ISIJ International 掲載記事概要

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Preparation and Beneficiation

Stirring effect in bath-smelting furnace with combined blowing of top and side blown oxygen and bottom blown nitrogen By T. HIRATA *et al.*

鉄鉱石の溶融還元法において，エネルギー効率が良く，生産性も高い鉄浴型溶融プロセスを開発するために，二次燃焼率（*PCR*），着熱効率（*HTE*），および鉄鉱石の還元速度に対するガス供給方法の影響を調査した，実験は通産省からの補助を受け，上吹き酸素，横吹き酸素，および底吹き窒素を使える 10 t 試験転炉を用いて行った．

その結果，上吹きおよび横吹き酸素と底吹き窒素との組合せにより，鉄浴とスラグとをおのおのに必要な強さで別々に攪拌できること，そのために *PCR*, *HTE*, および還元速度を向上できることが分かった．底吹き窒素は *PCR* と還元速度とを支配する粒鉄を生成するし，横吹き酸素は粒鉄生成には関係せずにスラグを攪拌し，*PCR* を下げることなく *HTL* を高める．上吹き酸素，横吹き酸素，底吹き窒素の適当な組合せにより，エネルギー効率が良く，生産性も高い鉄浴型溶融プロセスの実現に寄与することができる．

Smelting and Refining

Definition and determination of mixing time in gas agitated liquid baths By G. G. KRISHNA MURTHY *et al.*

Definition of mixing time has been examined more closely and the reported concentration *vs.* time traces were analyzed to determine mixing time. The obtained values of mixing time were compared with those estimated theoretically, employing numerical model of Krishna Murthy. The comparisons suggested that the mixing time values do not depend on the locations of the measuring probe or tracer injection point. Only an improper technique and instruments, or the misunderstanding of the definition of the degree of mixing, led some in the literature to believe that the mixing time was a function of location of tracer injection and position of the measuring probe. It was, therefore, concluded that the true characteristic value of mixing time, for a given set of operating conditions, should be independent of location of measuring probe and tracer injection.

Solidification Processing

Mathematical modelling of thermal stratification and drainage of steel ladles By P. R. AUSTIN *et al.*

Transient analysis of the temperature and velocity distributions of steel during ladle standing and draining has been conducted using a mathematical model based on the PHOENICS numerical package. Parameters investigated were stand time, average steel cooling rate, drainage rate and ladle geometry. Stratification was seen to develop due to natural convection, and the rate of stratification was found to be linearly dependent on the average steel cooling rate, independent of ladle geometry. Qualitative relationships were found between the parameters and the teeming temperature during draining. Plant trials showed good agreement between simulated and actual teeming temperatures.

Microstructure

Effect of controlled rolling on texture development in a plain carbon and a Nb microalloyed steel By R. K. RAY *et al.*

The effect of finish rolling temperature was investigated on texture formation in a plain C and a 0.034%Nb microalloyed steel. When finish rolled at 1 020°C (*i. e.* within the γ recrystallization range), the textures in both steels contain the {001}<110> and {110}<110> components. The sharpness of the {001}<110> component generally increases with decreasing finish rolling temperature down to 630°C, while the {110}<110> component gradually weakens and finally disappears after ferrite rolling. The microalloyed steel displays a much sharper texture than the plain C steel when finish rolled at 870°C (*i. e.* within the γ pancaking range for the Nb steel) and at 730°C (in the $\gamma+\alpha$ intercritical range). After finish rolling at 870°C, the major texture components in the microalloyed steel are {113}<110> and {332}<113>, in addition to the above two, while the plain C steel texture only contains some low intensity maxima. When finish rolled at 730°C, weak peaks appear at {223}<110> and {554}<225> in the plain C steel and stronger ones at {4411}<110> and {554}<225> in the microalloyed steel. After warm rolling at 630°C, the major texture components in both steels are {223}<110>, {554}<225> and {001}<110>.

