Technical session

Keynote speech

1. **Tibor Kvackaj, Professor PhD., Technical University of Kosice, Slovakia**
2. **Yoshiki Tsunekawwa, Distinguished Professor, Toyota Technological Institute, Japan**
3. **Xiong Shou-Mei, Professor Ph.D., Tsinghua University, China**

Session I. Advanced materials. Computer modelling and simulation

1. DEVELOPMENT OF ON-LINE CAE EXECUTION SYSTEM FOR SMART FACTORY

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These days, new revolutionary actions to improve the efficiencies of manufacturing start for factories in whole world, and they can be descripted by Industry 4.0 movement. Industry 4.0 includes many concepts to accomplish better factories, especially, smart factory concept is important section in them. The smart factory introduce the CPS (Cyber Physical System), IoT (Internet of Things) and IoS (Internet of Service) concepts. In this work, we developed the CAE execution systems to join CAE technologies with smart factory concepts. This system monitors the data gathered from manufacturing site in real time, and users can select the data-set to simulate through html-based user interface. To make this system, two separate services were developed, and each of them runs at local and server side to communicate.

2. RAPID DEVELOPMENT OF NEW CASTINGS IN OUR FOUNDRY BY SIMULATION TECHNIQUES - SOME INDUSTRIAL CASE STUDIES

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(Winner of the Soli Commissariat best technical paper award in 61st Indian Foundry Congress held in Kolkata in January 2013 & presented paper in 71st World Foundry Congress held in Bilbao, Spain in May, 2014)

This study reports an in house experience of the rapid development of new castings in our foundry by simulation techniques along with some industrial case studies.

This is also a detailed and step by step process of developing the export castings right from the tooling development to method and process standardisation by using 3D modelling software and casting simulation software.

To cope up with the stringent quality requirements of international customers, pilot samples are produced on computer screen to visualise and predict the defects which may occur in practical situation and taking corrective action and again verify the results. Until the model casting found defect free.

After that this method or process is implemented in practical situation under close observation of the process parameters.

Customer will no longer accept high levels of scrap, long lead time and so casting simulation become an industry standard to develop new casting in a short period of time with lesser number of trials.

In this paper the rapid development of American bogie- castings (side frame and bolster) as per AAR (Association for American Rail Roads) standards and development of some mining castings are described thoroughly with the help of simulation results and industrial case studies.

We have seen that in bogie castings which are box type constructions, hot tear defect is very common and serious defects which impair the soundness of the castings. Another serious defect is shrinkage at the junctions of ribs.

These two defects are well identified by using simulation and suitable corrective actions taken can be verified by simulation results.

Another serious problem in this type of steel casting is sand sticking defects at the bottom and corners of ribs or junctions.

Apart from that the cold shut at the pedestal leg or air entrapment at the bolster opening or pedestal leg areas can be easily identified and resolved by taking suitable actions with flow simulation results.

Apart from that the control of casting weight is another important factor for bogie casting. So, by designing suitable method to control weight and by proper design of core box and pattern and ultimately verify the casting weight by modelling software.

In mining castings produced for overseas customer, cold shut, air entrapment and scab defects can be easily solved by flow simulation and shrinkage defects by solidification simulation results.

With the help of simulation techniques it took only two weeks (only two trials) to make defect free bogie castings and similar time for each type of mining product.

So, good methoding practice adopted to eliminate potential defects in our steel foundry is well verified by simulation results.

Keywords: *Hot tear, Shrinkage, Air entrapment, Flow simulation, Solidification simulation, Cold shut, Pedestal leg.*

3. SIMULATION OF THE ENTIRE CORE MAKING PRODUCTION PROCESS

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A tool to simulate the core making process along with descriptions and applications of the core shooting, curing, and binder degradation models that have been developed have been presented. The three dimensional visualization of complicated physical processes provided by simulation is an extremely useful tool for analyzing and better understanding the effects of complex interactions between different process variables. Through core making simulation root cause analysis can be performed to eliminate or detect tendencies for core defects to occur.

The impact of tooling and process changes on the core quality can be evaluated without costly real world trials and the optimization of core box layouts and process parameters can be shortened and, thereby, costs can be reduced.

4. ALUMINIUM SAND CASTING GATING SYSTEM OPTIMIZATION VIA SYSTEMATIC USAGE OF CASTING PROCESS SIMULATION TOOLS

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Modern jobbing foundries have a strong requirement to achieve continuous cost reductions. Extensive trial and error approaches for new castings delay production, are cost intensive, and do not result in a

"right the first time" approach. While engaging in an autonomous optimization project on a real aluminium sand casting in high volume production, it was shown and proven that modern casting process simulation technologies can contribute significantly towards the reduction of trial and error runs, hence, providing extensive cost savings. The achieved time and cost savings using such technology - in this case through the geometrical optimization of a runner system - were significant. In addition, an optimal and robust process window was created.

Autonomous optimization is a modern tool fully embedded in state-of-the-art simulation technology and allows the casting expert to improve casting designs and processes further by exploiting boundary conditions and manufacturing efficiency. Robust process windows and continuous process optimization can be systematically implemented in a foundry operation.

This example of an optimization of a gating system for an aluminium sand casting is showing that a foundry - through using such innovative technology - can also improve its process knowledge through virtual experiments and is able to put this knowledge into practical solutions. That way process parameters and process conditions can be understood in a better way, with the aim to

improve them further. Numerical simulation in combination with autonomous optimization is, hence force, a very powerful tool for the pragmatic foundry expert and is becoming of prime importance.

5. THE EFFECT OF TITANIA ON LOWERING SINTERING TEMPERATURE AND PROPERTIES OF ALUMINA CERAMIC

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Study on the effect of TiO_2 content on Al_2O_3 ceramic properties is reviewed in this paper. The experiments were performed for ceramic samples of Al_2O_3-CaO-SiO_2-MgO system with an Al_2O_3 content of 96 to 98 %. TiO_2 of content 1 to 3 % was added to lower sintering temperature. The results showed that Al_2O_3 ceramic with 1 to 2 % TiO_2 may be sintered at 1500 and 1550 ^oC, and its mechanical properties satisfied application requirements for ballistic protection. Complex body armor made of Al_2O_3-TiO_2 ceramic and Kevlar composite has resisted 7.62x39 mm bullets fired from Russian Kalasnikov (AK47) rifle.

Keywords: *Ceramic, Sinter, Ballistic protection, Consolidation, Titania, Armor*

6. MECHANICAL PROPERTIES OF HIGH STRENGTH ZRO_2 ($3Y_2O_3$)-AL_2O_3 COMPOSITES PREPARED BY POWER METALLURGY METHOD

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Consolidation of Al_2O_3 containing various concentration of ZrO_2 with addition of 3 % Y_2O_3 (abbreviated as Al_2O_3-$ZrO_2(3Y_2O_3)$) solid solution powder with nanograin size is studied in the present work. Powder mixtures of Al_2O_3, $ZrO_2(3Y_2O_3)$ successfully precipitated by calcination route from $Al(OH)_3$ and $ZrO_2(3Y_2O_3)$ were placed in stainless steel die under uniaxial pressure of 250 MPa and then sintered at temperatures ranging in 2 stages: i) holding at 1150 to 1250 ^oC for 1 hour and ii) at 1550 ^oC for 1 hour. The relative density of sintered samples gradually decreased with decreasing ZrO_2 content after achieving the highest density (98.72 %) for 30% ZrO_2.
The microstructure of Al_2O_3-$ZrO_2(3Y_2O_3)$ composites was
observed on the fractured surface by scanning electron microscopy after breaking the sintere d samples. The phase identification was done using X-ray diffraction. High densification, have improved their mechanical properties.

Keywords: *Sintering, Density, Microstructure, Zirconia, Transformation toughness*

7. SYNTHESIS OF AL-ALN NANOCOMPOSITE BY LIQUID-REACTION ROUTE

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Al-AlN composite was synthesized in-situ by blowing nitrogen gas into liquid Al alloy with high content of magnesium. The important technological parameters such as reaction temperature and time, velocity and pressure of gas, etc. were considered and appreciated. The composite obtained with uniform distribution of fine AlN reinforcements can be used for elevated temperature applications.

8. MODELING OF CONTINUOUS RHEO-CASTING THE A356 ALLOY BY COMPUTATIONAL FLUID DYNAMIC (CFD)

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The computational fluid dynamic (CFD) modeling of continuous rheo-casting technology is aimed at manufacturing thin plates of aluminum alloy A356. The numerical simulation stabilizing time of the material crystallization was carried out by the ANSYS FLUENT code. The solidification and melting models with heat transfer and solid-liquid phase transition including latent heat of crystallization were simulated. The calculated temperature distribution and evolution also the cooling rate were examined and compared with hardness test in order to determine the semi-solid range - one determining factor for cast microstructure and mechanical property.

