THE EGYPTIAN INTERNATIONAL FOUNDRY CONFERENCE PROGRAM

EGYCAST 2022

ORGANIZED

BY

THE EGYPTIAN FOUNDRYMENS SOCIETY

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THE CENTRAL METALLURGICAL R&D INSTITUTE

THE TABBIN INSTITUTE FOR METALLURGICAL STUDIES

14-17 OCTOBER 2022

HURGHADA

Limitations and advancements of Sodium Silicate Inorganic Sand Binders; A Review

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Abstract

The use of Sodium Silicate as an inorganic eco-friendly sand binder is escalating. However, due to the inherent limitations the binder poses, it is not widely industrialized except in certain low-melting alloys casting. Curing performance, thermal stability, and moisture resistance are the major limitations currently addressed. This review aims to understand the fundamentals of these limitations and investigate the solutions proposed by researchers. Then we will analyze the applicability of these solutions in the high-tech area of 3D sand printing. From our analysis, we conclude that the curing mechanism is affected by the nature of the process (physical or chemical curing), the hardeners employed, the SiO2/Na2O molar ratio, and the pH of the medium. The thermal stability is directly affected by the curing mechanism, the morphology, and type of sand particles, and the presence of additives. Finally, moisture resistance is affected by the curing mechanism which is catalyzed in a high-temperature humid environment and hindered by promoters. Furthermore, the constraints of the high-tech application in terms of viscosity, solubility, and collapsibility reduce our freedom in tackling these limitations.

Keywords: Curing, Crosslinking bridges, Syneresis, Thermal deformation, Hygroscopy.

Fabrication of Aluminum Tanks from recycled Cans

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Abstract

Soft drink cans are being produced in huge amounts all over the world. However, most cans are being fabricated from aluminum. Recycling of such cans is a national target for introducing it in useful industrial applications. In the present study, the aluminum cans were melted and reinforced with nano-silicon carbides (SiC) particles. These particles were of average 50 nm size. Different percentages of SiCp were added to the cast (0, 2.5%, 5%, and 10%) using the stir casting technique. The cast samples were
rolled to improve reinforcement-particles dispersion, consequently, enhance the mechanical properties. Reference samples were cast to evaluate the enhancement before and after rolling. Microstructure observations were done using light optical microscopy (LOM). Different phases were detected using scanning electron microscope attached with energy dispersive x-ray spectroscopy (SEM-EDX). Additionally, some mechanical properties were studied. Optimization of results showed that plates reinforced with 5% SiCp revealed the highest strength and ductility. A prototype tank was fabricated using tungsten inert gas (TIG) welding. It was inspected with non-destructive testing (NDT). It revealed freedom from defects. The satisfactory results (theoretical and experimental) implies that the tank meets the design requirements and can be safely introduced into the industrial applications.

A study on the Microstructure of Heat Affected Zone of Austempered Ductile Iron Alloyed with 1.6% Cu and 1.6% Ni

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Abstract

Heat Affected Zone (HAZ) is the area where one or more changes from the starting state to the solid state engaged in heating have occurred as a result of the welding heat cycle. In this study, we attempted to weld Austempered Ductile Iron (ADI) of initial alloys ferritic matrix using Shielded Metal Arc Welding (SMAW) with E6013 electrode. A total of six alloys of ADI were austempered at 360 °C for 180 minutes after being austenitized at 900 °C for 15, 30, 60, 120, 180, and 360 minutes. The microstructures of the weld joint were characterized by using Optical Microscope OM, and image-processing technique. The microstructure of the partial fusion zone (PFZ) has nodular graphite, pearlite, and a little of martensite; austenite transformation zone (ATZ) consists of nodular graphite plus pearlite. Only a part of the austenitic- ausferitic matrix can transform to austenite at the repeated transformation zone (RTZ). No obvious change in the microstructure at the base metal zone (BMZ).

Keywords: Austempered, Ductile Iron, Microstructure, Affected zone, ADI, welding.

Effect of alloying elements on wear behavior of A356 Al-Si alloy

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Abstract

In this study, the Al-Si alloy (A356) was prepared in laboratory from high purity commercial alloys. alloying elements were added to the Al-Si alloy (A356); in the commercial purity; the first element is copper was added to the Al-Si alloy (A356); in the form of master alloy Al-30 wt.% Cu; with different percentage varied from 2 to 4 wt.%, Tin is the second element was added to the Al-Si alloy (A356); with different percentage varied from 1 to 3 wt.% , the last element is zinc was added to the Al-Si alloy (A356); in the commercial purity; with different percentage varied 2, 4, and 6 wt.%. The alloying elements were added to understand its influence on wear behavior of A356 Al-Si alloy in as-cast and heat treated condition. Wear test of alloys was carried out using homemade pin-on-disc wear tester at constant load of 0.886 Kgf and at sliding speed of 250 rpm. SAE 1040 steel was used as the disc material with 62 HRC in the wear tester. The results showed that The wear resistance of A356 alloys, either in as-cast or T6 conditions, increases proportionally with Cu added amount. The heat treated alloys generally have bitter corrosion resistance than as-cast alloys. while increasing tin content in the as-cast or T6 conditions increases wear resistance by 80% and 85% respectively. Addition zinc to A356 alloy in the as-cast or T6 conditions increases wear resistance by 93% and 31.5% respectively.

Keywords: Al-Si alloys, alloying elements, T6, wear resistance

Heavy duty ceramic dopped steel castings for sever applications

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Abstract

In this research a heavy-duty casting made of low alloy steel with ceramics dopped surface was developed to replace high manganese hadfield steel castings. The synthesis of the steel was carried out in a medium frequency induction furnace. At first the blend of steel scrap (0.41%C, 0.73%Mn, 0.28%Si, 0.023%P, 0.013%S, 0.85%Cr, 1.82% Ni and balance Fe, all in wt.%) was melted and heated to 1,580 C, followed by casting in the investment mold that has been designed and used for hadfield steel castings. The product technology as melt as surface finishing were studied and established. The effect of ceramics materials was analyzed highlighting how different ceramic materials were used can affect the final mechanical properties of the steel casting and surface wear resistance, aiming to optimize the best technological parameters, as well as looking at how ceramics composite materials effect on the working outer surface for induces the local reinforcement of the casts.

Keywords: cast steel, ceramics, manganese steel, wear resistance, hardness, mechanical properties

Failure Analysis of Ball Clevis Fracture (Case Study)

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Abstract

The failed ball clevis part is a component of the double tension string assembly for the 220 KV electricity transmission overhead line. Two ball clevis parts were connecting the yoke triangular plate with the ends of the two insulators racks. The failure of one ball clevis part occurred during maintenance works. The samples that were examined are four samples, two of them are locally made (one is intact and the other is broken), and the other two were imported from Japan and Italy. Detailed failure analysis was performed including visual examination, chemical analysis, hardness testing, microstructural characterization including light microscopy, scanning electron microscopy and energy dispersive x-ray spectroscopy. The results indicated that the local specimens are both made from ductile cast iron while the imported specimens are made from medium carbon steel. the microstructure of the local specimens (failed and new) revealed number of casting defects such as blowhole and pinhole cavities, large slag inclusions as well as areas of abnormal non-homogeneous structure of nodular, chunky, worm-like and flake graphite. The microstructure of the imported ball clevis samples is ferrite – pearlite typical of forged medium carbon steel parts and there are no metallurgical defects were observed.

Key words: Ball Clevis, ductile Cast Iron, Cast Defects, medium Carbon Steel.

Metallurgical Failure Analysis of Bearing Cover Fracture in Liquid Oxygen Pump (Case Study)

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Abstract

The bearing cover component of liquid oxygen pump was exposed to high stresses possibly due to mechanical vibration causes of bolt loosening, misalignment, etc, which started the cracking and led eventually to component fracture. No data was available about the bearing cover material. In the present investigation the root cause for the failure of a bearing cover component has been carried out. After a through visual examination of the as received pieces of the fractured cover, the following tests were carried out in order to arrive at the cause for the observed failure; elemental analysis; hardness; microstructural characterization using optical microscope (OM) and scanning electron microscope (SEM) with energy dispersive spectroscopy EDS analysis and fractography of the fractured parts to reveal the nature of failure. The results showed that the bearing cover material indicated that it is made of high phosphorus gray cast iron. The microstructure of is mainly Type A graphite flakes full pearlitic matrix in the core and has mixed type D graphite in ledeburite matrix in the thin parts and close to the surface. High volume fraction of eutectic iron phosphide (Steadite) with MnS as non-metallic inclusions. The causes of failure of the bearing cover component are the presence of iron phosphide (Steadite), casting defects / cavities, under cooled graphite, non-metallic inclusions reduced the material ductility and toughness. The failure mechanism is brittle transgranular cleavage fracture.

Key word: Liquid Oxygen Pump, Bearing Cover, Gray Cast Iron, Iron Phosphide

Metallurgical Failure Analysis of Insulator Metallic Caps in High Voltage Transmission Lines (Case Study)

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Abstract

Cap and Pin insulators are generally used on overhead transmission and distribution network to evacuate bulk power over long distance. The insulators could be in suspension or tension mold in string form to insulate the conductor from tower. Cap is the normal product for suspension insulators. Material for cap could be cast iron, cap have various kinds of design, including socket cap, tongue cap, clevis cap, etc. Mechanical damage of insulator caps due to short circuit during service in high voltage (500 KV) transmission lines. The received 5 insulators iron caps two of them were failed in service and other are new. The outer surface of all caps is galvanized. Detailed failure analysis was performed including visual examination, chemical analysis, hardness testing, microstructural characterization including light microscopy, scanning electron microscopy and energy dispersive x-ray spectroscopy. The results indicated that the composition, microstructure and hardness of the examined 4 caps indicate that the material characteristics conform to the ductile iron. The main cause of failure is the exposure of the insulator metallic caps to multiple arc strikes resulting from environmental conditions or damage of insulators that led to localized melting and change of microstructure of the heat affected zones causing loss of ductility and formation of quench cracks that eventually developed to complete fracture of metallic caps.

KeyWords: Ductile cast iron, insulators iron caps, casting defects, arc flashover strike.

