
2. **Critical assessment and thermodynamic modeling of the Al-Fe-O system.** D. Shishin, V. Prostakova, E. Jak, S. Decterov. [Read more]


4. **Modeling of heat transfer and interdendritic strain for exuded surface segregation layer in the direct chill casting of aluminum alloys.** M. El-Bealy. [Read more]

5. **Desulfurization from bauxite water slurry (BWS) electrolysis.** X. Gong, L. Ge, Z. Wang, S. Zhuang, Y. Wang, L. Ren, M. Wang. [Read more]


7. **Numerical simulation of the fluid flow, heat transfer, and solidification during the twin-roll continuous casting of steel and aluminum.** M. Xu, M. Zhu. [Read more]

8. **Investigation on residual stresses in an Al2024 deep drawn square cup.** J. Li, L. Deng, X. Wang. [Read more]

9. **7075-T6 aluminium alloy exfoliation corrosion sensitivity and electrochemical impedance spectroscopy under stress.** Z. Ji, Z. Jing. [Read more]

10. **Dynamic strength analysis of Al-6061-T6 threaded-pipe connectors under preload and internal pressure.** K. Ko, J. Ou, B. Hsu, J. Chen, M. Shu. [Read more]

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In this paper, the effects of anodic large bubble including bubble position and coverage on horizontal current (HC) in the metal pad in an aluminum reduction cell have been investigated using a three-dimensional electric model. Results show that the HC, the maximum HC, and inward HC flow are greatly influenced by the large bubble position and coverage. It is necessary to take the large bubble into account when we study the horizontal current in a cell.

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**Critical assessment and thermodynamic modeling of the Al-Fe-O system.** D. Shishin, V. Prostakova, E. Jak, S. Decterov

A complete literature review, critical evaluation, and thermodynamic modeling of the phase diagrams and thermodynamic properties of phases in the Al-Fe-O system at 1 atm total pressure are presented. Optimized model equations for the thermodynamic properties of all phases are obtained, which reproduce all available thermodynamic and phase-equilibrium data within experimental error limits from 298.15 K (25°C) to above the liquidus temperatures at all compositions and oxygen partial pressures from metal saturation to 1 atm. The complex phase relationships in the system have been elucidated, and discrepancies among the data have been resolved. The database of the model parameters can be used along with software for Gibbs-energy minimization in order to calculate all thermodynamic properties and any type of phase diagram section. The modified quasichemical model was used for the liquid oxide phase. A sublattice model, based upon the Compound Energy Formalism, was developed for spinel, which expands from magnetite, Fe3O4, to hercynite, FeAl2O4. The distribution of cations between octahedral and tetrahedral sites and oxygen nonstoichiometry in spinel are taken into account. The model for metallic liquid assumes random mixing of associates: Fe, Al, O, AlO, and Al2O. It describes well the minimum that is observed on
the solubility of oxygen in liquid iron as a function of the Al content. The solid solution between hematite and corundum exhibiting a miscibility gap, as well as a small solubility of Al2O3 in wüstite are quantitatively described by a simple Bragg-Williams model.

The voltage distribution between carbon anode and aluminum cathode in cryolite electrolyte saturated with alumina was determined using a scanning reference electrode to investigate the inter-electrode process during aluminum electrolysis. The results showed that the anode–cathode-distance (ACD) is consisted of three parts: a relatively stable cathode boundary layer, bubble-free electrolyte layer, and gas-liquid layer near the anode. The aluminum diffusion layer with high electronic conductivity as well as the crystallization of cryolite was observed at the cathode boundary layer. The thickness of the aluminum diffusion layer varied with current density, which further determined the critical ACD. The thickness, coverage, and releasing frequency of the bubbles on both laboratory and industrial prebaked cells were derived, and it is found that the average bubble coverage decreases with current density, and the average coverage at 0.8 A cm² is approximately 50 pct.