9. FINITE ELEMENT METHOD ANALYSIS OF SINGLE IMPACTS OF SPHERICAL PARTICLES ON FCD AND SCI

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Erosion is a phenomenon that damage the surface of material is removed by the particles impact. Erosive wear becomes a problem in pulverized coal injection system and rotating chute. In order to reach an aim of high safety and low cost, it's important to develop wear resistant material and to estimate of life service during erosion. According to research pertaining to erosion, three types of conditions are known to affect. The three type of conditions are particle condition, impact condition and impact material condition. Particle condition is particle hardness and particle shape. Impact condition is impact angle and impact velocity. Impact material condition is mechanical properties and structure.

This study investigated that impact angle dependently on erosive wear by Finite-element-method (FEM). LS-DYNA suitable for contact problems was used in this study.

Analysis conditions are shown below of specimens. Impact velocity of the particles was 20m/s. The contact time of the collision is 0.01ms. The dimensions of the impact material are 10 × 10 × 10mm. Impact material is a spheroidal graphite cast iron and spheroidal carbide cast iron. Spheroidal graphite cast iron was composed of spherical graphite and matrix. Impact particle was used spherical shaped steel shot with diameter 700μm. Impact angle was analyzed from 90deg. to 10deg..

For verification of the analysis result, a single impact experiments were conducted. The Correlation was obtained in result of experiment and analysis.

As a result of focused on equivalent plastic strain and Mises stress, The equivalent plastic strain and Mises stress of FCD was the largest at 60deg.. The equivalent plastic strain and Mises stress of spheroidal carbide cast iron wasn't difference at any of impact angle. Therefore, it's possible to test the efficacy of FEM analysis of impact angle dependency for high temperature erosive wear. In addition, the results of the analysis showed that spheroidal carbide could interfere with the distribution of equivalent plastic strain.

10. ANALYSIS OF SEVER PLASTIC DEFORMATION PROCESSES OF METAL AND ALLOY BY DISCRET SOLUTION METHOD AND DETERMINATION OF TECHNOLOGICAL PARAMETERS

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In this paper, method of discrete solution firstly is used to analyze process in equal channel angular extrusion (ECAE). Based on rigid block model of plastic deformation zone, it is modified upper bound solution in metalworking where numbers of rigid blocks increase infinitely allowing obtain more precisely solution. Determination of technological parameters as accumulative strain, hydrostatic stress, forces acting in contact surface, punch pressure and stress-strain states in plastic deformation zone taking contact surface friction between metal and dies were analyzed. Effect of friction force in formation of hydrostatic stress which creates special condition of processing and makes it become widespread is highlighted. Results of theoretical analysis reveal key aspect of sever plastic deformation technology and show that this method can be useful used for techniques design.

Key words: *discrete solution, slip line, upper bound, stress distribution, velocity hodograph*

11. INDIRECT REDUCTION OF IRON OXIDE BY CO GAS

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Iron oxide can be reduced to metallic iron by using solid carbon (direct reduction) and CO or hydrogen gas (indirect reduction). Indirect reduction of iron ore with by CO gas was investigated in this study. has been conducted. Total iron of the iron ore was determined as 65.84 %wt, and presented in hematite. Experimental work was carried out in a close system with controllable flux of inlet gas. The concentration of CO gas was adjusted at 60, 80 and 100%; the temperature was remained at 900, 1000 and 1100^oC; the holding time was 30, 60 and 90 minutes. Pellets of the iron oxide with diameter in the range of 12 ~ 14 mm was heated at 1200^oC and held for 2 hours. Specific area of the initial pellets was 0.199 m^2/g, volume of the voids was 0.001 cm^3/g and average diameter of the voids was about 16.872 A. This brought a positive condition for gas flux diffusion into the

pellets, thereafter speeded up the reduction rate of the iron oxide. The obtained results shown that factors as temperature, time and CO concentration affected the reduction degree and metallization of the heated pellets. It was concluded that optimal condition for indirect reduction of the iron ore pellets was 1000^{o}C, for 90 minutes and 80% of CO gas. At this condition, the reduction and metallization degree were calculated as 100 and 88% respectively.

Keywords: *reduction, iron ore, pellet, reduction degree, metallization*

12. EFFECT OF POLYVINIL PYRROLIDONE CONCENTRATION ON FORMATION OF SILVER NANOWIRES IN ANODIC ALUMINUM OXIDE TEMPLATE

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Scanning Electron Microcopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS) and X-ray Diffraction (XRD) were employed to characterize anodic alumina oxide templates and silver nanowires. The synthesis of silver nanowires by pyrolysis of $AgNO_3$ was realized in anodic aluminum oxide (AAO) templates at 170^{o}C for one hour. The fiber crystalline structure of silver nanowires was successfully prepared by reduction of silver nitrate in support of ethylene glycol (EG) and polyvinyl pyrrolidone (PVP).

By controlling the molar ratio PVP/$AgNO_3$ of 8/1, crystalline silver nanowires can be obtained while EG concentration is constant (6 ml/l). Dimension distribution of silver nanowires showed their best diameter and length of around (70÷80) nm and about 2 μm respectively.

Keywords: *Silver nanowires, AAO template, PVP/$AgNO_3$ ratio*

13. SYNTHESIS OF EU_2O_3-DOPED $CAALSIN_3$ FOR RED LIGHT-EMITTING PHOSPHOR

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Eu_2O_3 dopant with nitrogen gas instead of EuN directly was utilized. $CaAlSiN_3$: Eu^{2+} red phosphors with different concentration of Eu^{2+} addition were prepared by two-step solid state reaction process. The phase purity, morphology and particle distribution, and luminescence properties were investigated. Synthesized powders have a pure $CaAlSiN_3$ phase and consist of fine size particles. It showed a broad excitation band originating from UV region to 600 nm with centering at 450 nm, and indicated a strong emission peak at 645 nm. This phosphor showed chemical stability and low thermal quenching due to the rigid crystal structure of the host.

Keywords: *red-emitting phosphor, white LEDs, nitride phosphor, two-step solid state reaction*

14. APPLICATION OF MODEL OF PROCESS GRAIN REFINEMENT OF INHOMOGENEOUS POLYCRYSTAL MATERIALS IN TECHNOLOGY OF VIOLENT PLASTIC DEFORMATION

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Mathematical model of process grain refinement of inhomogeneous polycrystal materials explains formation of high angle grain boundary and creation of micropores. It has been used to study grain refinement and ductile fracture of metal and alloys by sever plastic deformation in equal channel angle pressing. Average grain diameter and porosity of metal have been got as function and permit to investigate influence of technological parameters on grain size refinement and ductile fracture. Technological parameters have been determined by finite element method, allowing to predict application, dies and tools.

Keywords: *model, grain refinement, polycrystal materials, plastic deformation, predict*

15. A STUDY ON RECRYSTALLIZATION OF ULTRA-LOW CARBON STEEL BY COOL TREATMENT

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Ultra-low carbon (ULC) steel contains less than 0.005%C wt of carbon and small amount of some other alloying elements.This steel has a good ductility, and is used to fabricate make many products which require a deep drawing quality. In practical, the cold-rolled cool treatment ULC steel needs to be annealed in order to remove residual stress and restore the initial ductility. Selection of temperature and holding time is very important for the next forming step. In this paper, ULC steels with various carbon contents were cold-rolled cool treatment in 90% of reduction and then annealed at 600^{o}C to determine microstructural evolution and changing in micro-hardness. Recrystallization ratio of the ULC steels during annealing was calculated from micro-hardness and John-Mehl-Avarami-Kolmogorov model (JMAK). The results show that the hardness of ULC steels was decreased when annealing temperature and holding time were increased. The reduction was dependent on chemical composition of ULC steels, and micro-alloying elements in the steel were significant to this phenomenon. Microstructure of ULC steels have changed from texture in the cold-rolled state to grains for ones which were dwelled in long time. At 600^{o}C, full recrystallization was completed in the ULC steels which were kept for 40 minutes; microstructure included the same size ferrite grains. However, kinetics of recrystallization for the cool treatment cold-rolled ULC steels must be study more clearly at higher temperature and longer holding time.

Keywords: *ultra-low carbon steel, recrystallization, annealing, ferrite, micro-hardness*

16. A STUDY TO DEVELOP NEW STEEL FOR HEAT POWER–STATION

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Internally pressured tubes are critical components in heat-exchanger applications, such as boiler water tubes, steam superheater elements and chemical plant reformer tubes. The conditions of temperature and time under which the failures occurred are deduced from the morphology of fracture and the changes in microstructure, and are correlated with the deformation mechanism and fracture mechanism for the tube materials. In this research, the microstructural evolution and properties changing of the P91 steels which was used for superheater tube in the coal power plant has been examined. Hardness and tensile test, optical microscopy were performed for the initial and failure steels. It was found that microstructure of the steel was changed with long-term use, thereafter failure time of the tube may be predicted. Further investigations and modeling is necessary to develop an optimized steel composition of advanced chromium steels.