Effect of TiO2 Nanoparticles Addition on the Microstructure, Thermo-Mechanical, and Electrochemical Properties of Al-Zn Alloy

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Abstract

The present study explores the preparation of Al-Zn alloy by the casting process and the effect of adding TiO_2 nanoparticles to the alloy. First, microstructures of both alloys were observed using a scanning electron microscope and the optical microscope to investigate the effect of the nanoparticles addition. In addition, the mechanical properties of both alloys were characterized using Vickers microhardness and stress-strain tests with different aging temperatures. The results show that the appropriate addition of nano-TiO_2 particles can refine the Al-Zn alloy and improve its mechanical properties and corrosion resistance.

Keywords: Al-Zn alloy; TiO_2 nanoparticles; microstructures; mechanical properties; corrosion resistance.

Evaluation and Control of Steel Clearness

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Abstract

In this "article review" the evaluation and control of steel cleanliness are reviewed. To meet increasingly severe quality requirements for steel in recent years, the technologies for producing clean steel have been developed. The need for cleaner steel requires decreasing the amount of impurities and controlling their size distribution, morphology, and composition. Because there is no single method to measure all of these aspects accurately, it is best, to combine several methods to evaluate steel cleanliness. The operation practices to improve steel cleanliness at the melting furnaces, ladle operation, tundish, and casting are reviewed, and touch on the prospects of improving steel cleanliness are pointed. A general observation is that a lot of work in progress concerning the development of clean steel processes and cleanliness evaluation.

Study on equilibrium and non-equilibrium solidification of low carbon boron-containing high-speed tool steel: effect of cooling rate and microstructure investigation

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Abstract

This work aims at understanding the microstructure features of new and developed low-carbon boron-containing high-speed tool steel (0.005 and 0.05wt.%). The investigated steel was explored during solidification under equilibrium and non-equilibrium conditions. SCHEIL-GULLIVER solidification simulation model and Thermo-Calc software were used for theoretical studies. SCHEIL-GULLIVER solidification simulation model was used to study the effect of the cooling rate on the microstructure of the investigated steel produced under non - equilibrium conditions. On the other hand, Thermo-Calc software was utilized to predict the changes in the microstructure characteristics of boron-containing high-speed tool steel in equilibrium conditions. For example, solidification starting temperature, chemical composition, and amount of each constituent. Furthermore, Thermo-Clac software was benefited for calculating the volume fraction and chemical composition of particles precipitated. The microstructure of produced steel was studied experimentally using optical microscopy and X-ray diffraction. The size and count of non-metallic inclusions (oxide – carbide, etc.) were intensively examined using Image analysis testing of produced steel.

The Scheil solidification simulation study results show that the cooling rate has numerous effects on the three-main-solidification reactions of investigated steel. The experimental results for microstructural investigation were close to the predicted data obtained by Thermo-Calc software. The experimental results demonstrate that the microstructure of the low carbon born containing steel is dense, well homogenous distributed, and higher ferrite volume fractions change with boron contents. Both variation of boron contents and the cooling rate did not only affect the amount of different constituents but also their chemical compositions.

Keywords

Tool Steel, Solidification, Non-Equilibrium, Boron, Microstructure

Applying the Concepts of Sustainability in Planning and Designing of Industrial Zones

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Abstract

Most of the developing countries - after gaming political independence - turned to industrialization as the only way to achieve economic growth and social progress. These countries considered industrialization the only path to development, forgetting that industrialization in developed countries is the product of economic, social and technological developments and booms that these countries have gone through for more than three centuries, during which the latter colonized the first and plundered their wealth, and eradicated the primitive industrial systems and craftsmanship in them, and prevented them to create and develop their own cognitive methods. This research aims to apply new strategies to achieve sustainability in industrial areas. Therefore, the research presents some new strategies to achieve sustainability in industrial areas, through which these areas are re- developed and rehabilitated as cultural polarization areas, in addition to the transfer and relocation of industries, along with technical poles, belts and green areas for a sustainable industrial city, with the integration of transportation methods and land use and the implementation of the strategy of the smart industrial city and the smart factory to activate the industrial city. The goal of the application was achieved by choosing an application model in Egypt, which is the city of leather in Rubiki, in Badr City, near Cairo, and an analytical study was made of its use of strategies to achieve sustainability. The strategies required for development have been applied, and experience has proven the success of this model, and it is distinguished from the current models by a set of advantages, as the system helped to achieve a sustainable industrial city, and dealt well with the problems existing in the industrial areas. We recommend at the end of the research the implementation of strategies to achieve sustainability in industrial areas.

Synthesis, characterization and simulation of Al-Si composites for automotive applications

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Abstract

The use of composites has directly enhanced the capability of fuel-efficient aircraft in the commercial arena and new-generation aircraft in the military sphere. A significant increase in the properties makes it possible to achieve the formation of a composite structure in aluminum alloys by introducing reinforcing ceramic particles into them. However, the aluminum-based composite materials currently developed, although superior in mechanical properties to classic aluminum alloys, do not always meet the requirements for their thermo physical characteristics. In this regard, the urgent task is the development of new compositions of composite materials for the automotive industry, with a good set of both mechanical and thermal properties. Al-Si/SiC composites were successfully manufactured using stir and squeeze techniques. Microstructure, aging behavior, hardness, thermal and mechanical properties were inspected. Microstructural investigation showed a uniform distribution of particles in Al-Si matrix and a significant reduction in porosity. Interfacial analysis indicated considerable bonding between the matrix and particles. Hardness, ultimate compressive and yield strength increased as particles content increased from 5 to 15 wt.%. Furthermore, aging process of Al-Si / SiC composites was accelerated by increasing particles content. Finite element modeling showed the dependence of the stress induced in the composite on the distribution of particles.

Keywords: SiC composites; Microstructure; Mechanical properties; Thermal properties; Simulation.

FAILURE ANALYSIS OF WELDED STEAM BOILER FLANGE

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Abstract

Steam boiler flange made of carbon steel alloy ASTM A105 was failed at area adjacent to the welding zone when the operating pressure and temperature suddenly increased over than designed ones. The failure occurred after 6 years in service. The flange and connected pipe failed segments was received for failure analysis and data collections. The flange was subjected to visual examination, non-destructive test, chemical analysis, microstructure observation, and hardness test. The results of chemical composition showed the conformity of flange material with the required specifications of ASTM A105, typically microstructure, hardness values with no abnormalities or creep indications. Also, the absence of cracks close to the ruptured area is excluding the possibilities of defective materials or overheating. Macro and micro-structures examination of the weld joint showed numerous welding defects such as porosity, lack of fusion and non-metallic inclusion at the boundary line between the root and filling passes. Apparently, the steam boiler flange material fractured due to fatigue crack. Fine striations within the beach mark of the fractured surface observed by SEM give a strong indication of fatigue failure. The crack initiated at the edges of welding defects and proceeded in the flange material due to the fluctuating radial stresses resulted from increasing and decreasing working pressure during service. A proper welding technique carried out by qualified welders are recommended for prevention of similar failure in the future.

Keywords: Steam boiler flange, carbon steel, welding defects, fatigue failure, proper welding technique, qualified welders.

Effectiveness of controlling parameters of Manganese direct alloying of the steel.

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Abstract

Manganese direct alloying (DA) of the steel has a high impact on steel making economics improvement and resource savings. Therefore, this study's aim was investigating effectiveness and the optimum conditions of the parameters controlling the Manganese DA technology. Manganese DA percentage, reductant (coke) amount, basicity of briquettes and raw material source were considered the controlling parameters in this study. Experiments and material balance program were set and designed. The raw materials were prepared and blended upon preset design. Briquettes were formed and dried. The manganese DA was conducted in 30 kg induction furnace. The metallic yield and recovery were calculated for each experiment and an analysis of variance was determined. Finally, the Effectiveness of controlling parameters of Manganese direct alloying of the steel was determined.

Keywords: Manganese direct alloying, ferromanganese, briquetting, design of experiments, analysis of variance.

Effect of Si-addition and heating rate on thermal expansion of Ti-15Mo-xSi alloys

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Abstract

Thermal expansion measurement was carried out for characterizing phase transformation of (Ti-15Mo-xSi) at different heating rates of 5 and 10 ∘C/min. Five Ti-15Mo-xSi alloys (where x = 0, 0.5, 1.0, 1.5, and 2wt.%) were studied regarding microstructure, initial and final transformation temperatures for getting majority of β phase. The results showed that as-cast samples primarily containing equiaxed β-Ti phase. The effect of transformation on samples dimensions is discussed and compared with changing Si contents for the investigated Ti-alloys during continuous heating and cooling using a dilatometric technique. Dilatometric heating curves obtained that two characteristic reflection points can be observed with increasing heating temperature. For the sample without Si addition, initial transformation temperature (Ts) was reported at 359 °C, and final transformation temperature (Tf) at 572 °C. For the samples containing Si between 0.5 to 2%, the initial and final transforming temperatures using first derivative curves were registered at 270-359 °C and 540-572 °C, respectively. In addition, thermal expansion coefficient of the investigated Ti- alloys without and with Si-addition has been studied. The transformation heating curve of the studied Ti-15Mo-xSi exhibiting typically S-shaped pattern.

Fabrication of Aluminium Composites using Recycled Swarf

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Abstract

In this study. Aluminuim Metal Matrix Composites (AMMCs) were fabricated using aluminium swarf. Recycled swarf was used as a matrix that is reinforced either by single (SiCp) or milled hybrid silicon carbides / Graphene / Silver (SiCp/GN-Ag) nano particles . The investigated composites were melted at 720 Celsius , whereas the nano particles were added at stirring rate of 650 rpm and stirring time of 5 minutes using stir casting technique. Four Friction Stir Processing (FSP) passes were applied for a group of cast composites to improve nano particles distribution within the matrix and also reduce or eliminate casting defects . The other composites group was used in its cast condition without applying FSP that is for the comparison purposes .

The microstructure observations using Light Optical Microscopy (LOM) and Scanning Electron Microscopy (SEM) , accompanied with analysis like X-Ray Diffraction(XRD) , Raman and TEM were recorded. The mechanical properties of friction stir processed samples were enhanced as UTS , Hardness was and elongation for reference and 3% hybrid reinforced composite typically.

