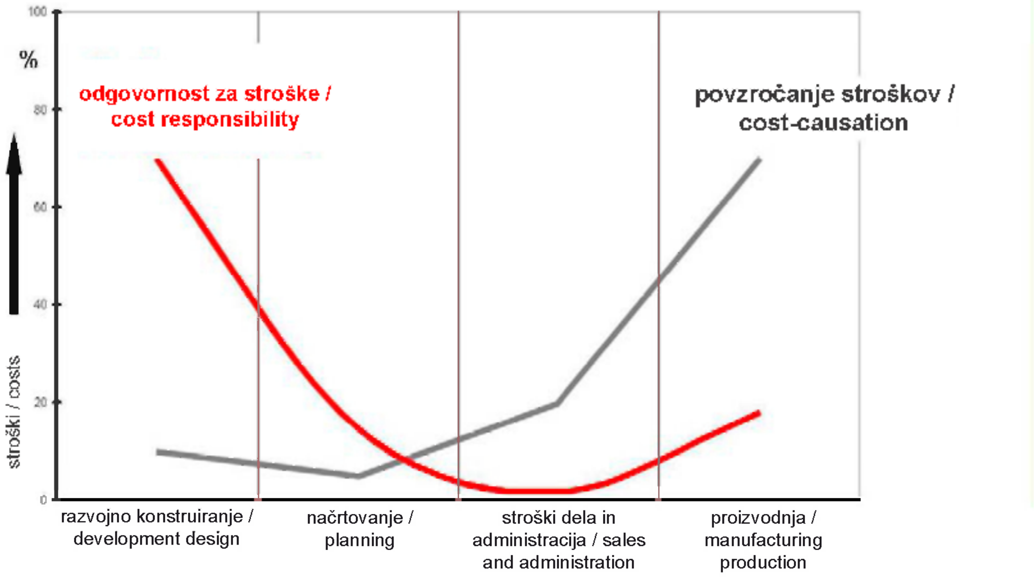
3. Širjenje razvojnega partnerstva med livarji in konstruktorji za optimizacijo začetne faze

Slika 11: Pri spremljanju posameznih faz nastajanja izdelka od razvoja do izdelave postane jasno, da velike stroške proizvodnje povzroča razvojna faza. Poenostavljeno, vse napake, ki so narejene v fazi razvoja, imajo velik vpliv na proizvodne stroške. To pomeni, da je treba vložiti več energije, sredstev in časa v fazo razvoja, da se izognemo tem negativnim učinkom.

accompanying measure. Potentials out of above mentioned energy-saving measures should be raised immediately.

Fig. 9 shows the total energy savings after taking a new iron-casting production-line in process with 41% less energy consumption in sum. It shows clearly, what in sum is possible.

Fig. 10 shows one aspect of light-weight design concerning the issue „CO2-Balance Sheet of the total Life-Cycle”, which should not remain unconsidered. Quotation mark: “environmentally light-construction will be only then achieved, if the savings of CO2 within the use-phase is higher than the ecological backpack out of an energy-intensive production” Unquote. This



Slika 11. Razširjeno razvojno partmerstvo livarjev in inženirsko konstruiranje za optimizacijo začetne faze

Figure 11. Expanded development partnership of foundrymen and design engineers to optimize frontloading