Keywords: *superheater steel, microstructure, precipitation, hardness, tensile strength*

Session II. Cast irons and steels

1. EFFECT OF RARE EARTH CONTENT ON FATIGUE STRENGTH OF SPHEROIDAL GRAPHITE CAST IRON WITH THIN THICKNESS

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Spheroidal graphite cast iron is excellent in mechanical properties. Therefore, it is widely used in various purposes. In spheroidal graphite cast iron the rare earth is used to improve the mechanical properties. In this study, the effect of rare earth contents on fatigue strength was investigated.

Test specimen has rare earth contents of 0, 0.3, 0.5, and 2.0 %. For fatigue test is used the plane bending fatigue test machine. The stop condition of fatigue test is the 10^7 time repetitions or fracture of specimen. Fatigue strength is the load stress if the specimens were not fractured. As result of plane bending fatigue test, fatigue strength of the test specimens containing rare earth was about 307 MPa. Fatigue strength of the test specimens without rare earth was 293 MPa, decreased 8 % as compared to that of specimens with rare earth. We discussed the factors that decreased the fatigue strength from fracture surface observation of the test specimens. As a result, casting defects were observed in the fracture surface. According to the area parameter model for casting defects, the stress intensity factor ΔK and threshold stress intensity factor ΔK_{th} were evaluated. As a result, the difference between the ΔK and ΔK_{th} increased for the test specimen without rare earth, that's why its fatigue strength is lowered.

The test specimen without rare earth ~~is~~ has less nucleation effect of graphite than the rare earth containing test specimens. Therefore, the graphite reduced expansion pressure due to the volume expansion when crystallized, that the casting defects are suggested of large size.

Keywords: *spheroidal graphite cast iron, rare earth, fatigue strength, casting defect, area parameter model, stress intensity factor*

2. EROSIVE WEAR CHARACTERISTICS OF AFTER HEAT TREATED MULTI-COMPONENT CAST IRON CONTAINING CR, V, MN AND NI

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High chromium cast irons, spherical vanadium carbide cast irons and multi-component white cast irons are used as wear resistant materials recently. They are extremely expensive because of the addition of Cr, Ni, Mo, V and W, etc. It's expected to reduce costs by suppressing the addition of these elements to develop an inexpensive wear resistant material.

In this study, erosive wear characteristics of 9 kinds of multi-component cast irons with varying vanadium and chromium content (10, 7.5 and 5 wt.% V with 0, 4.5 and 9 wt.% Cr) were investigated. The multi-component cast irons were after heat treatment (air cooling after holding at 1043÷1253 K for 7200 s). The solid particle erosion tests were conducted using irregularly shaped steel grits of 770 μm, 810 HV with impact angles between 30 ° and 90 ° and a particle velocity of 100 m/s. Microstructure, Vickers hardness, EDS and XRD were undertaken to analysis the results.

It has been found that 5V-9Cr, 7.5V-9Cr and 10V-9Cr showed good erosive wear resistance. In particular, with the increase of chromium content, erosion rate and impact angle dependence were decreased. This is because the residual austenite in the matrix changed into martensite by strain-induced transformation effect. Furthermore, 5V-9Cr with less impact angle dependence and excellent erosive wear properties can reduce the amount of expensive vanadium which makes the production cost reduction possible by increasing the amount of relatively inexpensive chromium.

Keywords: *erosive wear, heat treatment, multi-component, cast iron, residual austenite, work hardening*

3. HIGH TEMPERATURE EROSIVE WEAR CHARACTERISTICS OF HIGH CHROMIUM CAST IRONS

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This study investigated the effect of chromium content and heat treatment conditions on erosive wear of high chromium cast irons at 1173 K. The specimens of erosive test were containing 12, 17, 22 and 27 wt% chromium. Furthermore, as-cast specimens and heat treated one were prepared (abbrev.12Cr, 17Cr, 22Cr, 27Cr). Erosive wear tests were researched with high temperature erosion testing machine which consists of three furnaces. This machine can heat specimens, particles and in the atmosphere at 1173 K, 1073 K and 773 K respectively. Erosive wear tests were conducted using erodent particles which is alumina ball of hardness 1140 HV, impact angles between 30 and 90 degrees and a particle velocity of 100 m/s.

12Cr shows highest erosion rate as a result of test. The highest angle of 30° shows higher erosion rates with other specimen. Therefore we have forecasted on impingement angle of 30°. In case of as cast, as the Cr/C rate increases, erosion rate tends to decrease. In QT, there were not many differences except 12Cr. Among both of as cast and QT specimens, 27Cr shows the best erosive resistance.

It is clarified the reason of decrease of erosion rate due to Cr/C rate increase is ~~by~~ observed behavior and organization of erosion surface of carbide. Eutectic carbide close to abrasion aspect is fragmented into small pieces by collision between grains.

Depth of carbide layer of finely fragmented 12Cr was deeper than that of other 17Cr, 22Cr, 27Cr. Fragmented carbide layer of QT specimens is deeper than that of as cast one.

4. WHEN BARIUM CALCIUM INOCULANTS JUST DON'T GIVE THE FINAL CASTING PROPERTIES NEW AGE CASTINGS REQUIRE

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In Asia the most prolific part of the world for iron casting production with around 60 % of total global iron casting production being centered in this region, it is fair to say that when a foundry selects an inoculant, which is not Ferro Silicon the first choice will be a Barium Calcium inoculant, why because they are relatively low cost, easy to use and will work on most iron types.

Whilst we are not saying Barium Calcium inoculants should not be used, they do not in many of the high quality end of the iron casting market give the final casting properties that many end users now demand.

In this presentation we will give examples of when higher potency inoculants are required in order to meet the challenges of new cast iron grades and to help improve casting machineability. We will also explain why inoculants containing certain elements can reduce material consumption and bring higher financial rewards to the casting producer.

5. ELIMINATION OF MICRO SHRINKAGE DEFECT CREATED AT THE JUNCTION BETWEEN THE FEEDER NECK AND GRAY IRON CASTINGS

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In this paper, elimination of micro shrinkage defect created at the junction between the feeder neck and gray iron castings used in automotive industry was investigated. Mentioned part was produced using vertical sand molding line (DISA 240B) including significant amount of small and scattered holes which were visible without glass and microscope.

After reviewing the defects using optical microscopy (OM) and Scanning electron microscopy (SEM), these cavities were recognized as micro shrinkage. Also MAGMA Soft simulation software results confirmed the findings.

Therefore, in order to eliminate the defect, some changes on the size and geometry of the feeder and feeder neck was applied. The results of reality as well as the results of simulation using MAGMA Soft shows that the defect is removed due to solidification behavior change and elimination of hot spots in the part.

6. **ELIMINATION OF OXIDATION DEFECT CAUSED BY TURBULENCE IN CAST IRON PRESSURE PLATE USED IN AUTOMOTIVE INDUSTRY BY MAGMA SIMULATION SOFTWARE**

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In this article, the method to eliminate oxidation defect caused by turbulence in gray cast iron pressure plate used in automotive industry, is investigated. Mentioned part was produced using vertical molding line (DISA), green sand and with four cavities. In preliminary design, produced product was including some defects, after reviewing by optic microscopes (OM), scanning electron microscope (SEM) equipped by energy dispersive X-Ray spectroscopy (EDS), it has been realized that the defects are oxidation layers type.

Simulation results showed that the melt velocity in cavity ingate area is more than critical velocity. This can lead to create oxidation defect. Thus, a new gating system was designed to decrease the velocity of melt by smaller pouring cup and also ingate area. Actually, the pouring rate decreased comparing to the first design. The new design was evaluated by simulation software. The results show that the melt in ingate is laminar, smooth and without any turbulence. In addition, the velocity is less than critical value. Accordingly, parts produced by new design have no oxidation defect as final inspections confirmed.

7. **INVESTIGATION OF THE EFFECT OF TYPE AND AMOUNT OF INOCULANTS ON MICROSTRUCTURE, MECHANICAL PROPERTIES AND CREATED DEFECTS IN GRAY CAST IRON USED IN AUTOMOTIVE PARTS**

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In this article, removing the inclusion defect in gray cast iron pressure plate used in automotive industry has been investigated. Mentioned part was produced using automatic vertical sand molding line (DISA240B) with two inoculants types in Asia Pearlite Casting Industries. The first one was calcium-barium based, and another type strontium based that were used in various amounts. In produced parts by calcium-barium inoculants based, inclusion on surface and also subsurface was created.

After examination by optical microscopy (OM) and scanning electron microscopy equipped by X-ray spectrometer (SEM-EDS), it was found that observed defects include non-metallic inclusions with barium and calcium components existing in inoculants. Defective parts (including inclusion) percentage decreased by decreasing the amount of barium based inoculants percentage from 0.2 down to 0.1. Inoculation operation was improved by replacing the strontium based inoculants due to creating more primary eutectic cells in melt. Thus good parts without any inclusion are made with smaller and even graphite spread in metallic base. Also mechanical properties such as strength and hardness in parts increased using strontium based inoculants.