The {001}<110> and {110}<110> components are obtained, by transformation, from the {100}<001> (cube) and {122}<212> (twinned cube) components of the recrystallized γ. By contrast, the {113}<110> and {332}<113> components originate, respectively, from the {112}<111> (copper) and {110}<112> (brass) components of the unrecrystallized γ. During continued rolling in the $\gamma+\alpha$ or a range, these transformation texture components are further modified by deformation and ultimately give rise to the stable end orientations which constitute the well-known warm rolling texture in steels.

Influence of hot strip rolling parameters on austenite recrystallization in interstitial free steels By A. NAJAFI-ZADEH *et al.*

The influence of total finishing strain (from 2.1 to 3.2) and first finishing pass temperature (from 990 to 930°C) was investigated by means of multi-pass torsion tests on three IF steels containing Ti and/or Nb. All the tests were carried out at a strain rate of $2\,s^{-1}$. Under strip rolling conditions, static recrystallization is responsible for the high degree of interpass softening in the early passes of rolling. During the final passes, dynamic recrystallization occurs to a degree that depends on the composition of the steel, the total finishing strain and the temperature. The critical temperatures of the IF steels were defined by using a simulated plate rolling schedule. Subjected to the same strip rolling schedule, the niobium stabillized steel had the finest, whereas the titanium stabillized grade had the largest ferrite grain size. The present IF steels exhibit higher no-recrystallization temperatures (T_{nr}'s) during strip rolling (1-2 s interpass times) than under plate rolling conditions (30 s interpass times).

Effects of cold deformation on the morphology of α precipitates in β titanium alloys By H. OHYAMA *et al.*

室温ですべり変形，双晶変形，及び，応力誘起マルテンサイト変態を伴う変形を主として示す β 型チタン合金を用い，時効析出 α 相形態に及ぼす前加工組織の影響を調べた．

無加工材では β 粒界に優先析出し合体したフィルム状 α，これより成長したスパイク状 α，及び，粒内 α が析出する．これに対し，弱加工（5% 冷延）材では導入された格子欠陥も優先析出サイトとなり，α 相形態は変形様式を如実に反映する．すべり変形（Ti-15V-3Cr-3Sn-3Al）の場合は転位が局在した平面的なすべり帯が形成され，微細な α がこれに沿って点列状に並ぶ．双晶変形（Ti-16V-10Sn）の場合は双晶界面に α が析出，時効が進むにつれ合体し，フィルム状の層が対をなす．マルテンサイト変態を伴う変形（Ti-16V-4Sn）の場合はマルテンサイト（α''）から逆変態した β と基地の β との界面に α が析出し，この場合も時効が進むにつれフィルム状を呈する．一方，強加工（60% 冷延）材では初期の変形様式は反映されず，いずれの合金も微細2相組織を呈する．

Mechanical Behavior

Analysis of the occurrence of dynamic recrystallization in hot rolling by modeling of the stress-strain curve (Review)

By T. Fujita *et al.*

最近の高 Cr（8-13% Cr）耐熱鋼の発展と将来の展望を述べる．従来高 Cr 耐熱鋼は 550～580°C 付近までしか利用できなかったが，著者らの研究により 650°C まで利用できるようになった．著者らはすでに 1956 年に TAF 鋼を開発したが，その 600～650°C のクリープ破断強度は当時世界最高と言われた H 46, C-422 の 2～3 倍で，非常にすぐれている．

最近 TAF 鋼を改良して常温靱性および高温強度を著しく高めた蒸気タービンローター用 TR 1100，TR 1200 鋼およびボイラー管用 TB 9，TB 12 鋼を開発した．これらの鋼は蒸気タービンローター，動翼，ケーシング，ボイラー管などとして超超臨界圧火力プラントに，燃料被覆管，ラッパー管，蒸気発生管などとして高速増殖炉に，さらに第一炉壁として核融合炉に使用されるものと考えられる．これらの鋼の発展は高速増殖炉および核融合炉の実用化時期を左右する重要な鍵を握っている．この分野における著者らの研究は諸外国より 10～20 年進んでいる．