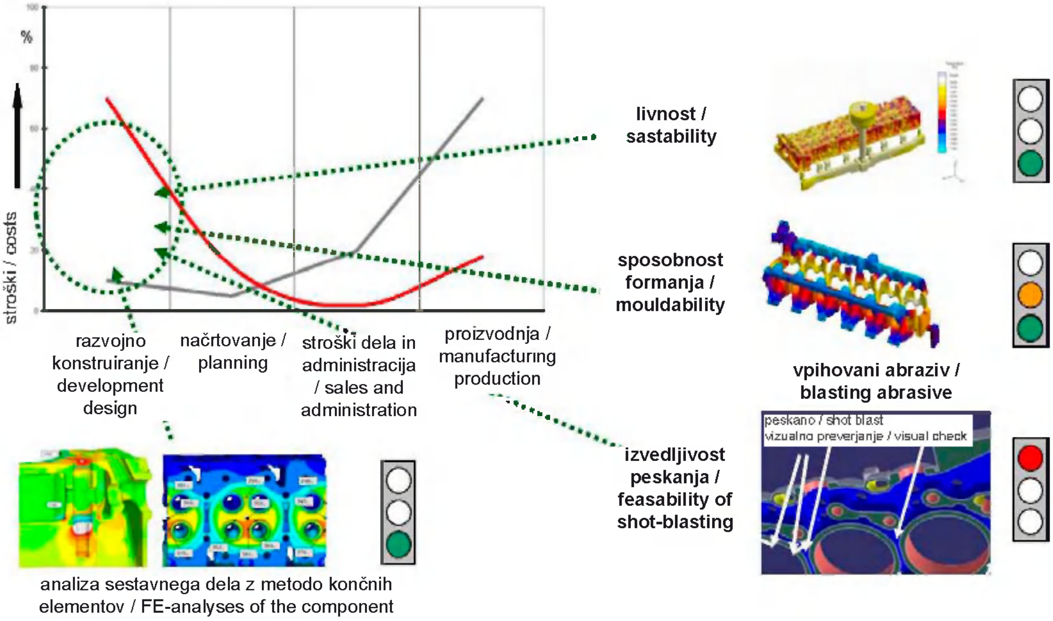
Livarne so dobro pripravljene. Zaradi intenzivnega sodelovanja med livarji in konstruktorji od samega začetka, obstaja možnost priprave primerne konstrukcije forme in ulitka.

Z orodji za simulacijo, ki so danes na razpolago, se livarji povezujejo z dobavitelji orodij in izdelovalci livarskih strojev ter postrojev, zato lahko razvijajo sestavne dele, pri katerih je tveganje v proizvodnji minimalno, s tem pa se zmanjšajo tudi proizvodni stroški. To se dejansko zgodi, še preden je izdelan prvi prototip. Na minimum skrajšani časi razvoja so rezultat tega. V praksi zato ne pride do predragih ulitkov in popravljanj ter tveganj, da se ne bi dosegli roki. Simulacije ulivanja in strjevanja so na tržišču dobro poznane. Simulacija izdelave jeder je razvita do popolnosti in uporabljena v mnogih primerih (slika 12).

argument, however, could also be used vice versa. An energy-intensive production – including the foundry process - which aims to a positive total ecological balance in the life-cycle of a part, is legitimate – even though to be favoured. Definitively the total ecological balance should be taken into consideration before extremely energy-intensive areas get charged in an extraordinary way. There is no need to say that such a view has to be discussed politically. But: It does not dispense the foundries of implementing above mentioned energy savings as soon as possible.

3. Expanded development partnership of foundrymen and design engineers to optimize frontloading

Fig. 11: By watching the single phases in product creation from development to



Slika 12. Simulacija izdelave jeder

Figure 12. Simulation of core production

Možnosti za napovedovanje razpada jeder in forme, kot tudi sposobnosti peskanja in čiščenja še vedno manjkajo. Izziv bo zapolniti to vrzel. V zaprtem krogu se lahko veliki stroški čiščenja ulitkov zmanjšajo na minimum pred začetkom proizvodnje, tveganja za investiranje pa se lahko zmanjšajo pri peskanju zapletenih ulitkov. Proizvodni stroški celotne verige procesa ulivanja in s tem povezane investicije so na ta način predvidljive. Navidezne pentlje optimiranja v sodelovanju s konstruktorji ustvarjajo ulitke, ki se lahko izdelajo brez tveganj in z majhnimi stroški. Realizacija te vizije bo velik izziv v prihodnosti na tem področju.

production it gets clear that the high costs in production are caused in the development-phase. Simpler, all mistakes which had been made during development, have a great impact on production costs. Consequently, much more energy, costs and time should be invested during the stage of development to avoid these negative effects.