Keywords: *gray iron, inclusion, inoculants, barium, strontium*

8. INFLUENCE OF THERMOSTATS HEAT MEDIATE PROCESS ON MICROSTRUCTURES AND PROPERTIES OF HIGH MANGANESE STEEL MN15CR2V

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In this paper, The improvement of microstructures and properties of High Manganese Steel by Chromium 2% and Vanadium 1% added(HMnS) by thermostats heat mediate process wereas presented in this paper. The results showed that the properties of HMnS was increasing when the temperature of thermostats heat mediate process is at 650^0C and the temperature of quenching is at 1090^0C. Moreover, with this process, microstructure image shows that finer austenite particles were more fined, the microstructure has distributed carbides appear in the matrix there was the appearance of carbides. Theis work showed the work-hardening mechanism of hardening by fine small austenite particles and carbide dispersion.

Keywords: *High Manganese steel (HMnS), thermostats mediate process, fine austenite particles, carbide dispersion.*

9. INFLUENCE OF VANADIUM CONTENT ON THE MICROSTRUCTURE AND MECHANICAL PROPERTIES OF HIGH-MANGANESE STEEL MN15CR2

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This paper showed the influence of the vanadium content on the grain size and the hardness of a high-manganese steel Mn15Cr2 (HMnS). As The vanadium content added alloying in to Mn15Cr2 steel had been done fine grain size in steel. the grain size of matrix phase reduced, The dispersive distribution of carbide increased formed and therefore the hardness increased of steel. The toughness impact of HMnS Mn15Cr2 with 1%V was 115J/cm^2. However, with the vanadium content increases to was added 2%, the carbide appeared on the boundary of grain, the toughness impact reduced compare to HMS Mn15Cr2 with 1%V.

Keywords: *High manganse steel (HMnS), Carbide, Vanadium, toughness impact*

10. INFLUENCE OF SHAPE OF WC ON EROSIVE WEAR BEHAVIOR OF CAST-IN INSERTION HIGH CHROMIUM CAST IRONS

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Surface damage that caused by impact of solid particles is called erosive wear. The phenomenon becomes a serious problem for bended section of pneumatic transportation pipe, valve, liner and so on. Erosive wear in pipe line occurs inner wall of pipe and could not be judged from the exterior of pipe, so periodical exchange of parts and the inner wall of the pipe to be thinned down was built up through welding in order to avoid causing accidents. In order to reach an aim of high safety and low cost, it's important to develop wear resistant material and to estimate of life service during erosion. This study investigate that the influence of shape of WC on solid particle erosive wear of cast-in insertion cast irons.

Four kinds of high chromium cast irons (Hi-Cr) were used as base metal. Shape and size of WC were □5 × 50, □8 × 50 and □ 8 × 50mm. The area raid of WC of test surface is 50% at maximum. The test specimens for erosive test were mechanically machined to be sized 50×50×14mm. Specimens were tested using a blast machine. Spherical shaped steel grits with average diameter 770μm, Vickers hardness 810HV were used in this study. The examined particle speed was 20 m / s , and the particle feed rate was measured with about 20.0 g / s , and the particle input 2 kg with changing their impingement angles respectively 30, 60 and 90deg. All the erosion tests were conducted at room temperature in 3600sec. Erosion rate was used to the evaluation of wear resistant.

A comparison of the base material and the cast-in insertion casting material. Erosion rate was decreased by insert casting the WC in all of the specimens. Also EDS surface analysis was performed detail in order to observe bonded surface of between WC and base metal of WC cast irons. All cylindrical shaped WC transverse-mounted specimen was observed reaction layer in bond surface. The hardness of reaction layer was higher as compared to that of base metal. On the other hand, square shaped WC transverse-mounted specimen, the void of about 50μm was observed in bond surface of between WC and base metal. Erosion rate of cylindrical shaped WC transverse-

mounted decreased in relations to square shaped WC transverse-mounted. From these result, it's considered that it's important for superior erosive wear resistance to formation reaction layer.

11. A STUDY OF STRUCTURE AND PROPERTIES OF AUSTEMPERED DUCTILE IRON (ADI)

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A ductile cast iron test bar (C=3,76; Si= 2,44; S = 0,015; P= 0,0056; Mn= 0,36; Ni= 0,89; Cr= 0,11; Mo= 0,12; Cu= 0,61; Mg= 0,036), produced in a commercial foundry using an electric melting furnace, has been used for the experiments. Austenitisation of all samples was carried out at 900oC for 90 min. in a electrical furnace under air pressure. Then samples were rapidly quenched into a salt bath held at austempering temperature of (280, 320, 360, 400^{0}C) for various times (from 0 to 550 min.) to obtain different ausferrite volume fractions. The transformation diagram and "process window" of this ADI was established. Some mechanical properties were met as international standards for austempered ductile iron.

12. THE EFECT OF AUSTEMPERING CONDITIONS ON THE FORMATION OF STRUCTURE AND PROPERTIES OF AUSFERIT DUCTILE IRON (ADI)

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The carbon saturation content in austenite which depends on temperature and holding time at high temperature was studied. Its influence on the austempering transformation after austenitisation was also presented. The results show that the structure and properties of ADI depends on austenitisation, austempering temperature and holding time.

Keywords: *ADI iron, ausferit iron, austenitisation, austempering transformation, austempering temperature, mechanical property*

Session III. Non ferrous metals and alloys

1. DIRECT OBSERVATION OF COPPER REMOVAL FROM LEAD BULLION BY MEANS OF ALUMINUM

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The commonly used method for copper removal from lead bullion by application of sulphur cannot always be effective since a part of the sulphur becomes oxidized and has negative influence on environment because of SO_2 emission to atmosphere. The process is often repeated which results in

longer process duration as well as higher costs. A new technology for copper removal from lead with use of the metallic aluminium was studied in laboratory scale. The decoppering of lead has been conducted by melting of aluminium on lead surface and the slowly stirring. The liquid Al phase absorbs Cu from lead in result of decreasing solubility of that element with temperature drop.

Liquid Al-Cu alloy solidifies in eutectic point in the temperature of about 540 °C and it can be collected from the lead surface.

The aim of this study was direct observation of melting, wetting and spreading aluminium on liquid lead surface. The sessile drop technique incorporating X-ray imaging of drop profile was used. The X-ray images were used to determine of the wetting angle and then to the surface tension calculations. After cooling, the solidified samples were tested for the presence of copper in aluminum by scanning electron microscopy.

Keywords: *lead bullion, refining, decoppering*

2. EFFECT OF MELTING CONDITION ON FLUIDITY OF LEAD FREE SULFIDE BRONZE

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Substitution of leaded castings for water supply products has been required because lead is harmful for human body. A lead free bronze with dispersed sulfide is one of the substitute bronze. The lead free bronze has excellent properties.

However, melt fluidity is not known very well even characteristics of solidification is different from the conventional leaded bronze. Effect of casting temperature and deoxidation treatment on melt fluidity of the lead free bronze is investigated. The lead free bronze was melt in a high-frequency induction furnace. Casting temperature was changed for changing viscosity of the melt.

Additive amount of deoxidation agent was changed for changing a suspended oxide in the melt. The fluidity was analyzed by mean of solidification microstructures and thermodynamics. The fluidity is almost same as the conventional leaded bronze. The fluidity is improved with increasing the additive amount of deoxidation agent.

Keywords: *bronze, fluidity, copper alloy, deoxidation, solidification temperature, lead free alloy*

3. WEAR CHARACTERISTICS OF PITCH-BASED CARBON FIBER REINFORCED ALUMINUM ALLOY COMPOSITE UNDER DRY SLIDING CONDITION

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Wear characteristics of pitch-based carbon fiber reinforced aluminum alloy composites under dry sliding condition have been investigated by pin-on-disk wear test. The composites were fabricated by squeeze casting. The effects of the fiber reinforcement on the wear characteristic were discussed. By reinforcing the alloy with the carbon fiber, wear loss of the aluminum alloy was greatly reduced. The friction coefficient of the composite was stable during the wear test compare to the unreinforced aluminum alloy. For the unreinforced aluminum alloy, the wear surface of the steel counterface disk specimen was fully covered with aluminum. On the other hand, iron and carbon were detected on the wear surface of the counterface combined with the composite. These results indicate that the carbon fiber act as a solid lubricant to reduce the wear loss.

Keywords: *Carbon Fiber, Aluminum, Composite, Squeeze Casting, Wear*

4. EFFECTS OF SINTERING TEMPERATURE ON THE MICROSTRUCTURE AND MECHANICAL PROPERTIES OF CU-TIC COMPOSITE

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The powder mixtures of Cu and TiC were compacted at 200 MPa and were then sintered at various sintering temperature ranging from 800 to 900 ^{o}C for 1 h in reduction environment. In this study, the effects of the sintering temperature on the microstructure and mechanical properties of the TiC reinforced copper based composite have been investigated. The obtained SEM images and their corresponding EDX analysis showed that the higher the temperature is, the higher amounts of Ti and C in copper matrix were observed. It indicates a high rate of alloying process, which increases significantly the mechanical properties of the composite material. Moreover, the appearance of Cu in TiC particles confirms a strong adhesion between them.