White cast irons and high Cr-white cast irons: Types, Microstructure and Applications

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Abstract

The most common abrasion-resistant ferrous materials having carbon greater than 2wt% in the form of cementite is called white cast iron. Whit cast irons, and specifically high chromium white cast irons, have been developed worldwide for making mechanical components of crushing and grinding machines due to the combination of high wear resistance and good mechanical strength. Microstructure of white iron contains massive cementite (white) and pearlite. Most white cast irons contain less than 4.3% carbon, with low silicon contents to inhibit the precipitation of carbon as graphite. Based on the amount of alloying element existing in the white irons, they can be classified into different groups as normal white cast irons, low alloy white cast irons, high alloy white cast irons, nickel-chromium white cast irons, chromium-molybdenum white cast irons, and high chromium white cast irons with Chinese standard, ASTM standard and Australian Standard. Normal white cast iron has no alloying element, low alloy white iron contains less than 5% alloying elements and high alloy one has more than 5% alloying elements. White iron is used usually in applications where abrasion resistance is important and ductility not required, such as liners for cement mixers, ball mills, certain types of drawing dies and extrusion nozzles. White iron is generally considered unweldable. The absence of any ductility that can accommodate welding-induced stresses in the base metal and heat affected zone adjacent to the weld results normally in cracking during cooling after welding. White cast irons can be also heat treated by applying hardening (austenitising, air-quenching) and tempering to induce maximum abrasion-resistance with reasonable fracture-toughness. Annealing, stress relieving can be also applied.

Breed Great Mischief, Case Study of Chlorine Cylinder Explosion

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Abstract

A one ton chlorine cylinder has exploded after two days of charging at El Nasr Company for Intermediate Chemicals -Abu Rawash . As a result of this explosion, a mushroom - shaped chlorine smother was formed and extended over an area of 40m diameter. The accident was immediately dealt with using water jets and the cylinder was moved farther away from the storage area.

The exploded cylinder was sent to Central Metallurgical Research and Development Insatiate (CMRDI) to perform detailed investigations, as the institute investigates metallic failures where a fatality, substantial property damage, or significant environmental impact has occurred.

Detail investigation shows that, all valves and fusible safety plugs were in good condition, without blemish. cylinder thickness within the acceptance range. Also, the main weld lines in the cylinder head are free from defects.

Based on the results obtained in this investigation, it could be concluded that the cylinder failure may be attributed to a manufacturing defect, As the breakdown started in minor weld, that is the poor-quality weld of the protective U-shape beam circulating the cylinder for safe handling.

Limitations and advancements of Sodium Silicate Inorganic sand binders in 3D sand printing

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Abstract

According to the Environmental Protection Agency, 70% of the metals are produced by sand casting. This emphasizes the importance of using eco-friendly inorganic sand binders for casting applications. Sodium Silicate has been utilized in sand binding since 1950 and is continuously modified till now. However, the binder is not widely used except in casting of low-melting point alloys due to its inherent limitations. In this review, we are addressing the thermal stability, the curing performance, and the moisture resistance as the main limitations facing Sodium Silicate binders. Our aim is to first understand the fundamentals of the limitations. Then, investigate how authors and companies tackled the limitations using different mechanisms and additives. Then, analyze how their solutions can be implemented in high-tech advancements like 3D sand printing, and ablation casting. Finally, we are recommending more attention to the research gaps found. From our analysis, we conclude that the curing mechanism is affected by the nature of the process (physical or chemical curing), the hardeners employed, the SiO_2/Na_2O molar ratio, and the pH of the medium. The thermal stability is directly affected by the curing mechanism, the morphology, and type of sand particles, and the presence of additives. Finally, moisture resistance is affected by the rate of reverse hardening which is catalyzed in a high-temperature humid environment and hindered by promoters. Furthermore, the constraints of the high-tech application, 3D sand printing, in terms of viscosity, solubility, and collapsibility reduce our freedom in tackling these limitations.

Keywords: Sodium Silicate binders, 3D sand printing, Curing, Crosslinking bridges, Syneresis, Thermal deformation, Hygroscopy

Failure Analysis of Rail Vehicles Screw Coupling

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Abstract

In screw coupling, the strength and impact resistance are among the most important factors contributing to the fracture behavior of these parts. The best mechanical properties can be provided by defect free structure (2). For example, the existences of casting defects, stress concentration, reduce the load-bearing capacity of any parts. Thus, the manufacturing defects normally determine the final mechanical properties of the parts (3).

The present study was carried out to determine the failure causes of the screw coupler, with regards to the metallurgical and mechanical aspects.

The results shows that the surface finish of both screw and link (very rough surface finish), the variation of link material from the recommended one in UIC Code (International union of Railways) and the inappropriate heat treatment process applied on the screw material that lead to the poor mechanical properties and the wrong microstructure; all contribute to the occurrence of fatigue failure of the screw. However, the existence of inclusion in the link leads to its brittle fracture. Both contribute to the failure of the screw coupling of Train. Moreover, the quality of forging (existence of porosity and cold lap defects) has a great effect on the performance of screw coupler. Many recommendations were illustrated to overcome the occurrence of such failure case.

Domestic Ferroalloys industry: Current Status and Future Prospects

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Abstract

The ferroalloy industry is closely related to the steel industry. Ferroalloys are added during the steel production process to improve various properties such as tensile strength, hardness, plasticity, fatigue resistance, corrosion resistance and friction resistance, in addition to other tasks such as reduction and oxidation processes and control of non-metallic inclusions in steel.
The ferroalloy industry began in Egypt in the second half of the twentieth century. In the late sixties and early seventies of the last century, the production of ferrosilicon alloy began at Kima Company in Aswan, depending on the availability of quartz ore and exploiting the electric energy generated by the High Dam.
The Egyptian Ferroalloys Company was established in 1976 for the purpose of producing ferrosilicon and other ferroalloys. The site was chosen in the city of Edfu, for its proximity to the source of electric power and also for the availability of pure quartz ore in the Umm Heglig area. The company has four submerged electric arc furnaces, each with a capacity of 25 MVA, with a production capacity of about 48,800 tons per year of ferrosilicon alloy. The operation of the first and second furnaces began in the first half of 1987, and the third and fourth furnaces operated in the second half of 1988.
On the other hand, the Sinai Manganese Company was established in 1957 to exploit manganese ores in Sinai. The ferromanganese factory was established in 1966 in the city of Abu Znaima in South Sinai to exploit the manganese ores available in the Umm Bagma area in South Sinai in the production of ferromanganese alloys. However, the work was stopped in 1967 as a result of the Israeli aggression. After the October 1973 war and the liberation of Sinai and its return in 1979 to the arms of the homeland, the company rehabilitated the ferromanganese factory, and the actual production began in 1993 with a production capacity of 36,000 tons per year of high-carbon ferromanganese alloy containing 75% manganese and 6-8% carbon using a closed submerged electric arc furnace and a power station operating with a capacity of 21 MW. This alloy is produced from local manganese ores, imported manganese sinter and local fluxing materials (limestone and dolomite) using coke as a reducing agent.
At the beginning of 2021, the Sinai Manganese Company started the industrial production of silicon manganese alloy to meet the needs of Egyptian steel companies from this alloy. At this stage, domestic manganese ores and manganese sinter are used as a source of manganese in the production of silicon manganese alloy. After implementing the industrial line to produce high manganese slag and low manganese pig iron from poor, low-grade domestic manganese ores, the produced high manganese slag (instead of manganese sinter) will be used with local manganese ores in the production of silicon manganese alloy.
Domestic steel production witnessed a steady increase during the second half of the twentieth century and the elapsed years of the twenty-first century as crude steel production increased from about 0.7 million tons in the middle of the twentieth century to about 10 million tons in 2021.
This increase in steel production is accompanied by a steady increase in the consumption of ferroalloys. This requires the expansion of the local production of ferroalloys by exploiting the available capabilities and raw materials to increase the added value of local ores, support the local manufacturing of Egyptian products, reduce the import bill and drain foreign exchange, in addition to the possibility of exporting to the global market, which increases the foreign exchange earnings coming into the country.
In this paper, we review the possibilities of producing some ferroalloys locally at the industrial level, which the research team in the Steel and Ferroalloys Department at Central Metallurgical Research and Development Institute succeeded in producing at the pilot plant level at CMRDI. These ferroalloys include ferrosilicon-magnesium, low and medium carbon ferromanganese, high and low carbon ferrochrome and ferrotitanium.

Ultrafine Structured Austempered Ductile Iron (ADI)

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Abstract

This paper discusses new novel approach to produce ADI with ultrafine structure and unique combination of mechanical as well as physical properties. Ultrafine ADI structure was achieved by applying ultrasonic treatment (UST) during solidification of the molten iron, an approach seems easier to implement than the thermomechanical treatment. Extensive metallographic investigations show that the ultrasonically treated ductile iron samples provide extremely fine graphite and excessive nodule count with more than 2000 nodule/mm^2. The rather high nodule count of the fine graphite resulted in decrease the size of eutectic cells; therefore, after performing austempering heat treatment, an ultrafine ausferrite is produced in the ADI. The dilatometry studies for the developed ADI alloys showed that the time required for the completion of the ausferrite formation in UST alloys was four times shorter than that required for statically solidified SG irons. SEM micrographs for the ADI alloys showed an extremely fine and short ausferrite structure together with small austenite blocks in the matrix.

Keywords: Austempered Ductile Iron, microstructural refinement, thermo-mechanical treatment, dynamic solidification, ultrasonic treatment, intercritical ADI, kinetics of austempering, dual phase ADI.

An overview on Thin Wall Cast Iron Castings and its Applications in Automotive Industry

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Abstract

New trends in the design of automotive components have been focused in the production of thin-wall cast iron castings in order to save materials and energy. Recently, there has been an increase in demand for thin wall iron castings (TWCI) with a wall thickness below 3 mm and with a high strength to weight ratios. The development of thin wall technology will permit the automakers to make a better informed choice between competing materials and thin wall cast iron with its different types (DI, ADI, SiMo DI and Vermicular graphite iron), thus decreasing the overall cost of the automobile. The effect of various parameters to produce sound and free-carbides ductile iron castings was discussed. The parameters included molding materials, chemical composition, pouring temperature, types of inoculants and its amount as well as austempering treatment parameters for ADI and other foundry basic practices. New trends and developments of thin wall castings for four grades of iron casting have been reported. The four grades are: ductile iron for primary pump bodies, ADI for gears and hollow connecting rods, heat resistant SiMo for exhaust manifolds and finally vermicular graphite iron for heads and brake systems. Recent research work at CMRDI has revealed that thin wall cast iron plates (3mm thick) made of DI, ADI and SiMo DI can be produced without carbide formation by controlling the parameters mentioned above.