Modeling of heat transfer and interdendritic strain for exuded surface segregation layer in the direct chill casting of aluminum alloys. M. El-Bealy
This investigation on the formation of exuded surface segregation layer “ESSL” is intended to provide experimental and simulated comparison to verify the model developed previously by El-Bealy. Preliminary verification and calibration of the previous 2D mathematical model are demonstrated by quantitative errors between the previous measurements and predictions of temperature and macrosegregation. Also, the results from these comparisons reveal that the errors are in the reasonable and within allowable limits. These comparisons lead to the fact that the exuded surface segregation layer mostly forms on the middle slice of broad sheet ingot face and in the early stages of mold zone. The model predictions point out also that the different interdendritic strain hypotheses associated with fluctuations of mold cooling conditions. This affects the interdendritic liquid flow between the equiaxed crystals which influences the severity of ESSL formation and its macrosegregation level. The mechanism of ESSL with heat flow and interdendritic strain generation has been analyzed and discussed. The quantitative comparisons between the previous experimental results and numerical simulation in this investigation reveal also several solutions to prevent this defect for future work.

Desulfurization from bauxite water slurry (BWS) electrolysis. X. Gong, L. Ge, Z. Wang, S. Zhuang, Y. Wang, L. Ren, M. Wang
Feasibility of high-sulfur bauxite electrolysis desulfurization was examined using the electrochemical characterization, XRD, DTA, and FTIR. The cyclic voltammetry curves indicated that bauxite water slurry (BWS) electrolysis in NaOH system was controlled by diffusion. Additionally, the desulfurization effect of NaCl as the electrolyte was significantly better than that of NaOH as an electrolyte. As the stirring rate increased, the desulfurization ratio in NaCl system was not increased obviously, while the desulfurization ratio in NaOH system increased significantly, indicating further that electrolysis desulfurization in NaOH solution was controlled by diffusion. According to XRD, DTA, and FTIR analysis, the characteristic peaks of sulfur-containing phase in bauxite after electrolysis weakened or disappeared, indicating that the pyrite in bauxite was removed from electrolysis. Finally, the electrolytic desulfurization technology of bauxite was proposed based on the characteristics of BWS electrolysis.

A new process is developed to obtain high-quality AA1235 aluminum foil stocks and to replace the traditional manufacture process. During the new manufacture process, AA1235 aluminum sheets are twin-roll casted directly through electrolytic aluminum melt (EAM), and subsequently the sheets are processed into aluminum foil stocks by cold rolling and annealing. Microstructure and mechanical properties of the AA1235 aluminum sheets produced through such new process are investigated in each state by optical microscope, scanning electron microscopy, X-ray diffraction, orientation imaging microscopy, transmission electron microscopy, etc. The results show that compared with the traditional AA1235 aluminum foil stocks produced through re-melted aluminum melt (RAM), the amount of impurities is decreased in the EAM aluminum foil stocks. The EAM aluminum foil stock obtains less b-FeSiAl5 phases, but more a-Fe2SiAl8 phases. The elongation of EAM aluminum foil stocks is improved significantly owing to more cubic orientation. Especially, the elongation value of the EAM aluminum foil stocks is approximately 25 pct higher than that of the RAM aluminum foil stocks. As a result, the EAM aluminum foil stocks are at an advantage in increasing the processing performance for the aluminum foils during subsequent processes.

Numerical simulation of the fluid flow, heat transfer, and solidification during the twin-roll continuous casting of steel and aluminum. M. Xu, M. Zhu