また著者らは高 Cr 耐熱鋼の熱処理についても研究を行い，従来にない安定した熱処理を開発し，長時間高温強度を著しく高めた．

Characteristics of vanadium and titanium microalloyed steels forged at intermediate (warm) temperatures through simulation by torsion (Note)

By F. Penalba *et al.*

This study concerned the response of medium carbon steels microalloyed with vanadium and titanium, to deformation in intermediate ("warm") temperature zone. Titanium varies from 0.003 to 0.039% in weight.

A critical automotive component (the constant velocity universal joint) warm-forged has been studied by means of a hot torsion simulation technique. Besides its warm-ductility, the influence of the heating temperature before "warm" forging, the "warm" deformation temperature and the weight percentage of Ti on the final steel properties (grain size, microstructure and hardness), was determined.

It was found that the optimal ductility is reached between 750 and 775°C and that the best characteristics (smallest grain size and highest hardness) are obtained with a Ti weight percentage of 0.019% and at lower deformation temperatures (from 700 to 750°C). Hence, the automotive component might be warm-forged close to 770°C in order to obtain the best mechanical characteristics with enough warm-ductility to avoid warm-forging problems.

Influence of dynamic recrystallisation on the tensile ductility of steels in the temperature range 700 to 1 150°C

By B. Mintz *et al.*

The role of dynamic recrystallisation (DRX) in influencing the hot ductility of plain C-Mn and microalloyed steels was examined by comparing the critical strain for dynamic recrystallisation with the fracture strain in a hot tensile test. The temperature range examined was 700 to 1 150°C and the strain rates were varied from 3×10^{-2} to $3\times10^{-4}\,s^{-1}$.

For coarse grained plain C-Mn and C-Mn-Al steels solution treated at 1 330°C and cooled to the test temperature, the presence at the γ grain boundaries of thin films of deformation induced ferrite at temperatures between the Ae_3 and the undeformed Ar_3, leads to strain concentrations which give rise to poor ductility. The presence of these thin films prevents the occurrence of DRX. For these steels, the Ae_3 temperature, which marks the onset of good ductility is generally high enough to lead to DRX, so that it is not possible to assess its independent contribution to restoring the hot ductility. In coarse grained C-Mn-Nb-Al steels, DRX and the full recovery of ductility are often not observed until the test temperature is higher than 1 000°C. This is related to the strain-induced precipitation of NbCN below 1 050°C. However, even when recrystallisation is not possible, the ductility can be improved if the amount of strain-induced NbCN is reduced.

For fine grained plain C-Mn and microalloyed steels heated directly to the test temperature, DRX often occurs in the trough. Grain boundary migration rates have to be sufficiently high to prevent crack linkage from occurring, and this often necessitates the resolution and coarsening of particles so that they are no longer effective in pinning the boundaries. Finally, of interest in this work was the observation that as the initial grain size d_o is refined, its influence in encouraging DRX becomes more marked than that given by the simple $d_o^{1/2}$ relationship in the equation $\varepsilon_p = Ad_o^{1/2}Z_p$, where ε_p is the critical strain to the peak stress, Z is the Zener-Hollomon parameter and A and n are constants.

Analysis of the occurrence of dynamic recrystallization in hot rolling by modeling of the stress-strain curve (Note)

By R. A. N. M. Barbosa *et al.*

Surface and Environment

Influence of heat treatment on the properties of wear resistant tungsten carbide embedded nickel base coating produced by gas thermal spray process

By P. K. Ghosh *et al.*

The hard surfacing of mild steel substrate was carried out by thermal spraying of commercially available nickel base tungsten carbide powder under oxy-acetylene flame. The influence of pre and post spray heating on the morphology, hardness and wear characteristics of the coating were studied. The increase in preheating upto 400°C and post spray heating upto 900°C was found to enhance the hardness and wear resistance of the coating. However, the properties of the coating were found to vary across the coating showing a maximum hardness and wear resistance in the region somewhere in between its surface and the interface with the mild

ブックレビュー/編集後記

steel. The possibilities of occurring of various kinds of transformation during spraying as well as during post spray heat treatment has been analysed as a cause of variation in distribution of property across the coating.