Recyclability of Aluminum Piston Alloy

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Abstract

Aluminum is one of the most recycled and recyclable materials in use today. A recycled aluminum cans, car parts or window frame is often recycled directly back into itself. Recycling is a critical part of the modern aluminum business. Making recycled aluminum only takes around 5% of the energy needed to make new aluminum, reducing carbon emissions and saving money for businesses and end consumers. As a result, nearly 75% of all aluminum ever produced is still in use today. In most industrial markets like automotive and building, recycling rates for aluminum exceed 90%. Industry recycling efforts in the U.S. save more than 90 million barrels of oil equivalent each year. Capability to re-melting aluminum alloys scrap without losing its alloying elements and finding optimum pouring temperature are the purpose of this paper, and the results will determine the possibility of reusing piston alloy to make components similar to those they were recycled from. Automotive cast aluminum scrap obtained from pistons were used as experimental specimens, which melted via an electrical furnace then poured at four different temperature 680, 720, 760, and 800 °C into a strip fluidity steel mould. The chemical composition of the four specimens were examined using spark emission spectrometer and the length of melted metal that flowed through the mould strips was measured as well, to determine fluidity. Also, an optical microscope used to detect microstructure defects. The chemical composition ratios of alloying elements before and after recycling showed that the resulting alloys could be closely equivalent to the commercial alloy that was originally used to make the components. In addition, higher the pouring temperature greater the casting fluidity. Generally, the consumed aluminum piston alloy can be re-melted and used to produce many parts.

Keywords: Cast, Recycling, Aluminum Piston alloys

Modeling and experimental investigation of machinability of cast α/β titanium alloys using wire electrical discharge machining (WEDM)

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Abstract

Titanium (Ti) alloys are considered hard to machine materials, and therefore, wire electrical discharge machining (WEDM) is preferred over the conventional turning and milling processes for machining Ti- alloys. The present work used response surface methodology (RSM) to evaluate the effect of two different input parameters, cutting speed and number of cuts, on surface roughness (Ra). In addition, analysis of variance (ANOVA) was also used to find out the most significant factor on surface roughness. Furthermore, surface integrity and surface hardness of Ti-6Al-7Nb (Ti67) and Ti-6Al-4V (Ti64) have been evaluated under rough cut and trim cut modes of the WEDM process. The rough-cut mode resulted in high thermal damage with high surface roughness (Ra) 5.68 and 4.53 μm in Ti67 and Ti64 respectively. In contrast, Significant improvement in surface properties of Ti67 has been obtained using trim cut mode with reduced surface roughness (0.96 μm), and (0.88 μm) of Ti64. Rough cut and trim cut modes of WEDM played a significant role in enhancing the surface hardness of the two alloys.

Keywords: Ti-6Al-7Nb, Ti-6Al-4V, WEDM, RSM, surface roughness, micro-hardness

Nickel Based Superalloy Castings for Different Applications

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Abstract

A superalloy, or high-performance alloy, is an alloy able to withstand extreme temperatures that would destroy conventional metals like steel and aluminum. Nickel based superalloys are selected for use in certain applications due to their characteristics. These alloys have an exceptional combination of high temperature strength, toughness, and resistance to degradation in corrosive or oxidizing environments. Among the important characteristics are creep
resistance at high temperatures, good surface stability, and corrosion and oxidation resistance. Because of these characteristics they are widely used in aircraft and power-generation turbines, rocket engines, nuclear power and chemical processing plants and other challenging environments. The availability of superalloys during past decades has led to a steady increase in the turbine entry temperatures, and this trend is expected to continue. New generations of superalloys can tolerate average temperatures of 1050°C with occasional excursions to temperatures as high as 1200°C, which is approximately 90% of the melting point of the material. Increased operating temperatures and higher efficiency in gas turbines and jet engines can reduce CO_2 emission, thus contributing to the slowing of climate change.

Keywords: Ni Base Superalloys, casting, metallurgy, development, properties, applications.

Failure analysis of firefighting underground pipe

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Abstract

6” seamless firefighting underground pipe failed in the form of many cracks on 6 clock position resulting in water spill. The failed pipe was investigated to establish an overview of whether its failure is related to material aspects or operating conditions. The procedure of investigation was built on studying the parent material and rupture area. Composition analysis, mechanical properties, and microstructure of the pipe material were conformed to AWWA151 ductile cast iron. Based on the obtained results from visual inspection, MT and microstructure observation, failure had no connection to material aspects but it was directly related to mechanical dents on the outer surface of the pipe. The root cause of cracking occurred in the received pipe is due to mechanical dents which initiate cracks from the outer surface to inner surface of the pipe.

Failure Analysis of Pipe to Elbow Weldments at Fuel Gas Plant

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Abstract

Failure analysis of 1" pipe to elbow drain scrubber discharge weldments at fuel gas plant was investigated. After ~ 4 years operation the pipe welded to the 90° elbow was showed severe leakage. In order to find out the cause of failure, detailed study was carried out using visual inspection, dye penetrant testing and magnetic particles inspection, together with ultrasonic thickness meter to measure the remaining pipes wall thickness. Microstructure was investigated using optical microscope and scanning electron microscope (SEM) equipped with energy dispersive x-ray analysis (EDX). Chemical analysis of the tube and elbow base metals was examined using spectroscopic analysis. Internal corrosion products were analyzed using x-ray powder diffraction (XRD) and EDX.

Spectroscopic analysis of the 1" pipe and elbow base alloys was conformed to the ASTM A105. XRD analysis of inner surface corrosion products revealed existence of

iron oxides, iron sulfide, iron sulphate $Fe_2(SO4)_3$ and $FeSO_4.H_2O$. In addition, Iron chloride hydrate and Halite (NaCl) were also detected.

In the outer surface of the failed pipe near pipe to the 90° elbow weld joint, deep undercut was observed due to wrong welding technique, from which cracking was initiated. At the inner surface of the failed pipe stress corrosion cracking (SCC) was observed. Misalignment of the pipe welded to 90° elbow is obvious as well as the 45° elbow. Excessive weld penetration, porosity and slag inclusions were seen in the pipe to elbow welded joints. The 90° elbows is large in size for the 1" pipe, therefore high amount of heat input was used to fill the gap between elbow and pipe. Although, the 90° elbow is threaded type it welded to the non-threaded pipe and the 45° elbow is socket welding type it welded to threaded pipe.

Failure is attributed to wrong welding technique, misalignment, wrong elbows size and short pipe length (~ 3cm length) welded to two elbows, resulted in high residual stress assisted stress corrosion cracking (SCC)in sulfide and chloride containing fluid. To overcome this problem, welding should be done by qualified welder. Prior to welding confirm alignment, check appropriate elbow size to fit in pipe. Inspectors should follow up during welding.

Manufacturing of new generation of HSS reinforced with GNSs suitable for machining of high chromium & austempered ductile cast irons

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Abstract

Powder metallurgy technique was used for manufacturing of high-speed steel (HSS) S390 alloy. The effect of nano-graphene additions on microstructure and mechanical properties of S390 HSS alloy were investigated. Mechanical milling for 48 hours in a planetary ball mill with the addition of different ratios of nano-graphene sheets (0,0.25,0.5,0.75,1%) was established. The mixed powders were warm compacted by uni-axial press at 550 ◦C under 500 MPa. Then sintering process was achieved in a vacuum furnace at 1370◦C for 1 hour. Density and mechanical properties were evaluated for the studied samples. X-ray diffraction analysis was used for investigating the milled powders and sintered samples. The specimens were metallographically examined using Scanning Electron Microscopy (SEM). XRD pattern of S390 HSS powder after milling process revealed the presence of (γ) iron (Austenite) and also a small peak of (α) iron (Martensite). There are four principal carbide phases were identified which are corresponding to Fe3W3C and the smallest one for Cr_2C_3 and the other two peaks for VC and M_6C (tungsten rich carbides). In addition, a peak for molybdenum metal was found at 2θ 74 degree. XRD pattern after sintering of compacted samples showed three mean peaks belonging to (α) iron (Martensite) phase, while (γ) iron (Austenite) disappeared. The other carbide peaks (VC, Cr_2C_3, M_6C) were also presented and there was no change. Both hardness & wear resistance increased as the graphene percent increased due to the formation of more primary carbides that formed during solidification with coarse microstructure.

Keywords: High speed steel, Nano-graphene sheet, Powder metallurgy, Mechanical properties, Microstructure.

Advantage of Continuous Temperature Measurements in Continuous Casting (CasTemp System)

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Abstract

Temperature of liquid steel (in Tundish) is one of the most important parameters during continuous casting. Accurate temperature measuring decreases the possibility of break outs and freezing. Also, enable the operation to be completed economically by keeping the minimum superheat to save energy and improve the quality. The advantages of continuous temperature measuring (technically and commercially) have been illustrated. A complete system to measure the temperature continuously either during casting or during tundish preheating has been presented. The CasTemp technology already applied in the continuous steel casting and with minor adjustments could be applied in different applications in the foundry. There are some critical steel grades cannot be continuously casted with regular continuous casting can be continuously casted with the using of CasTemp system.

Excessive heating of the steel above the liquidus temperature leads to some defects as columnar structures in cast ingots, central porosity, axial segregation, and heightened susceptibility to crack formation. In this study, via CasTemp and CasTip systems, the liquid steel temperature will dynamically have controlled and illustrates how using a superheat system based upon a measured liquidus value instead of one calculated on steel composition has affected the caster operations.