Keywords: *Sintering, Density, Microstructure, Composite, Properties*

5. FABRICATION OF DIAMOND AND TIC REINFORCED COPPER BASED COMPOSITE USING HOT PRESSING TECHNIQUE

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The presence of reinforced particles in the copper matrix can improve the copper matrix in terms of wear resistance and mechanical strength. In the present work, copper-based composite reinforced with mixture of TiC and diamond particles were prepared by the powder metallurgical technique. Copper matrix, TiC and diamond powders were mixed mechanically by ball milling for 1 h, then pre-cold-compacted at 300 MPa. The samples were then sintered using a hot pressing at 900 ^{o}C for

5 min at an uniaxial pressure of 10 MPa. To evaluate the efficiency of hot pressing process, the copper based composites were also consolidated by conventional sintering process at the same temperature for 1 h. The obtained SEM images clearly shows the importance of the process conditions. A much better bonding between the copper matrix and the reinforced nanoparticles was achieved in the case of hot pressing compared to the conventional counterpart. The latter presented a large gap surrounding the diamond particles due to the poor wettability between the TiC and diamond particles with molten copper matrix. Consequently, the obtained density, mechanical strength and wear resistance of the composite fabricated via hot pressing were significantly surpassed those of pressureless sintering. In addition, the mechanical wear resistance of the composite increased with the concentration of diamond varied from 1 to 5 mass %.

Keywords: *Hot pressing, copper composite, TiC, diamond, mechanical strength, wear resistance*

6. FABRICATION OF FE-TIB_2 NANOCOMPOSITE WITH USE OF HIGH-ENERGY MILLING FOLLOWED BY IN-SITU REACTION SYNTHESIS AND SINTERING

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Metal matrix composites reinforced with nano-particles are very promising materials which is suitable for a large number of applications. Fe-based composites reinforced by TiB_2 particulates have attracted much attention due to its excellent mechanical properties as well as low coefficient of thermal expansion. In-situ formation results in the clean particle-matrix interfaces with higher interfacial strength, finer reinforcement size and better particle-size distribution. Hence, the in-situ technique is the optimal choice for the synthesis of nanocomposite.

In this study, Fe-TiB_2 nanocomposite was in-situ fabricated from titanium hydride (TiH_2) and iron boride (FeB) powders by high-energy ball milling and subsequent heat-treatment. High-energy ball milling was chosen for mechanical activation as an effective method to achieve the desired results subsequently. The specific energy was calculated from the measured results of electrical power consumption during milling and used for discussion on the powder characteristics and the subsequent reaction behavior. About 20 % of the input energy was transferred into the material at the milling speed of 500 rpm and 33 % at 700 rpm. By increasing the milling energy, distribution of starting powders was gradually homogeneous and reduced their size to a nanoscale. Moreover, the thermal behaviors such as decomposition of TiH_2 and the formation reaction of TiB_2 from Ti and FeB were lowered. Obviously, Fe-TiB_2 nanocomposite powders after reaction synthesis showed more homogeneous microstructure for powder mixture milled with higher specific energy. Microstructure was characterized by smaller 5 nm TiB_2 particulate homogeneous distributed in Fe matrix.

Understanding the reaction mechanism helps controlling the affecting factors to achieve the best results. Phase change was analyzed by X-ray diffraction and phase distribution was observed by electron microscopy during reaction synthesis of powder mixture milled with various milling

conditions in order to explore the formation mechanism of TiB_2 particles in Fe matrix. The result indicated that titanium reacts with boron at the interface of Ti and FeB by gradual diffusion reaction, forming TiB_2 particles, reducing the amount of boron and induced phase transition of FeB to Fe_2B. The process ended when whole the Ti phase transferred into TiB_2 phase and Fe matrix formed from the position of Fe_2B left. The reaction rate strongly depended on the size and distribution of FeB particles. With the finer FeB, the more homogeneous microstructure of Fe-TiB_2 composite powder formed, involving nano TiB_2 particles distributed in the Fe matrix.

Most refractory reinforced - metal composite are used for wear resistance parts and cutting tools, so sintering is always next stage of the manufacturing process of materials. A part of this study intended to examine the consolidation of nanocomposite. The sintering process was performed by both pressureless (PLS) and pressure (SPS) sintering techniques. The main effecting factors of sintering time and temperature were investigated. The result showed that microstructure and properties of the composites strongly affected by sintering time and temperature. With the dominant advantage of low sintering temperature and short sintering time, the SPSed-samples retained nano-size TiB_2 particles and obtained very high density and hardness. The PLSed-samples showed sub-micrometer TiB_2 particles, but the hardness obtained also high, equivalent to some WC-Co systems.

7. AL 6060 CHIPS COMPACTION USING A POWDER METALLURGY TECHNIQUE

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The authors presented the possible technologies to produce aluminium alloys components from low cost machined chip wastes instead of aluminium alloy powder. The Al 6060 was recycled by using the powder metallurgy technique to determine the effect of porosity distribution on mechanical property and microstructure of materials. The movement of chips within the die during cold compaction was analysed through numerical simulations using the software product of Deform 2D. Density of the compacted specimen was measured by an Archimedes method, and the pore morphology with respect to area and mean diameter of the pores was observed and evaluated by an image analyzer. According to the study on the process of compacting, there were defined optimal parameters for decreasing the porosity and enhancing the pores distribution.

Keywords: *aluminium chips, compaction, porosity, finite element method*

8. EFFECT OF ELECTROMAGNETIC STIRRING PROCESS ON THE CHANGE SHAPE, SIZE INTERMETALLIC PHASES AND MECHANICAL PROPERTIES OF A356.0 ALLOY

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Electromagnetic stirring process for semi-solid alloy in the temperature range from 585 to 605^0 C, stirring time from 5 to 20 seconds before pouring into the mold to obtain the equiaxed structure and

improve the mechanical properties of the alloy is studied. Especially, in this paper, the effect of electromagnetic stirring process on the change of the shape and the size of intermetallic phases, hence to improve the mechanical properties of A356.0 alloy is investigated more in details.

Keywords: *electromagnetic stirring; semi-solid; intermetallic phases, mechanical properties*

9. IN FLUENCE OF COMPOSITION TO PROPERTIES OF INTERMEDIATE ALLOYS ROSE GOLD

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In this papper a study on the influence of compositionto properties of intermediate alloy rose gold is presented. The results show that when the silver content increased to about 25% Ag , the hardness of the alloy increased significantly, and intermediate alloy composition 76% Cu, 24% Ag is considered best to use to manipulate rose gold jewelry.

Session IV. Heat, cryogenic and surface treatments

1. IN-PROCESS LOW TEMPERATURE CARBURIZING OF HYBRID CARBON COATED DIECAST MOLD

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Diecast mold surface is repeatedly heated up 550 ^{o}C and cooled down 150 ^{o}C along with compressive pressure of 50 MPa. Thus diecast mold surface is subjected to severe thermal stress arising from successive contacts of molten aluminum alloy and liquid parting agent, so that the thermal fatigue causes heat cracks on the mold surface after several ten thousands of diecast-shots. The author's group developed the hybrid carbon coating on mold surface to improve both the mold life and casting quality. The coating is characterized by heat insulation at an infusing step and good heat transfer at a solidifying step during a diecast cycle, which leads to little temperature drop in molten aluminum, but rapid solidification. Prior to the molten metal pouring, the cavity surface was generally sprayed by oil-typed parting agent after rubbing of fullerene. We found the fact that the diecast mold surface which was subjected to 12000 diecast-shots in practical uses, was revealed to be carburized in thin surface layer. In order to make mold life much longer, the mold is intentionally carburized in such conditions similar to the practical diecast cycles, thus is self-healing of diecast molds. As the first step of fundamental experiments, the low temperature carburizing was carried out on a pure iron substrate at heating temperature of 550 ^{o}C for 48 h in low pressure chamber of 30-100 Pa with compressed fullerene. The diffused carbon is recognized approximately 50 □m in thickness on the cross-section of a pure iron substrate. Hence the hybrid carbon coating rubbed with fullerene improves the mold surface properties by in-process carburizing, which is self-healing in multiple practical diecast cycles.