The foundries are well prepared. Due to intensive cooperation between foundrymen and design engineers as from the beginning, there is a possibility to take action for receiving an appropriate mould- and casting design.

With simulation tools which nowadays belong to the state of the art, foundrymen are in connection with their tool suppliers and foundry machines and plant manufacturers and therefore in a position to develop a component, which minimizes the risk of production and reduces production

4. Vlaganje v raziskave in razvoj kot tudi akademsko izobraževanje/ usposabljanje ter stalno nadaljnje usposabljanje

Vsi zgoraj omenjeni vidiki kažejo livarne v luči najmodernejših tehnoloških in proizvodnih obratov ter visoko razvitih postopkov. Te tovarne so realnost. Težko se jih primerja z zastarelimi nekdanjimi livarnami iz druge polovice prejšnjega stoletja in nimajo več nič skupnega s tistimi livarnami. Mehatronika, procesna tehnika, kemijska tehnika in računalništvo so dodani klasičnemu tehničnemu znanju o formanju in ulivanju. Virtualno delo zahteva posebno znanje ter zelo dobro izobrazbo in se ne more več brez tega.

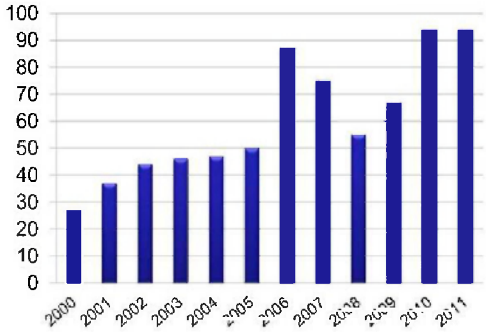
Za izpolnitev te zahteve, so potrebni dobro izobraženi delavci in tehniki s sodobnim tehničnim znanjem, ki ga daje optimalna univerzitetna izobrazba.

charges. This occurs virtually, even before the first prototype is made. Minimized times of development are the result and exhausting and cost intensive casting and correction loops and their implemented risk of deadline do not apply. Casting- and solidifying simulation are well established in the market. Simulation of core production has been developed to a maturity stage and has been introduced in many cases (Fig. 12).

Possibilities to forecast decomposition of core and mould of castings as well as the ability of shot-blasting and fettling is still missing in this queue. The challenge will be to close this gap. In a closed circle high fettling costs can be minimized prior to production and risks of investments can be reduced at shot-blasting of sophisticated castings. Production costs of the complete casting process chain and necessary investments are predictable in this vision.

Akademska izobrazba / Academic education

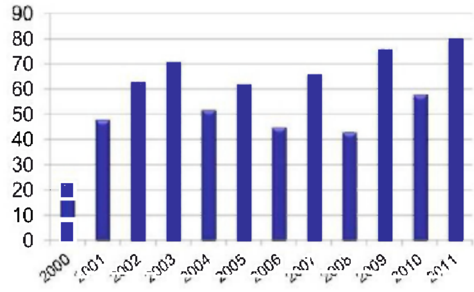
livarski inženirji / foundry engineers 2000-2011



vir / source: BDG

- približno 28 diplomantov je končalo dodatne študije: livarski inženir in diplomirani inženir na VDG-akademiji / Approximately 28 graduates finished the additional studies: Giessereifachingenieur (VDG) über die VDG-Akademie

livarska tehnologija za mojstre (preddelavce) / foremen foundry tehnology 2000-2011



vir / source: BDG

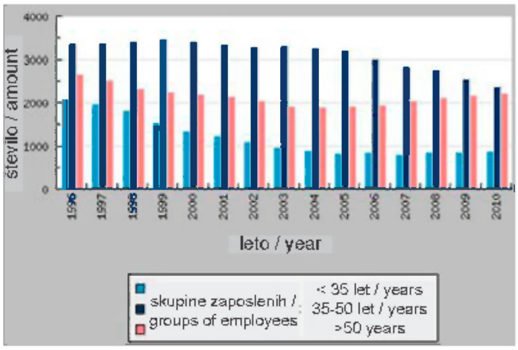
- v povprečju je končalo 60 udeležencev na leto / in average appox. 60 successful participants/year
- v povprečju približno 20 udeležencev z dodatno izobrazbo: livarski tehnik s spričevalom/ In average appox. 20 participants additional education: certified tehnician foundry technology