会員には「鉄と鋼」あるいは「ISIJ International」のいずれかを毎号無料で配布いたします．「鉄と鋼」と「ISIJ International」の両誌希望の会員には，**特別料金 5 000 円**の追加で両誌が配布されます．

ブックレビュー

●研究者のための資料写真の撮り方●

鈴木昭夫，吉田　成，岡宮誠一，田口榮一，鷲野谷秀夫　共著
1991 年 6 月　理工学社発行
B 5 判，201 頁，定価（税込）3, 296 円

学術研究のための資料撮影技術が簡単にマスターできます！

学術研究にとって資料写真は切っても切れないものであります．また，専門家に依頼することなく，研究者自身が最適の条件で撮影できれば，たいへん有利に研究を進めることができます．

本書はこれらを満たすために，下記に示すようないろいろな分野における学術写真撮影技術がわかりやすく解説されております．ご承知のとおりカメラや感光材料の技術進歩は目覚ましく，常に進歩に追随した技術に対応していく必要があります．その点からも本書を一読されることをお薦めいたします．

収録されている項目は，考古学資料・歴史資料・工学資料・美術資料・医学資料・写真の保存の 6 項目で，内容は，基礎的な撮影技術から，X 線写真・赤外線写真・高速度写真・顕微鏡写真などの専門領域におよび，執筆はそれぞれの専門家が担当されています．

（(社)日本鉄鋼協会　下川成海）

●編集後記●

新しい年度の第一号の「鉄と鋼」をお届けします．昨年十月から編集の体制が大幅に変わりました．それによって従来は和文会誌分科会の仕事が，論文審査に 90%，その他企画的な業務 10% という内容から，論文審査 30%，会誌の企画，改善策の検討など 70% というような割合に変化しました．

来月号からは，論文の掲載順もある程度内容に配慮したものになる予定です．企画記事（解説・講義・談話室など）を検討するのも含めて，論文の掲載順も決めるなど，本当の編集業務らしくなって来ました．

大学の人，企業の技術者といった雑誌づくりの素人集団のボランタリーな活動で支えられているわけですが，今年から，広報の編集などに経験の深い人のお知恵も拝借しようというわけで，企業の広報誌の編集に携わっている方々にお願いして輪番で和文会誌分科会にお一人ずつ参加して，ご意見を承ろうということにしました．

どこの学会でも，論文を読む会員，読める会員の比率が下がり，論文の発表数とその質が学会の活力のバロメーターであるにもかかわらず，論文誌の旗色はよくありません．「鉄と鋼」は会誌に論文を掲載している会員一万人クラスの学協会誌としては珍しいものかも知れません．論文を会誌に掲載することが会員のためにならないとまで考えたくありませんが，本年の課題は，来年一月号から判のサイズを現行の B5 から A4 に変更するのに際して，せめてレイアウトの面でも会員によろこんでいただける会誌にするために工夫をしたいと思っています．なお A4 化に伴って会誌の表紙のデザインを変更することになり，現在，デザインの募集を行っています．毎月一万部以上発行され，十年以上は基本デザインは変更せず用いられるでしょうから，腕とセンスとに自信のある方は是非チャレンジしていただくとよいかと思われます．

最後になりましたが，今月号から新しく「現場技術報告」の枠を設けました．いかがでしょうか．投稿の際，刷り上がりでつぶれてしまう小さな字を使用した図表であるかどうかは是非チェックして下さい．

（J. K.）