Keywords: *low temperature carburizing, hybrid carbon coating, fullerene, diecasting, mold, self-healing*

2. JOINING OF DIECAST ALUMINUM ALLOY WITH LOW CARBON STEEL PLATES BY SPOT WELDING

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Joining of diecast aluminum alloy with low carbon steel plates is one of the promising solutions to realize weight reduction of automotive body components. Two major joining processes of friction stir spot welding (FSSW) and self-pierce riveting (SPR) have been examined to achieve such dissimilar joints in practical uses. However, each process has its own difficulties to be overcome for much wider applications, that is, the short tool life and shape limitation to works, the severe surface damage and less effect in weight reduction, respectively. Spot welding (SW) for aluminum/iron (Al/Fe) joints shows low joining efficiency due to the brittle reaction layer of intermetallic compounds at the interface, though it is a well-established joining process for steel plates. Our preliminary experiments exhibit that shorter the heating period develops thinner the reaction layer at the interface in Al/Fe joints. Therefore, the authors focused on SW of aluminum alloy with steel plates, in which extremely small amount of Al-Mg powder were supplied into the interface as activator to reduce oxide layer on an aluminum surface through the thermit reaction. The tensile shear strength of Al/Fe joints is greatly improved by the novel SW process with Al-Mg powder because of the reduction of oxide layer on an aluminum surface through the thermit reaction, as well as its exothermic reaction. Hence the reaction layer thickness is also maintained less than 1□m in Al/Fe joints performed by the novel SW process, which gives us the highest joining efficiency of aluminum-side fracture in tensile shear tests.

Keywords: *diecast aluminum alloy, low carbon steel, spot welding, Al-Mg powder, intermetallic compound, thermit reaction*

3. PROCESSING OF MULTIPHASE STEEL BY CONTROLLED PLASTIC DEFORMATIONS

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Controlled pressure processing and controlled cooling of C-Mn-Si TRIP steel in laboratory and process conditions were realized. Influence of cooling regimes realized as controlled cooling by air and water jet to isothermal holding conditions on ferrite and martensite formations and mechanical properties were studied. The highest ferrite fraction X_F = 65 % was obtained after application of furnace holding temperature T_h = 570 °C and holding time t_h = 250 s in both cooling regimes (slow

cooling rate 6 °C/s and quick cooling rate 250 °C/s). Mechanical properties in the large value interval ($R_{p0,2}$ = 530-900 MPa, R_m = 750-1450 MPa, A5 = 8-33 %) in depending on phase fractions were obtained. The results obtained in laboratory were confirmed by process conditions.

Keywords: *steel C-Mn-Si, saturated austenite, hot rolling, controlled cooling*

4. EUTECTOID TRANSFORMATION BEHAVIOR OF NIOBIUM-BASED MULTIPHASE ALLOY

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Nb-Si based alloy is expected as a material having a heat resistance in excess of Ni based super-alloys currently used for the aircraft engine turbine blades. However, the Nb-Si alloy is poor in toughness and oxidation resistance at high temperature. Although αNb_5Si_3 in Nb-Si alloy is advantageous in heat resistance and oxidation resistance, the eutectoid reaction to form the αNb_5Si_3 is very slow. Therefore, heat treatment is usually required to form it. Addition of Al, Cr and Mo can be expected to improve the toughness and oxidation resistance of the alloy. In the present study, Nb-18Si-5Cr-5Al-5Mo alloy is prepared by arc melting and clarified the effects of the elements on the eutectoid transformation behavior during heat treatment at 1573 K. The lattice parameters of Nb solid solution and Nb silicide was obtained using XRD and Rietveld analysis. Observation of microstructure and quantitative analysis of each phase were conducted by SEM and FE-EPMA. As-cast alloy consists of Nb solid solution, Nb_3Si, βNb_5Si_3 and Cr_2Nb. By the heat-treatment for 50 h, αNb_5Si_3 was formed, but Nb_3Si and βNb_5Si_3 still remained. 100 h heat-treated alloy consists of Nb solid solution, αNb_5Si_3 and Cr_2Nb. These results indicated that the eutectoid transformation did not complete by heat treatment for 50 h, but completed for 100 h. By the heat treatment, lattice parameter of Nb_5Si_3 increased because Cr and Mo were substituted with Nb in Nb_5Si_3, and that of Nb solid solution increased because Si and Al content in Nb solid solution decreased. Transfer of these elements during the heat treatment is considered to have the some effects on the eutectoid transformation.

5. EFFECT OF SINTERING TIME AND TEMPERATURE ON MICROSTRUCTURE AND PROPERTIES OF ALUMINUM FOAMS

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In the present work, aluminum foams were fabricated by powder metallurgy route. 1.5 wt.% TiH_2 was used as foaming agent. Mixture powders of aluminum and TiH_2 was ball-milling for 2h and pre-compacted in cylindrical shape at the pressure of 500MPa. Foaming process was done in Argon gas at various temperatures; 680, 720 and 770^oC. In order to investigate the effect of foaming time, the

samples were heat treated for 3, 5 and 10 minutes at 720^{o}C. After foaming, microstructure and mechanical properties of foaming, samples were investigated using optical microscope (OM), scanning electron microscope (SEM) and compressive strength tester. The results show that aluminum foams have closed-cell structure with spherical shapes. The density of fabricated aluminum foams are less than 1g/cm^{3}. The highest compressive strength obtained at the value of 13MPa in this work.

Keywords: *Aluminum foams, TiH_2 foaming agent, sintering time, temperature sintering*

6. TOWARDS IMPROVED UNDERSTANDING OF THE HEAT TREATMENT OF ALLOY WHITE IRONS

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High Cr-Mo and Ni-Cr Alloy White Cast Irons are widely used for their resistance to abrasive wear in applications such as liner plates and grinding media in tube mills, crushing rollers and tables in vertical spindle mills and the impellors and bodies of slurry pumps. Although austenitic High Cr-Mo irons can be used as-cast, they are normally heat treated before service. Thermal treatments include softening for tool machining, destabilization, air hardening and tempering. The Ni-Cr irons cannot normally be used as-cast and are always heat treated to minimize austenite retention in their microstructures. The physical metallurgy underlying choice of alloy composition in alloy white irons, the formation and control of as-cast microstructures, and their subsequent structural modification and control by heat treatment is quite complex. Fine scale microstructural characterization via electron microscopy therefore plays a key role in furthering our understanding of the phase transformations that control the microstructures, and hence the service performance of these irons. This paper reviews the metallurgical development and applications of alloy white irons and then considers how both Scanning and especially Transmission Electron Microscopy and associated micro-analytical techniques can provide valuable information on microstructures in High Cr-Mo irons. Particular attention is given to the effects of thermal treatments on the nature of eutectic and secondary carbides and on the matrix structures.

7. INFLUENCE OF HEAT TREATMENT ON THE WEAR RESISTANCE OF BCUAL9FE4 ALLOY

Nguyen Hai Quan, Phạm Mai Khánh

Aluminium bronze is one of the wear resisting engineering materials that work under a environment with high stress. BCuAl9Fe4 casting alloy was investigated. Adding a small Fe content also contributed to improve the wear resistance for this alloy. After carrying out some heat treatment processes, the microstructure,hardness and wear behaviors of BCuAl9Fe4 alloy were researched. The results indicated that in heat treatment processes of BCuAl9Fe4 alloy, it occured eutectic reaction $\beta \rightarrow (\alpha+\gamma_2)$,that contribute to improve the wear resistance for this alloy.

It's clearly that we can apply some suitable heat treatment processes to improve the wear resistance of BCuAl9Fe4 alloy.

Key words: *Aluminium bronze, heat treatment, microstructures, friction, wear behavior*.

8. EFFECT OF MODIFICATION ON MICROSTRUCTURE OF A356 ALUMINIUM ALLOY

To Duy Phuong[1)], Dang Huu Dung[2)]

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Abstract: A hypereutectic aluminum-silicon alloy with content of 13-14%Si, designed as A13S, was modified. The change of microstructure was identified by optical microscopy. The results show that halogenous can change the morphology and size of the primary silicon and control the length of needle-like eutectic silicon or dendrite. After modified by halogenous salts, the primary silicon of star-like and coarse platelet is changed to polygonal with less cute angles and decreasing average size. The eutectic silicon is also changed because it grows from the tip of angles on the primary silicon and is influenced by the morphology and size of primary silicon. The eutectic silicon changes from needle-like or dendrite shape to short bars and dots with less average length.

Key words: *aluminum-silicon alloys; modification; halogenous; primary silicon; eutectic silicon*

9. EFFECT OF HEAT TREATMENT ON MICROSTRUCTURE AND HARDNESS OF HIGH SILICON ALUMINIUM ALLOYS

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Abstract: The influence of solution heating at 540^{o}C 1-6 hours, quenching into 20^{o}C cool water and ageing at 175^{o}C 2-8 hours in air on transformation of acicular, plate-like and flake-like morphologies to broken grains and gradually form round to globular ones was researched.

The microstructural eutectic silicon, α-aluminium, acicular intermetallic phases in high silicon aluminium alloys were examined with confidence microscopy, scanning electron microscopy and X-ray ...

The results showed that the solution treatment at 540^{o}C 1-2 hour then quenching attained very positive influence on the alloy's tensile strength.