Slika 13. Razvoj izobraževanja strokovnjakov v nemški livarski industriji

Figure 13. Development of experts in the German foundry industry

demografske spremembe in pomanjkanje strokovnjakov / demographic change and lack of experts

rudarski, metalurški in livarski inženirji / mining, metallurgy and foundry engineers



- starost 50+ stalno narašča / age 50+ increases constantly
- predvideno staranje / forseen overaging
- pomanjkanje strokovnjakov bo naraščalo / lack of experts will increase
- zahteve po novih tehnologijah se bodo stalno večale / demand on new technology will increase more and more

Slika 14. Demografske spremebe in pomanjkanje strokovnjakov

Figure 14. Demographic change and lack of experts

Slika 13 kaže izobraževanje strokovnjakov v nemški livarski industriji. Ti visoko kvalificirani delavci bodo dvignili raven vrhunskih strokovnjakov v livarnah.

Za dosego teh ciljev je potrebna izvrstna infrastruktura na univerzah ter izobraževalnih centrih, kot je npr. v Nemčiji. V povezavi z močno in inovativno industrijo, ki dobavlja, in izdelovalci livarskih strojev ter postrojev se bo temu kos. Prihodnji projekti se bodo obravnavali uspešno. Programi raziskav in razvoja, ki jih obravnavajo vsi sodelujoči partnerji, kjer sodeluje in jih koordinira BDG, so osnova za visoko raven livarstva v Nemčiji.

Slika 14: Največji izziv v prihodnjih letih bo obvladovanje naraščajočih potreb

Virtual loops of optimization in cooperation with their designer generate castings which can be produced without risk and with low costs. To realize this vision is the big challenge for the future in this subject.

4. Investment in research and development as well as in academic studies / training and a continuous further training.

All above mentioned aspects show foundries in their lightning of most modern technology and production plants and highly developed processes. These factories are real. They hardly meet the archaic world of former foundries in the second half of the last century and have nothing in common with these former foundries anymore. Mechatronic, process engineering, chemicals and computing were added to the classic technical Know-How of forming and casting. Virtual work requires specific know-how and an excellent education and cannot manage without them anymore.

To meet these requirements it is necessary to have well educated specialized workers and technicians being on the actual stand of technic and an expanding stock of employees which received an optimal university education.

Fig 13 shows the development of experts in the German foundry industry. These highly qualified employees will force High Tech in foundries.

To reach all these aims it requires an excellent infrastructure at universities and education and training centers, as you can find them for instance in Germany. In combination with a powerful and innovational supplier-industry and foundry machineand plant manufacturers these subjects can cope. Future projects will be handled dobro izobraženega osebja, upoštevajoč demografski razvoj.

Bistvena bodo vlaganja v izobraževanje zaposlenih na eni strani in predstavitve livarske industrije kot prihodnjega privlačnega modernega zaposlovalca na drugi strani, bosta glavna izziva, s katerim se bodo soočile posamezne livarne. Teh nalog se bodo morale skupaj lotiti vse vpletene strani - od livarn, do dobaviteljev ter izdelovalcev livarskih strojev in postrojev.

successfully. Research and development programmes successfully handled by all partners involved and under coordination and in co-operation with BDG are the basis for this high casting level in Germany.

Fig 14: The greatest challenge within the upcoming years will be to manage the growing demand of well-educated personnel considering the demographic development. Substantial investments in education and studies of employees on one hand and presenting the foundry industry as an attractive modern working place for future employees on the other hand, is the central challenge, which each single foundry should face up with. These tasks should be lifted collectively from all involved parties in foundries, suppliers as well as machinery and plant manufacturer.