Keywords: Superheat – Liquidus – Freezing – Breakout – Continuous Casting – CasTemp - CasTip

Influence of heat treatment on Cr-Mo-W martensitic stainless steel

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Abstract

Different martensitic stainless steel grades were designed with different content from Mo and W. induction furnace (30 kg capacity) was used. Molten steel was cast in sand ingot. The cast was heated up to 1100 ^{o}C and hold for two hours. Start forging temperature was 1050 ^{o}C and finishing forging temperature was 900 ^{o}C. The forged steel was cooled in open air. The forged steel was heated up to 925 ^{o}C and hold for one hour; followed by rapid quenching in water. The quenched steel was treated at different temperatures (ranging from 300 ^{o}C up to 700 ^{o}C) followed by air cooling. Microstructure examination was carried out for the quenched steel. Hardness was measured for the heat-treated steel. The influence of heat treatment temperature and different alloying elements on hardness was investigated.

Keywords: Cr Steel, Mo-W steel, martensitic steel.

Microstructure Control of Al-Ce Alloys for Automotive Applications: A Review

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Abstract

The recent research on Al-alloys focuses on the systems that contain intermetallic precipitates with high-temperature stability. Hence using rare earth elements to achieve this purpose minimizes the advantage of conventional casting as one of the most economical fabrication processes, an alternative way becomes mandatory. In this regard, the group of Al-Ce alloys is currently receiving attention as the most suitable high-temperature candidate for the automotive industry. In the current review, the metallurgy of Al-Ce alloys and their special microstructure that gives them unique high-temperature mechanical properties are discussed. The research works that focus on microstructure modification of these alloys are also covered. Special attention is given to melt solidification under vibrations as an efficient technique to control the microstructure of Al-Ce alloys. Future trends and prospects of these promising alloys are also discussed.

Keywords: Al-Ce alloys; Microstructure; Mechanical properties; Microstructure control.

Acknowledgments: The financial support from the Egyptian Science and Technology Development Fund (STDF) through grant No. 43967 is acknowledged.

Wear and Corrosion Characteristics of Centrifugally Cast α-Aluminum Bronze

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Abstract

The present investigation aims to study the wear and corrosion characteristics of centrifugally cast α – aluminum bronze alloys. The experimental program was based on three groups of α-aluminum bronze group; the aluminum contents were as follows: 3.5% 5.5% and 7.5% respectively, while iron contents were varied from 0 % to 4%. The iron was added to the previously mentioned groups of aluminum bronze alloys.

The different groups were prepared by centrifugal casting in a metallic mold in the form of sleeves having a length of 180 m outside diameter of 50 mm and thickness of 10 mm. the mold rotational speed was 2000 rpm, the groups of the alloys were all prepared by melting in an induction furnace, fluxes and refiner were applied during the melting process.

The groups of the aluminum bronze alloys were analyzed by spectrometer, samples for microstructure; hardness, wear and corrosion tests were prepared in accordance to the standards.

The results reveal that; the increase in aluminum content leads to an increase in the hardness, where the increase in the iron content has a slight effect on the increase of hardness.

The wear resistance was also improved by the increase in the aluminum content, meanwhile the corrosion resistance was deteriorated by the increase in the iron content.

It was found also that the increase in the iron content to 4.0 leads to refining effect on the microstructure, (within the experimental rang) resulted in a slight increase in the hardness for the α-aluminum bronze groups.

Keywords: α-aluminum, centrifugal casting, wear characteristics, Corrosion resistance, Hardness, Iron

Development properties of Al-5Cu/B4C composite alloy produced by casting for high potential application

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Abstract

In recent years the prospective of MMC materials for considerable improvement in performance over conventional alloys has been documented widely. However, their production costs are still relatively high. There are several production techniques available to manufacture the MMC materials: there is no unique route in this respect. Metal matrix Composite used in this production process, to determine their mechanical and physical properties. Since the technology that concerns the various manufacturing processes, especially as regard their history, are often customized by individual manufacturers to suit the specific necessity. The production techniques can vary considerably depending on the choice of material and reinforcement and of the types of reinforcement. Property combinations such as high specific strength and stiffness, low thermal expansion coefficient, good damping capacities, superior wear and corrosion resistance, and good high temperature stability and mechanical properties are common features observed in MMCs. Composite materials of B_4C solid particles create a rigid reinforcing frame in the matrix, which gives the aluminum alloy unique properties (stiffness, strength, thermo physical and electrical properties) after the introduction of copper powder, allowing it to be used with Al-Cu-B_4C alloy for the production of rolled products. The purpose of this research boron carbide (B_4C) is reinforced in the aluminum matrix composites to increase the more conductivity and characterized for their mechanical properties such as hardness and tensile strength. Al-5%Cu aluminum alloy metal matrix composites will be reinforced with Boron Carbide (B_4C) particles up to 2, 5 and 7 % was produced by stir casting. Particulates may subsequently add using the squeeze casting process. The squeeze casting technique decreased the porosity of the final composites. In this research, the following composites will be evaluated and tested experimentally. They are tensile strength, hardness, improved stiffness, reduced density (weight), improved high temperature properties, controlled thermal expansion coefficient, thermal/heat management, enhanced and tailored electrical performance, improved abrasion and wear resistance, control of mass (especially in reciprocating applications) and improve damping capabilities.

Keywords: Metal matrix composites (MMC), Crystallization, Wear-resistant, coefficient of thermal expansion (CTE), Aluminum-matrix composites, hardness.

Failure Analysis of Engineering Components Introduction and Procedure, REVIEW ARTICLE

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Abstract

Engineering components frequently fail in service despite the efforts of design and materials specialists, and despite the applied procedures of quality assurance and control. In some cases, material failures can lead to many potentially catastrophic consequences, which can cause financial losses due to poor product quality, necessary repair or component replacement, production downtime, in addition to environmental contamination or even loss of life. In such situations and to minimize the risk of failure reoccurrence, it is frequently necessary to establish the failure root causes in terms of design validity, selection and quality of material, fabrication procedure, service conditions and so on. Inevitability of engineering system or component failure stems from factors such as unavoidable corrosion and wear and tear, abnormal service conditions, substandard maintenance practices, improper inspections, production errors, design errors, injudicious selection of materials, material imperfections, overloading and other service abuses of the system or component; and other unknown causes. Failure analysis is multi-disciplinary arena and requires synergy of expertise including fractography, corrosion, mechanics, alloy theory, phase transformation, NDT, tribology, etc. and is often difficult and frustrating task, but understanding how to approach an analysis and how to interpret observations provides a basis for assuring meaningful results. The present review article includes the definition and importance of failure analysis, the types, mechanisms and causes of materials damage and failure, the methodology and procedures for conducting successful failure analysis process, the material characterization tools used in failure analysis, how to interpret the analysis findings and write the failure analysis report.

Grain Refinement Of AZ91Mg Cast Alloy (Review Paper)

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Abstract

Grain refinement is an established technique which basically reduces the grain size of material with the direct intention to improve its finished properties or characteristic. On the other hand grain refinement of cast magnesium can be achieved by two methods represented by increasing the cooling rate and adding chemical grain refiner while the basic microstructure of AZ91 magnesium alloy consists of primary α- phase in which aluminum rich β- phase (Mg 17 Al12) is precipitated along grain boundaries is a cast magnesium alloy widely used to produce die cast components due to relatively high strength, excellent corrosion resistance, and good cast ability. In this present review article, the research methods grain refinement and effect that on characterization of microstructure and mechanical properties of mgAZ91 cast alloy.

Keywords: Grain refinement, AZ91 magnesium alloys, ß-phase (M g17 Al 12).

Recent trends in the design, phase formation and properties of low-cost high entropy alloys

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Abstract

New category of alloys is the High-entropy alloys (HEAs) that contain five or more principal elements in equal or near-equal percentages with high configuration entropy (ΔS_{conf} >1.5 R, where R is the gas constant). Different methodologies to design new HEAs are applied. The phase equilibrium prediction by the commercial software like ThermoCalc is useful tool for researchers. Also, the empirical relations between metastable phases formation, alloy properties and the thermodynamic parameters are widely used. Recently, the machine learning and artificial intelligent techniques are being developed by many researchers. One of the new HEAs which possess good combination of low-cost alloying elements, has single FCC solid solution structure, good cold workability and mechanical properties is $Al_5Cr_{12}Fe_{35}Mn_{28}Ni_{20}$ alloy. In the present study, the design considerations to strengthen $Al_5Cr_{12}Fe_{35}Mn_{28}Ni_{20}$ HEA with alternating the Al, Mn, Fe and Ni content as well as thermomechanical processes are investigated. Further alloying with Si which is a BCC stabilizer and silicide former to improve the corrosion and oxidation resistance is also discussed. The alloys were produced using arc melting. Followed by different thermochemical treatments. Elemental mapping of the as-cast alloys was conducted using electron microprobe analysis. Subsequently, the mechanical properties of the as-cast and processed alloys were determined using microhardness measurements, tensile and compression tests. The microstructure evolution was studied using X-ray diffraction and electron backscatter diffraction. It was observed that after substituting Mn with Al up to 15 at. % in $Al_{5+x}Cr_{12}Fe_{35}Mn_{28-x}Ni_{20}$ alloy, the microstructure has changed from FCC to a mixed structure (FCC and BCC). In addition, the yield stress of $Al_{15}Cr_{12}Fe_{35}Mn_{18}Ni_{20}$ increased by ~180% at least. The modification of the alloy by alternating the Ni content resulted in an increase in yield stress to 200% at least. In the same way, the cold rolling resulted in an increase in yield stress to 300% at least. However, the alloys did not maintain its good tensile ductility as it has declined from 48 to ~10%. On the other hand, the new alloys have better mechanical properties in the room and high temperatures as well. The corrosion resistance of the alloys is controlled by the microstructure and seems deteriorates in the duel-phase alloys.

Keywords: High-entropy Alloys (HEAs), Alloy Design, Strengthening, Microstructure, Mechanical Properties, Corrosion Resistance.