Keywords: *Aluminium alloys, solution treatment, ageing, acicular eutectic, silicon, intermetallic phase, tensile strength, hardness.*

10. CORROSION AND CASTABILITY OF DIFFERENT BRONZE ALLOYS SUITABLE FOR OUTDOOR SCULPTURES

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The corrosion and castability of several bronze alloys (base on UNS C83600-85Cu, 5Sn, 5Zn, 5Pb in wt%), suitable for casting of outdoor sculptures, were investigated in this paper. The elemental composition of the alloys was searched to fulfill specific criteria such as: good resistance toward corrosion of acid rain and casting characteristics conformable to artistic purposes. The as-cast of bronze alloys specimens were exposed to aggressive solutions for different periods through a wet-dry technique. Preliminary results, showing the difference between the resistance toward corrosion and castability for different alloys.

11. INFLUENCE OF HEAT TREATMENT PROCESS ON THE MICROSTRUCTURE AND HARDNESS OF HIGH-MANGANESE STEEL

Phạm Mai Khánh[1], Lê Thị Chiều[1], ...

This papper studies the effect of heat treatment process to the microstructure and hardness of high Manganese steel. With the process 2 (the new heat treatment), the hardness value increases. Moreover, microstructure images has distributed carbides appear in the matrix and the smaller particles.

Keywords: *heat treatment, carbide dispersion, manganese steel, microstructure, hardness, distribution*

12. INFLUENCE OF THE TEMPERATURE AND TIME NITROCARBURIZING ON THE MICROSTRUCTURE AND THE HARDNESS OF NITROCARBURIZING LAYER OF 20XM STEEL

Nguyen Dương Nam[1],Le Thi Chieu[2], Trieu Khuong[3], Đao Van Lap

This paper presents the influence of nitrocarburizing temperature and times on the microstructure and the hardness of case depth of 20XM steel. The result showed with 840^0C and 3 hours (with C_P = 1,03): the grain size is very fine and no defectin the microstructure.of case. The hardness of surface layer is higher (62-65HRC), the hardness of center sample is 37 – 39HRC; the hardness is descending from surface to center.

Keywords: *20XM , nitrocarburizing, temperature, times*

13. PHASE TRANSFORMATION DURING HEAT TREATMENT OF CU-15NI-8SN ALLOY

Le Thi Chieu[1]Sai Manh Thang[2] Nguyen Duong Nam[1]

After casting, the Cu-15Ni-8Sn alloy was solution annealed at 820^oC,rapid quenching to, room temperature and reheated for aging at difference temperature and time. During aging, from unifom solution, the alloy atoms diffuced, created spinodal structure, improve hardeness for alloy. Incease aging temperature, the phaseγ with low hardeness developed. The diffence of harness of phases in microstructure and high strength making alloy meet requerments heavy loads bearing.

14. A STUDY OF TECHNOLOGY FOR MULTILAYER OF TIALSIN/CRN SUPER HARD COATING ON WC-CO SUBSTRATE BY MAGNETRON SPUTTERING

Doan Dinh Phuong, Luong Van Duong

In recent years, hard coating materials based on transition metal nitrides have found a wide-spread application in the field of machine parts and cutting tools in order to improve wear resistance and extend lifetime. In this study, multilayer TiAlSiN/CrN coating was deposited on Si wafer and WC-Co substrate by magnetron sputtering. Morphology and thickness of coatings were check by SEM, the effect of layer coatings and bilayer thickness on hardness of coatings were analyzed and evaluated. Fiction coefficient also was investigated and compared to TiAlSiN, CrN monolayer and WC-Co substrate. This result showed that fiction coefficient of multilayer TiAlSiN/CrN coating is lower than a monolayer and WC-Co substrate.

Keywords: *hard coating, multilayer, magnetron sputtering, TiAlSiN, CrN monolayer, WC-Co substrate.*

Session V. Moulding materials and rapid prototyping technologies

1. SLOSHING SUPPRESSION CONTROL DURING BACKWARD TILTING MOTION OF POURING LADLE WITH WEIR

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In the pouring process of the casting industries, one of the important things to produce high quality casting is to achieve the desired flow rate of molten metal for keeping fluid level in sprue cup at constant and also controlling the pouring weight by tilting motion control of ladle. Thus, automatic pouring systems have been developed for above aims. On pouring control, it is also desired to shorten pouring time and cut off pouring quickly so that temperature decrease of molten metal can be prevented and cycle time can be reduced in one batch process. But, quickly backward tilting ladle motion for pouring cutoff causes sloshing on the inside of ladle. In conventional studies, feedforward tilting control input is designed for simple trapezoidal shape ladle to suppress sloshing of ladle.

However, in actual ladle, there is a weir for contamination prevention of molten metal. The weir separates nozzle side and body side of ladle. It induces different flow from ladle without weir on the inside of ladle.

Therefore, this study presented sloshing analysis of automatic pouring ladle with weir and proposed the control approach to suppress the sloshing while tilting ladle backward cutoff pouring.

On this sloshing analysis, CFD simulator was used and casting iron was assumed as target fluid. Analysis results showed that both U-tube like vibration and actual tank sloshing on liquid surface were caused by backward tilting ladle motion. U-tube like vibration comes from volume movement between body side and nozzle side.

The simple mathematic plant model was built so that some control theories can be applied to it and its model parameters were derived from CFD analysis results. In this study, input shaping approach was applied to control sloshing suppression. Input shaping control was designed for backward tilting motion control at pouring cutoff. Effectiveness of the proposed suppression control input was evaluated by comparison with non-controlled case on CFD simulations.

2. THE EFFECT OF TECHNOLOGY PARAMETERS ON THE PROPERTIES OF RAPID PROTOTYPING IMPELLER FOUNDRY PATTERNS

Do Van Quang[1], Nguyen Nhu Hieu and Dao Hong Bach

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Fused deposition modelling (FDM) is a fast growing rapid prototyping (RP) technology due to its ability to build functional parts having complex geometrical shape in reasonable time period. The quality of built parts depends on many process variables. In this study, wax compositions ? material was used and two important process parameters such as layer thickness and air gap are considered. Their influence on two responses such as tensile, bending strength and surface roughness of test specimen is studied. Obtained results were applied to fabricate foundry patterns of impeller which were predestinated for casting by investment casting method.

Keywords: *FDM, investment casting, impeller, rapid prototyping*

3. THE IDEA OF COMPLETELY SUPERVISED MANUFACTURING PROCESS OF JET ENGINE CRITICAL PARTS USING INVESTMENT CASTING METHOD

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The paper shows an example of completely supervised manufacturing process of jet engine critical parts using investment casting method. The objective of this approach is to determine the influence of process parameters, including a type of ceramic coating on the product quality in the form of turbine blades. Approach took two types of coatings – based on colloidal silica and ethyl orthosilicate. Significant from the point of view of the completely supervision is to track the technological line, not a single ceramic mould, but also the position of a single blade. The realization of this objective will ensure there Expert System and 3D scanning, thermal imaging and computed tomography. It should be noted that these NDT techniques are not used in the classic investment casting process.

4. THE USE OF 3D SCANNING METHODS IN DESIGN AND SUPPORT OF FOUNDRY PROCESSES REALIZATION

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*The paper presents an example of the possibilities of using photogrammetric methods, including 3D scanning in design and support of foundry processes realization. Described examples of the use 3D scanning to create models for MES simulation of casting processes. Another of the presented applications of 3D scanning is to support the process of design moulds and cores by analyzing excess material, visualization of their assembly and analysis of wear. Optical techniques are also used to control the quality of the product based on the comparison results of the scan to *. CAD model. Possible through the use of robots is fully automated measurement, carried out in line. Using the trend analysis, it is possible to control the operating casting process.*

5. GREEN FURAN RESIN APPLICATION FOR FOUNDRY

Johnny

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TEMC successful to produce green furan application for Taiwan foundries with the low F.A contain human and environment friendly. Also we introduce this green product to all over the world because traditional furan high F.A contain harmful health and not friendly with environment.

6. INVESTIGATION OF PERMEABILITY OF FULL MOLD PATTERN COATINGS FOR IRON CASTINGS

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The full mold casting process, in which an expanded polystyrene pattern (EPS) is embedding in molding sand and pyrolysis off when contact with the pouring metal liquid, provides an effective manufacturing technique for castings such as machine tool's bed. The surface coating layer applied on the expanded polystyrene pattern (EPS) serves as to separate the metal liquid and sand mold, not only to increase the strength and stiffness of the EPS, but also to assist purging of gases from gasified EPS during its decomposition, products from pyrolysis of the EPS pattern. The quality of this coating layer could affect the soundness of castings. The important parameters of the coating layer for this application are named as thickness, adhesive, uniformity, permeability, heat conduction and high temperature properties. In general, coatings with good resistance to the hot cracking and the stability are the key factors for an excellent grade. In this paper, the permeability

nature of full mold pattern coatings has been studied. Experimental equipment has been built for measuring the volume flux pass through coating with argon as the flow medium. Layer coating was applied on a stainless steel mesh disk which served as a supporting. The Darcy's law suited for porous material has been reviewed and used to calculate out the specific permeability, k. The specific permeability of coatings are reported in a unit of Darcy (10^{-12} m^2) which been affect by the thickness and composition. It shows that coating layer permeability is a very important parameter in full mold foundry practice. The microstructures characteristic of various coatings are also related to its permeability.