The commercialization of aluminum twin-roll casting was realized in the early 1950s, while it is still a dream for engineers to produce steel strip by this process. In the present paper, a two-dimensional mathematical model is employed to study the fluid flow, heat transfer, and solidification during the twin-roll casting for both steel and aluminum. The turbulent flow in the pool is examined using the Lam and Brethemot low-Reynolds-number turbulence model. In order to facilitate the comparison and analysis, a new transformed coordinate system (r, u) is established. Characteristics of the momentum boundary layer and the solidification front are described. Reasons of the formation of the wedge-shaped zone near the surface of rotating roll are given. In the transformed coordinate system (r, u), the effect of the centrifugal force induced by the rotating roll is presented using the velocity component in the r direction and the pressure gradient in the r direction. At last, the evaluation of the solidified shell in the pool is analyzed. The results show that the twin-roll casting is a roll-rotating-driven process. The variation of the thickness of the momentum boundary layer can be divided into three stages and its thickness is very uniform at the last stage. Near the roll surface, there exists a wedge-shaped zone induced by the near-roll-surface shear flow that washes the mushy zone front, which increases the depth of the liquid pool and decreases the length of the rolling region. The rotating roll gives rise to the stirring effect to the pool region and the metal is moving away from the roll surface in the positive radial velocity region, and the effect of the centrifugal force becomes weak in the lower part of the pool. At the solidification front, the non-dimensional effective heat transfer coefficient distribution in steel twin-roll casting is larger than that in aluminum twin-roll casting. Considering that the turbulence level is determined by the flow pattern in the pool region, which demonstrates the importance of the geometry of the feeding system in steel twin-roll casting. The evaluation of the solidified shell in aluminum twin-roll casting is a parabolic growth, while in steel twin-roll casting, the parabolic growth only occurs in the lower part of the pool.

Investigation on residual stresses in a Al2024 deep drawn square cup. J. Li, L. Deng, X. Wang

The mechanical properties and dimensional stability of aluminum alloy sheet parts are strongly influenced by residual stresses. However, few studies deal with residual stresses in aluminum alloy sheet parts processed by deep drawing at elevated temperature. In
this work, the through-thickness residual stresses distribution in a 2024 aluminum alloy deep drawn square cup was determined by layer removal technique and X-ray diffraction. It is found that the distribution of the tangential residual stress in the bottom circular arc shows a different with the width direction residual stress. Both the width direction and axial residual stresses in the side wall show some dependence on the axial position and decrease from the mid wall towards the cup bottom. The calculation method based on a wide sheet bending theory is capable of describing the distribution features of residuals stress in the bottom circular arc of the square cup.

7075-T6 aluminium alloy exfoliation corrosion sensitivity and electrochemical impedance spectroscopy under stress. Z. Ji, Z. Jing
Exfoliation corrosion susceptibility under tensile-bending stress of 7075-T6 aluminium alloy was tested with a self-made tri-fulcrums loading fixture. The test results of both microscopic characterisation and electrochemical impedance spectroscopy indicate that the alloy’s exfoliation corrosion susceptibility in exfoliation corrosion solution increases evidently for tensile-bending stress. The electrochemical impedance spectroscopy of the loaded sample soaked for 12 hours manifests double capacitance arcs as the mark of propagated exfoliation corrosion, which takes 24 hours for the unloaded one to reach the same results. Results analysed by equivalent circuit model also prove the accelerating effect of tensile-bending stress on exfoliation corrosion susceptibility.

Dynamic strength analysis of Al-6061-T6 threaded-pipe connectors under preload and internal pressure. K. Ko, J. Ou, B. Hsu, J. Chen, M. Shu
Threaded-pipe connectors are commonly employed in jointing pipelines in hydraulic and pneumatic systems. In an effort to avoid catastrophic incidences from the pipeline deteriorating, it is crucial to comprehend physical and mechanical properties on the thread connections. This paper is purportedly focused on the stress-and-strain analyses of the threaded pipe connector made of Al-6061-T6 (1¼ PT), the material of construction of aircraft structures and petroleum facilities, under preload and with internal pressure. Under the preloaded junction, both first and last threads in the pipeline connection are at most susceptible. With the internal pressure, the threaded-contact stress becomes more homogeneously distributed. Because of the contact stress, poising on the first few threads under the preloaded stage, being flattened, the last thread bears the highest contact stress. Finally, we execute an empirical experiment to reveal deformation phenomenon for the threaded-pipe connector, whose result corroborates the previous simulation studies.