Hybrid Composite Foams Based on Pb Alloys for Lightweight Batteries

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Abstract

A low-cost direct melt foaming approach was used to develop a new Pb alloy-based composite foams containing hybrid of gas pores and closed cell porosity in the form of hollow ceramic particles to be alternative to the traditional Pb grids in Lead acid battery (LAB). The novel Pb alloy-based composite foams were used as plates in manufacturing of lightweight LAB. The LAB was evaluated in terms of weight saved and electrochemical performance, including cyclic voltammetry, galvanostatic polarization and specific discharge capacity. The cyclic voltammetry results of the composite foams revealed that the composite foam required a higher voltage for oxidation, indicating that Pb oxidation occurred at a slower rate in the composite foams. Galvanostatic measurements showed that the composite foam took a longer duration in the oxidation of Pb into $PbSO_4$, implying that the battery developed in the current work would have a longer lifespan than a conventional LAB. The specific electrical discharge capacity of the LAB made of composite foams was higher than that of traditional LAB. The density of the composite foam plate was much lower than those of the conventional Pb alloys, indicating that the weights of the composite foam plates were lower than those of the conventional lead alloys. These findings suggested that the LAB with plates made of composite foams developed in the present work can be a feasible alternative to traditional traditional Pb grids used in LAB.

Keywords: Pb grid, Pb alloys based composite foams, lead acid battery, curing, cyclic voltammetry, galvanostatic polarization.

Recent Trends in Casting Technology of Functionally Graded Metallic Alloys

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Abstract

Functionally graded materials (FGMs) consider a new type of heterogeneous composites that are defined by a continuous change of properties along at least one direction. Their properties lead to fulfillment requirements of applications due to development of the industry such as aerospace, automotive, machinery, and biomaterials. Metal matrix composites (MMCs) with a continuous change in reinforcement volume in one matrix alloy direction are functionally graded metallic alloys (FGMAs). Recent developments in FGMAs casting technology, including processing processes, potential applications, and mechanical characteristics, are discussed. Several casting processes, including centrifugal casting, squeeze casting combined with stir casting, sequential casting method (liquid-liquid casting), cast-decant-cast, and compound casting (liquid-solid casting), can be used to make various engineering components for FGMAs, such as pipes, shafts, gears, bushings, hammers, and rolls. Future trends and recommendations for future FGMAs manufacturing with improved characteristics, cost-effectiveness, and mass production are offered based on the scope of this research.

Keywords: Functionally graded metallic alloys, casting processes, solidification, properties, applications of FGMs, future trends.

Solar Powered Water Desalination Unit as a Commercial Modular

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ABSTRACT

This project presents an experimental solar powered water desalination unit as a commercial modular. The project explores constructing a prototype to investigate experimentally the AD system to estimate the proper designing and operating parameter.

The project also producing an adsorption desalination unit for 1000 L /day as commercial unit which considered first commercial adsorption desalination.
The investigated study shows that the proposed hybrid system is capable to work efficiently under Egyptian weather conditions with providing desalinated water and cooling effect throughout the year.

Key Words:- adsorption; cooling; desalination; solar energy;

INTRODUCTION

Many countries around the world, especially developing countries and countries in the Middle East region suffer from a shortage of fresh water. Egypt specially is facing increasing water supply challenges in form of demand growth due to population growth and development of agricultural and industrialization fields. The project explore an experimental solar powered water desalination unit as a commercial modular. The SHAD system presents a solution for water shortage in coastal area and the regions having high salinity brackish water in addition to cooling effects[1-2].

System description

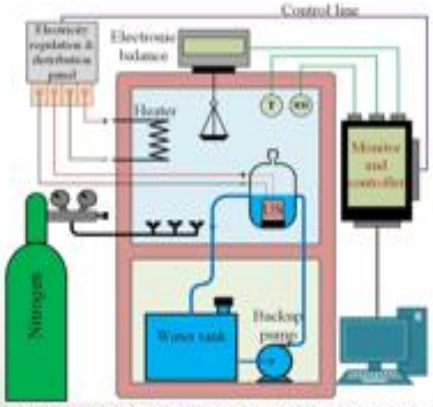

Fig.1: schematic of adsorption Rate measuring

Fig.2: Photo of adsorption Rate measuring

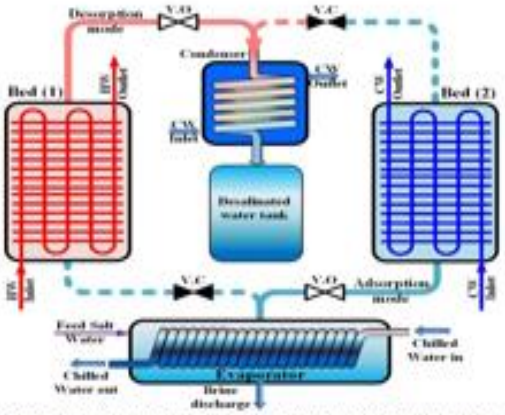

Fig.3: Schematic of adsorption desalination unit

Fig.4: Photo of adsorption desalination unit

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Solar Powered HDH Desalination system under Egyptian weather conditions

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ABSTRACT

This paper present simulation model for a solar powered humidification and dehumidification desalination under Egyptian weather conditions. Solar radiation of Assuit city is expressed using TRNSYS software . The average desalinated water production and GOR are 20 kg/hr and 2 respectively. It can be concluded that the hybrid ADCS which is driven by solar energy can be used effectively with the Egyptian weather conditions.

Key Words

HDH; desalination; solar energy

INTRODUCTION

In comparison with other desalination methods, the humidification-dehumidification (HDH) method has a number of advantages such as simple design, flexibility, low maintenance and capital cost, long lifetime (over twenty years), utilization of low-grade energy, operation at atmospheric pressure, applicability in rural areas for supplying the freshwater needed for agriculture and drinking [1–2].

The HDH method resembles the natural water cycle and solar stills are known as its simplest form . The basis of the HDH method is the separation of these processes and recovery of the latent heat of condensation and thereby improving system performance . In the simplest case, an HDH system has 3 sections, namely air/water heater, humidifier, and dehumidifier

Result and discussion:

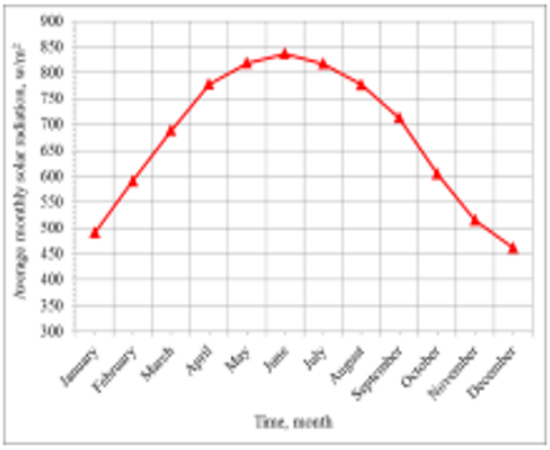

Fig.1: Deslanated Average monthly variation of SR in Assiut

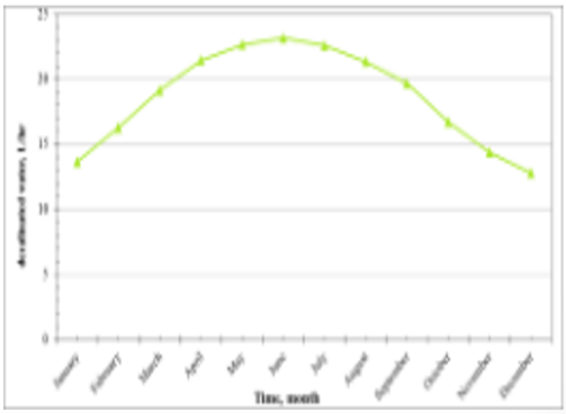

Fig.2: Desalinated water production of solar HDH at Assuit city through the year.

References:

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Solar powereddual purposes cooling and desalination unit for stand alone house.

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ABSTRACT

This paper presents a simulation model for dual purposes cooling and desalination unit for stand alone house The proposed solar-powered hybrid adsorption desalination and salt hydrate employing silica gel and copper sulfate as adsorbent material and salt hydrate respectively under Egyptian weather conditions Solar radiation of Assuit city is expressed using TRNSYS software.

The system outcomes are explained for each month in terms of gain output ratio (GOR), specific daily water production (SDWP), and specific cooling power (SCP). The investigated study shows that the proposed hybrid system is capable to work efficiently under Egyptian weather conditions with providing desalinated water and cooling effect throughout the year.

Key Words:- adsorption; cooling; desalination; solar energy; salt hydrate

INTRODUCTION

Many countries around the world, especially developing countries and countries in the Middle East region suffer from a shortage of fresh water. Egypt specially is facing increasing water supply challenges in form of demand growth due to population growth and development of agricultural and industrialization fields. This study presents innovated solar powered hybrid system between salt hydrate desalination and ADCS system (SHAD) The SHAD system presents a solution for water shortage in coastal area and the regions having high salinity brackish water in addition to cooling effects [1-3].

System description

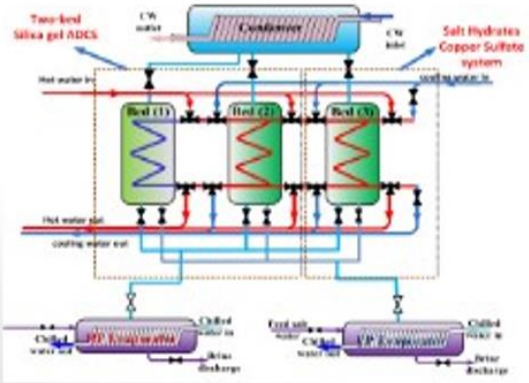


Fig.1: Hybrid salt hydrate and ADCS systems

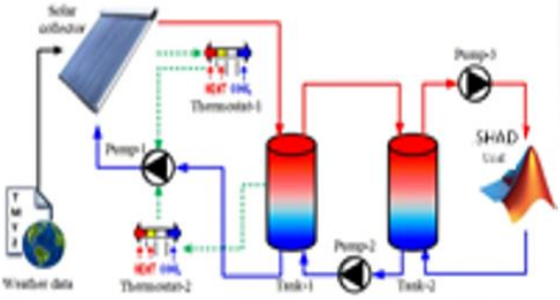


Fig.2: Solar-assisted hybrid SHAD cycle using TRNSYS.