7. THERMAL DECOMPOSITION FACILITY FOR THE ODOR IN A FOUNDRY

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Recently, the trouble is increasing between a foundry and nearby residents due to generate the environmental pollutants from the various processes in casting product. Most of civil complaints are being caused by the odor in a foundry.

In this study, the high-temperature oxidation method was studied to remove the odor substance. The oxidation device is miniaturized using by electrical heat generating system and reduced energy consumption using by a heat exchanger.

It was confirmed that the odor substance from the phenol resin binder combustion in sand mold is decomposed under the value of the emission standard of Korea when the oxidation chamber temperature is set upon 900 ℃.

8. A STUDY OF…..INVESTIGATING OF ESTABLISHING THE OPTIMAL CONTENT OF LOST FOAM COATING WITH MODIFYING CASSAVA STARCH GLUE FOR IRON CASTING.

Dinh Quang Nang, Nguyen Anh Quoc, Do Phuong Thao, Nguyen Viet Ha

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Nguyen Viet Ha. Chaiman General Director Mai Dong Company Limited.

Effect of coating ingredients based on the zircon powder and modifying cassava starch binder on the spreading, coating firm thickness, trailing durability and viscosity of the coatings is investigated. From it the coating having optimal components is established as the rate between zircon powder and the glue is 1.45; Austrian bentonite – 1% and additive 2% compared with the

zircon powder . It is used to make the lost foam coasting for gray and ductile iron casting in the Mai-Dong Company Limited.

Key words: *Lost foam coating, cassava starch, bentonite, trailing durability, viscosity*

9. A THE STUDY OF ……IMPROVEMENT IN THE PROPERTIES OF LOST FOAM CERAMIC COATING

Do Phuong Thao[1] , Dinh Quang Nang[2] , Tran Viet Thuong[1]

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In this paper, the effect of additives (adhensive latex, carboxymethyl cellulose – CMC, bentonite Trugel 100 and kaolin) on major properties of lost foam coating based on zircon refractory and colloidal silica as binder were presented. The properties of the coating were investigated such as stability, viscosity, adhesion, strength (abrasion resistance), cracking and structures of the coating. The results show that adhensive latex increases the strength, CMC, bentonite Trugel 100 and kaolin increase the stability, adhesion and strength of the coating. Two compositions that have favorable performances and without cracking are suggested. The first formula is zircon, colloidal silica, 5% adhensive latex, 1% CMC and 0.3% bentonite Trugel 100. The second one is zircon, colloidal silica, 5% adhensive latex, 1% CMC and 4% kaolin. The first one has more preeminent properties.

10. A STUDY OF PRODUCTION ON LOST FOAM COATINGS WITH ADHESIVE AGENT FROM CASSAVA GLUE USING FOR IRON

Dinh Quang Nang, Mai Thi Yen[1], Do Phuong Thao[1], Nguyen Viet Ha[2]

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Effect of coating ingredients based on the Pha-Lai fly ash and silica powder on the spreading, coating firm thickness, trailing durability and viscosity of the coatings is investigated. From it the coating having optimal components is established. It can be using for lost foam casting of cast gray and ductile iron with small weight.

Keywords: *Lost foam coating, cassava kley, bentonite, trailing durability, viscosity*

11. THE EFFECT OF POLYETHLENE WAX ON PROPERTIES OF WAX PATTERN IN INVESTMENT CASTING PROCESS

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In investment casting process, wax patterns have a significant affect to quality of casting products. To produce wax patterns which have good quality to obtain many requirements of investment casting process, the materials which are used to fabricate wax patterns have to ensure requirements such as: high mechanical properties, low shrinkage and thermal expansion, high soften temperature….This paper investigated the effect of polyethylene wax contents on properties of wax patterns. Obtained results showed that mechanical properties of wax patterns were increased as

increasing of PE wax content. However, the shrinkage of wax patterns was minimum value at 10 wt% of PE wax content.

Keywords: *casting process, wax pattern, shrinkage, expansion, polyethylene, mechanical properties.*

12. THE INFLUENCE OF MOULD COATING ON THE CASTING METAL QUALITY

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The graphite moulds were deposited by different coatings. The deposition was realized by PA PVD technique and as the result of this operation the hybrid multilayer W/Zr/DLC was formed. Also the thermal spraying technique was used to produced ZrO_2 + Y_2O_3 + glassy carbon coating and Al_2O_3 + glassy carbon coating. The behaviour of coating in the testing condition during liquid alloy flow by moulds was investigated and analysed. The stick of liquid metal effects were observed and compared between coating moulds and pure graphite moulds. It was found that in pure graphite moulds the liquid metal penetrated inside the graphite and lead to worst casting condition. The result of metal sticking was also worst surface of products.

Session VI. Foundry technology, equipment and manufacturing

1. DEVELOPMENT OF CHILLED ALLOY DUCTILE IRON ROLLER

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Rollers used in hot rolling process generally experiences mechanical wear and thermal shocking; a material selected must be able to provide resistance to this high temperature contact fatigue. Among hardened alloy steels and high speed steels, the chilled ductile iron castings provide better quality and also the cost effectiveness. The addition of alloying elements would improve the lifetime of roller further. In developing the roller castings, chilling ability of iron block mold, balancing alloy chemistry of Mn, Cr, Mo and Ni in the molten iron, effectiveness of nodulization and inoculation are factors to achieve the design target in terms of hardness distribution and microstructure feature necessary for a hot rolling process. The microstructure of roller core portion turn out as a pearlitic nodular graphite ductile iron, but contains different volume among and morphology of carbides which affected mainly by the cooling rate at that specific radial location distances from the roller surface and also combine together with the elemental segregation effect. The results show that a chilled alloy ductile iron roller with suitable hardness distribution and combination of

characteristic microstructure can provide an excellent working life. In this paper, details of developing concepts and experimental results of for a cast iron roller are presented.

2. MANUFACTURING TECHNOLOGY FOR HOLLOW STRUCTURE BY HIGH PRESSURE DIE CASTING

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Weight reduction is a key measure to enhance fuel economy of a vehicle. When a weight reduction is applied to suspension parts, high stiffness is also required. To achieve both high stiffness and light weight, it is effective to adopt a hollow structure to the main structure. For manufacturing of a hollow structure by aluminum casting, Gravity Die Casting (GDC) has been widely applied because of its slow charging speed contributing to avoid high pressure to the foundry sand core. In GDC, the molten metal is generally charged at a speed of 1 m/s or slower and this low speed keeps the pressure low. However, in this method, the charging time is prolonged and the wall thickness reduction is restricted.

Accordingly, it was needed to establish a method of hollow structure casting that can be implemented to HPDC, because HPDC is capable of thin wall casting and realizing a short process time. However, in HPDC, the injection speed is usually 30 to 40 m/s. If this condition is applied to a hollow structure, its high injection pressure causes the breakage of the sand core. Consequently, to implement HPDC to a hollow structure, it is required to reduce the injection pressure.

When the filling speed is increased, the core tends to break. In this project, we have developed a method to estimate changes of pressure distribution when filling molten metal by the casting simulation in order to analyze damages to the core. Through the analysis, we discovered occurrence of impulsive pressure waves. Furthermore, the impulsive changes of molten metal pressure have been confirmed through the precise measurement of molten metal pressure. On the basis of the aforementioned findings, we have established a method to prevent core damage by controlling impulsive pressure waves by modifying the flow path. That enabled the application of HPDC to a large-sized hollow structure part with a weight of 4 to 5 kg. Thus, HPDC became applicable to the productions of hollow structure large parts of a motorcycle wheels and swing arms, which used to be produced by GDC.

In conclusion, the developed method contributed a weight reduction by 10% and a process time reduction by 75%.

Key words *HPDC, sand core, hollow structure, injection pressure shock wave,*

3. IMPROVED FILLING ACCURACY USING A HYBRID METHOD AND VACUUM ANALYSIS OF HIGH PRESSURE DIE-CASTING PROCESS ATTACH

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4. RESEARCH AND APPLICATION OF RHEO-DIECASTING PROCESS FOR THICK-WALL COMPONENTS

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Rheo-casting process of Al-Si alloy is studied in two different routes: by cooling slope and by blowing inert gas into the melt. The microstructure obtained is fine, spheroidal form with grain size less than 40 □m, roundness factor less than 1.5. Combined with high-pressure die-casting process a new process, known as rheo-die casting is developed for thick-wall components, such as pump body, which is in general difficult to produce by die-casting method because of the pore formation. The result is good: the component structure is sound, almost no pore was found.