Result and discussion:

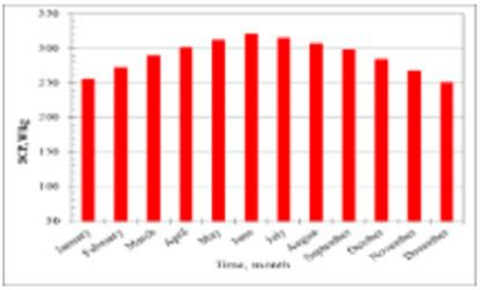


Fig.2: Average SCP of the solar powered hybrid SHAD

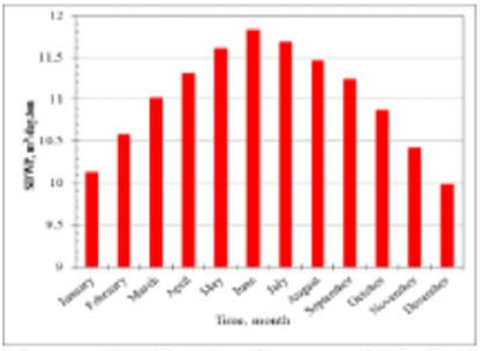


Fig.3: Average SDWPof the solar powered hybrid SHAD

Conclusion:

- The investigated hybrid system has higher performance in SDWP, SCP and COP by 57%, 55%, 25% respectively.
- The system could be is driven effectively with the Egyptian weather conditions

References:

[1] Zejli D, Benchrifa R, Bennouna A, Bouhelal O, A solar adsorption desalination device: first simulation results. Desalination 2004;168:127–35.

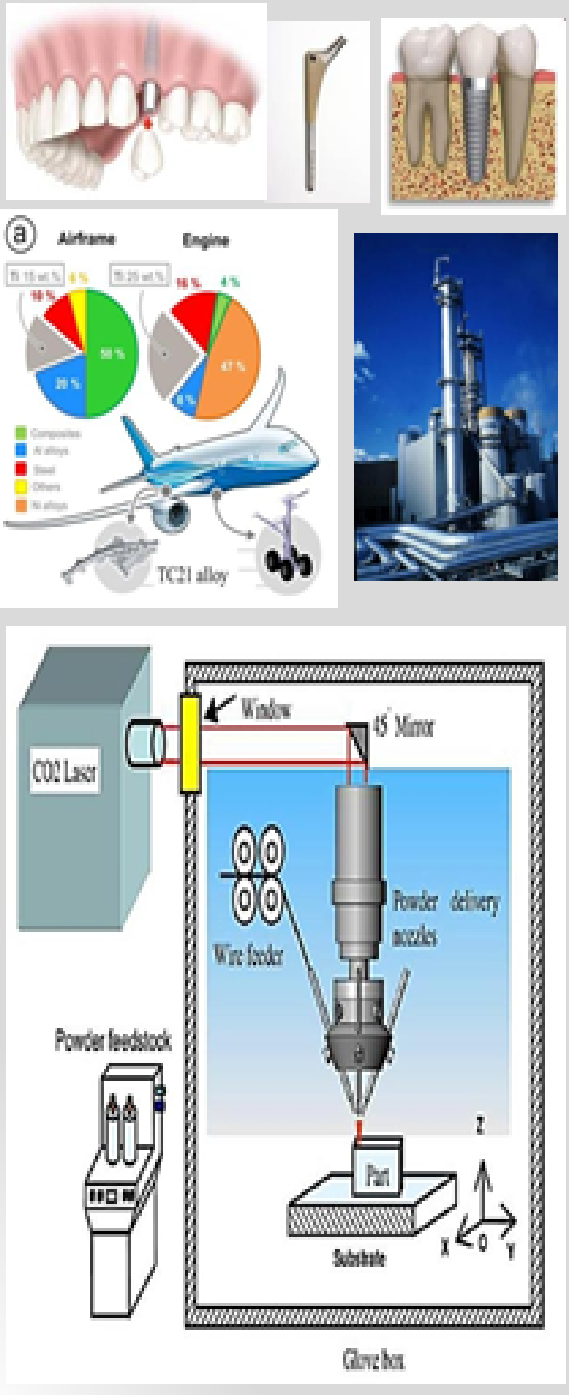
[2] Alsaman AS, Askalany AA, Harby K, Ahmed MS. A state of the art of hybrid adsorption desalination–cooling systems. Renewable Sustainable Energy Rev 2016;58:692–703.

Advanced surface treatments of titanium alloys for future industrial and biomedical engineering applications

Ramadan N. Elshaer, Fathy El-Sayed, Khaled Ibrahim

ABSTRACT

Titanium alloys are widely used in manufacturing spare parts for aerospace and biomedical applications as well as petroleum sectors due to their superior mechanical and chemical properties. However, the main problem for titanium is low wear resistance due to its low hardness. Hence, this project aims at investigating and introducing a new technology of advanced surface treatments on titanium alloys. This can be applied for enhancing hardness-depth distributions, wear, corrosion resistance and fatigue properties, of titanium alloys for industrial and biomedical applications. Commercial pure titanium (CP-Ti) and other titanium alloys (TC21, Ti-6Al-4V & Ti-13Nb-13Zr) will be cast as rods using vacuum arc remelting furnace. Three different surface treatment techniques will be applied on the investigated titanium samples. The first one is plasma nitriding that will be carried out in a temperature range of 600, 700, 800 & 900°C for 6, 12 & 24 hours, respectively, in a containing media (N2, H2, Ar). The second surface treatment is laser treatment that will be performed using laser power = 20 W, laser spot diameter = 1.1 mm, and laser scanning speed = 100: 700 mm/min with an interval 100 of mm/min. The last treatment is combined (plasma + laser) surface treatment, which called surface pretreatment. This will be used for further wear enhancement and deeper hardening by alteration of near-surface microstructure prior to plasma nitriding. Fatigue properties will be studied on the optimum conditions that will be obtained from the mechanical and chemical tests for the proposed titanium alloys. By achieving these goals, it will be the first time in Egypt and the Arab countries for casting of different grades of titanium alloys as well as introducing a new technology of surface treatment on titanium alloys that can be used in aerospace, petroleum sector and biomedicals applications.



Solidification microstructure and mechanical behavior of iron-manganese-nickel-aluminum high entropy alloy

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Key words: High entropy alloys, Intermetallic compounds, Microstructure, solidification, Mechanical properties

a. Background

High entropy alloys are multicomponent solid solution materials that comprise of five or more elements in near equiatomic proportions to maximize configurational entropy and so stabilize their microstructures [1-5]. These unconventional structures provide opportunities for achieving unprecedented combinations of phase stability and mechanical performance [6, 7], especially overcoming the strength-ductility trade-off [8]. Although there are still arguments on if these multicomponent alloys are really stabilized by entropy or not, we here call it "HEAs" for it's popularity in the literature [9].

Nevertheless, aluminum has a great effect on promoting the characteristic properties of high entropy alloys, but it was well proved that aluminum has a great affinity for segregation at the liquid-solid transition period. In fact, the segregation of aluminum should give impression of the mechanical and structural character of HEA, either positive or negative. In this research, investment casting mold has been designed with fluctuated modulus to monitor the effect of solidification time. Consequently, the segregation behavior of the constituent alloying elements on the mechanical and structure of the high entropy alloy designed.

Solidification microstructure and mechanical behavior of as-cast single-phase FCC HEAs FeMnNiAl with some detailed attention given to melting and homogenization have been investigated using computational thermodynamics and experiments. To overcome the extrinsic effects found in small-scale laboratory button samples, vacuum induction melting was used to create ingots weighing up to 5 kg. Different compositions of the targeted alloy were developed through melting of pure metals in induction furnace. X-ray Fluorescence (XRF), optical microscope, and SEM have been used for monitoring the chemical, and phase constituents among the different regions of solidification. In addition, the mechanical properties of the designed alloy have been determined using uni-axis tensile test, and impact toughness. It was well proved that the solidification time has a significant effect on promoting the characteristic properties of iron based high entropy alloy containing aluminum. Aluminum shows high percentage with increasing the solidification time. In addition, the mechanical observations proved that decreasing the solidification time enhance and improve the mechanical properties

b. Methods

Specimens of high entropy alloy, FeMnNiAl, were prepared by induction melting of mixtures of commercial-purity metals (purity greater than 99.5 wt.%) under atmosphere of high-purity argon. Subsequently, the alloys were remelted 3 times to improve chemical homogeneity. The

investment mold that has been used for casting high entropy alloy has six samples for tensile and similar for impact. The dimensions of the interior cavity of the mold have been drawn by solid work and were thereafter submitted for simulation using pro-cast simulation program to identify the solidification time at each section of the mold. The specimens were separated, they were then polished and etched with Picral 4% and submitted for microstructural observation using scanning electron microscope (FEI Inspect S 50-Netherlands) equipped with EDX. The chemical composition of the samples was analyzed by XRF. Uni-axis tensile test with strain rate 10^{-1}s, was performed using computer controlled universal testing machine (WDW-300). The impact test has been conducted for as cast samples with standard dimensions of 10*10mm cross section and 55 mm in length, using JBW-500N impact test instrument.

Fig. 1. Investment mold containing six tensile and impact specimens

c. Results

Thermocalc software with PBIN database was used for predicting the structure and the change of the constituent phases among the liquid-solid transition regime. As given in Fig.2, aluminum has a great affinity for forming different categories of intermetallic compounds such as Al3Ni2 and Al3Ni5 based on the temperature. In the present study, with increasing temperature, Al3Ni2 is more stable throughout the austenite matrix. On the other hand, Al3Ni5 has a similar share with Al3Ni2 as decreasing in temperature. In the meantime, austenite structure is the main matrix of this alloy, which is corresponding to the high content of nickel and manganese that are considering as the austenite stabilizer elements.

Microstructure observations with the aid of scanning electron microscope depicts that the main matrix among the different solidified sections is austenite and intermetallic compounds at the boundary of austenite. In regarding to the thermodynamic calculations and microstructure observations Al3Ni2 and Al3Ni5 precipitate on the boundary of austenite through the structure of different sections. However, it is observed that austenite grain size fluctuates among the sections studied. Coarse structure is observed at the sections that are solidifying later (choke area) and the fine structure is at the sections that solidified early (samples), as shown in Fig.5. Thereby, it is clear that the structure is dependent on the solidification time, which indicates to the change in mechanical properties that can be predicted at the samples according to their solidification time.

d. Conclusion

This study, investigated experimentally and theoretically the segregation of alloying elements in the designed high entropy alloy Fe-Mn-Ni-Al. The following conclusions can be concluded:

1- Microstructure observations with the aid of scanning electron microscope of the studied HEA depicts that the main matrix among the different solidified sections is austenite which is corresponding to the high content of nickel and manganese that are considering as the austenite stabilizer elements, and intermetallic compounds at the boundary of austenite.
2- With increasing temperature, Al3Ni2 compound is more stable throughout the austenite matrix. On the other hand, Al3Ni5 has a similar share with Al3Ni2 as decreasing in temperature.
3- According to the simulation data, the solidification time in the studied mold is fluctuated. Sprue area and the will of gate have the highest solidification time in the mold; the solidification in all samples started from the cavity followed by the runner.

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Metal selenide nano-materials as electrode material for lithium-ion batteries and supercapacitors

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Keywords: Nanorod arrays; hydrothermal reaction; lithium-ion battery; hybrid supercapacitor; energy storage.

The growing need for renewable energy and environmental concern has prompted extensive study into energy storage devices. One of the most important categories of these materials is the transition metal chalcogenides [1-3]. Nanorod arrays of nickel selenide grown on nickel foam were synthesized via a simple one-step binder-free hydrothermal method.

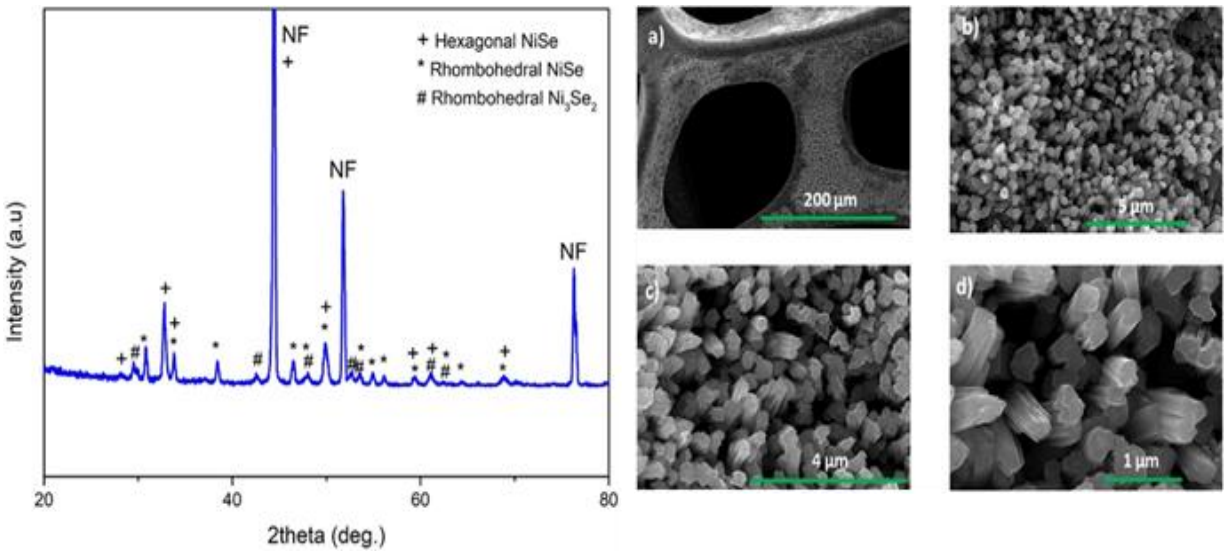

Fig. 1. XRD pattern and FE-SEM image of Ni_XSe_y nanorod array.

Nanorod arrays of Ni_xSe_y with unique electrochemical performance when inspected as an active electrode material for both lithium-ion batteries and supercapacitors, the as-prepared electrode gave an initial discharge capacity of 632.8 mAh g^{-1} with a reasonable rate capability and coulombic efficiency.

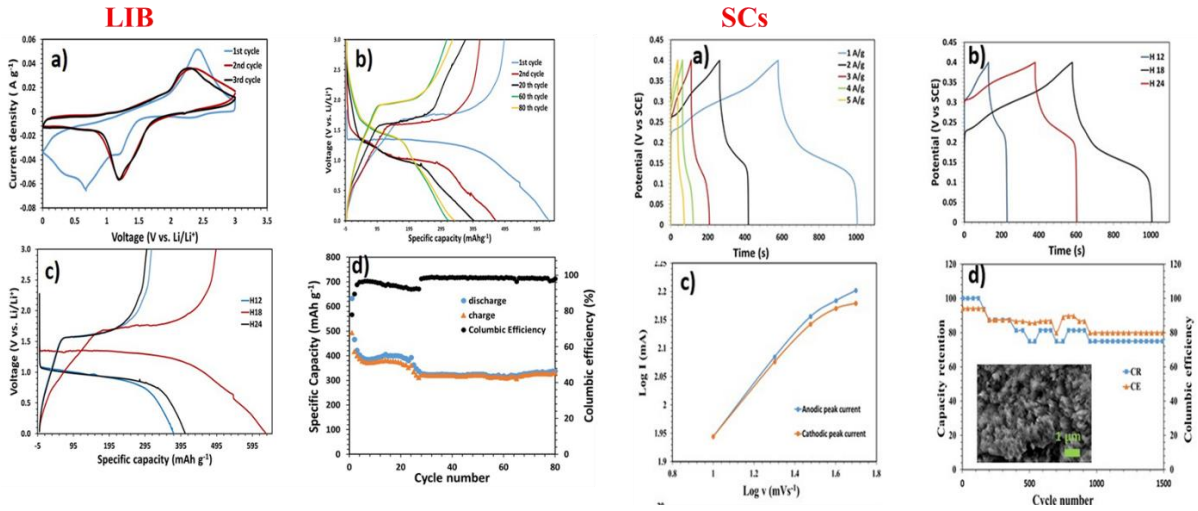

Fig. 2 LIB and SCs performance of Ni_xSe_y nanorod arrays.

Also, other metal selenides were synthesized, studied, modified by adding carbon materials, and applied to energy storage applications such as SnSe nanorods anchored on rGO nanosheets.

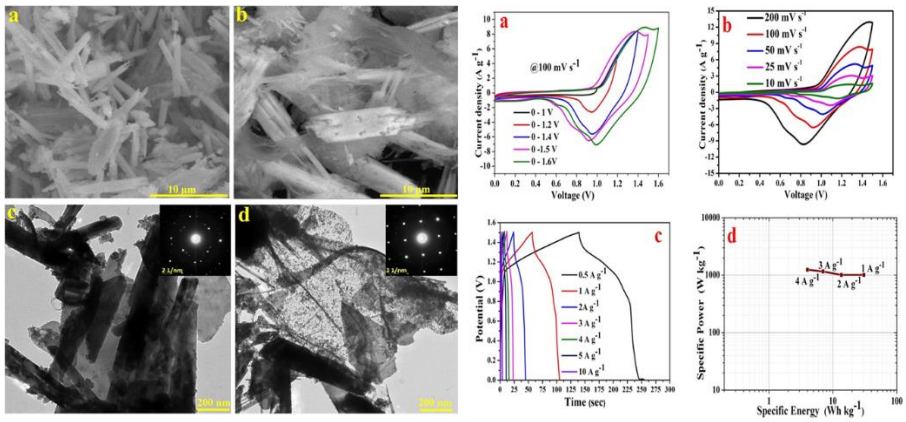

Fig. 3. SEM and TEM image and SC electrochemical performance of SnSe/rGO

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EFFECT OF CONTINUOUS CASTING PROCESS PARAMETERS FOR STEEL BILLETS ON ROUND CROSS SECTION PRODUCTS

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Key words: continuous casting, steel billet, billet casting, near net shape casting, standalone rolling mill

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1. Backgroung

Continuous casting is the vital step in the steel plant for converting liquid steel into solid slabs or billets/blooms. The success of continuous casting has a significant impact on the economy and quality of steel products. New technologies have been actively developed in the process over the last few decades in order to increase productivity and, as a result, lower operational costs [1,2]

Nowadays CCM also , could be considering as second turning point a in transformation from standalone rolling mill to standalone mini mill or endless rolling mill , where is the rolling mill has been merged directly to steel melt shop , SMS , with a major benefit , which is no more need for the steel billet reheating furnace unit , where is the CCM merged directly to the rolling mill stands through induction heater [3, 4].

The recent work investigates the developing of endless rolling mill will be studied as a CCM third turning point , based on major question, can we maximize the benefits, where is no more need for roughing stands stage of rolling mill , by studying of various factors impact on casting minimum round – cross section of carbon steel billet by continuous casting machine to be feeding to the intermediate stands stage directly.

The present work aims to investigate how much can the merging of (BAT), utilize and optimize to serve well the targeted transformation of standalone production and manufacture units concept and comply with the sustainable development goals with focusing on the consumption and production and to ensure sustainable consumption and production patterns.

e. Methods

An industrial plant trial for optimizing the process parameters in round billet continuous casting mold with electromagnetic stirring (M-EMS) was performed , in which the influences of stirring parameters with M-EMS on the solidification macrostructure of high carbon steel were investigated. The macroscopic qualities of round steel billets with M-EMS for different stirring parameters were tested by industrial plant trials. M-EMS as a good casting technique has a significant effects for improving the whole quality of high carbon steel and promoting the final product performance. Optimum stirring parameters of M-EMS is important for playing its full role

f. Results

The Overall Equipment Effectiveness (OEE) is a proven approach to increase the overall performance of equipment. Focused on improvement and autonomous maintenance which are the two important activities to enhance equipment performance. As well as the transform to the overall process effectiveness (OPE) methodology. In addition, implementation of lean production and clean process to enhance process eco-performance.
The OPE of the process are sufficient high for sustained capacity planning, furthermore, social cost as a framework is proposed for implementing the OPE methodology to enhance overall process performance.

g. Conclusion

The present work concluded that, the increased casting productivity, especially with the introduction of high speed billet casting (HSBC), re-emphasized the importance of high performing mold electromagnetic stirring (M-EMS) in attaining the targets of productivity and product quality. To provide operating flexibility and to enhance metallurgical performance, adapting M-EMS design to the requirements of casting practice with either the open stream pouring or submerged entry nozzle (SEN) has become critical. in that context, it is especially important to assess the effects of EMS design parameters that control is the key to EMS compatibility with the continuous casting practice and its high metallurgical performance.

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