Editorial

Winter. A glorious season of the year. The entire Northern Hemisphere from Alaska to Sakhalin is covered with snow at the turn of the year. Europe, not only Alps and other mountainous regions, but also Scandinavia have swarmed with skiers. Lots of snow covered roads and streets posing many problems to carriers and also to community services. Many kids are filled with joy. Sledging, skiing, skating, fighting with snowballs and making a snowman – these are the common delights. Sledging cavalcades, skeering and also skidoo rides belong to the winter attractions in many regions. Many months long darkness prevails in the arctic regions above the Polar Circle – polar night. It is a very difficult to bear, frosty season of the year for many regions.

Materials for service at the low and extremely low temperatures feature an extensive area of knowledge for materials science specialists. It is worthwhile, at the opportunity of cogitation upon the winter weather, to give one's attention to these problems, as even trips at this season of the year call for practical knowledge and applications of this subject area. In general, the problem of low temperature is of especially great importance in engineering. Cryogenics is the science that addresses the production and effects of very low temperatures. Prof. Kamerlingh Onnes of the University of Leiden in the Netherlands first used the word "cryogenics" in 1894 to describe the art and science of producing the extremely low temperature. He used this word in reference to the liquefaction of permanent gases such as oxygen (which had been liquefied at -183°C a few years earlier – in 1887), nitrogen, hydrogen, and helium (a race was in progress to liquefy the remaining permanent gases at even lower temperature). The word "cryogenics" originates from the Greek words "kryos" meaning "frost" and "genic" meaning "to produce". Under such a definition it could be used to include all temperature below the freezing point of water (0°C). Over the years the term cryogenics has generally been used to refer to temperature below approximately -150°C. The temperature of -273.15°C is a limit to the lowest temperature that can be achieved, which is known as absolute zero.

Cryogenics has many applications. Cryogenic liquids, such as oxygen, nitrogen, and argon, are often used in industrial and medical applications. The electrical resistance of the most metals decreases as temperature decreases, but the most of metals become superconductors because they lose all electrical resistance below some transition temperature. Superconductivity in some metals was first discovered in 1911 by Kamerlingh Onnes, but since 1986 high temperature superconductors as a type of ceramics, have been found to be superconducting at much higher temperatures, currently up to about 145 K. Metals, typically niobium alloys cooled to 4.2 K, can produce extremely high magnetic fields with no generation of heat and no consumption of electric power (once the magnetic field is established – the metal remains cold) and are used for the magnets of magnetic resonance imaging systems. Other applications of cryogenics include fast freezing of some foods and the preservation of some biological materials such as human blood, tissue, and embryos and livestock semen. The cryosurgery consists in freezing of portions of the body to destroy unwanted or malfunctioning tissues, and could be used to treat cancers and abnormalities of the skin, uterus, liver, cervix, and prostate gland.

Many metals, especially those with very high strength or constructional materials in service at low temperature, demonstrate very low ductility connected with their minimal plastic deformation capability. Material cracking in these cases is controlled by propagation of fractures at high rates albeit the average stress in force in the constructional element is relatively low and the external load does not grow. Assessment of materials properties based on classic strength tests fails in these cases. Therefore, test methods derived from fracture mechanics become more and more important, making it possible to determine the capability of material to counteract in propagation of fractures, i.e., assessment of the crack resistance.

Cryogenic steels are used in the temperature range from below 0°C to helium boiling point, i.e., about -269°C, in chemistry and petrochemistry, refrigeration, shipbuilding-, aircraft-, and nuclear industries, in space technology, and also for liquid gases tanks design. As the temperature goes down the strength grows, whereas the steel ductility and brittle cracking resistance deteriorate. Lowering the temperature results in reduction of the dislocations mobility and their so called freezing. There is a sudden impact value reduction on the temperature/impact curve, and the point of contraflexure on the t_k curve determines the transition temperature into the brittle state, the so called nil ductility transition temperature. This phenomenon, characteristic of metals with A2 and A3 lattices, does not occur in alloys with A1 lattice. Impact strength of KV = 27 J is assumed as the boundary value for many steels. To avoid damage or failure of structures in service at the low temperature, steels are used for them characteristic of the nil ductility transition temperature lower than the service temperature. Ni is the main alloying addition in cryogenic steels. The element shifts the nil ductility transition temperature t_k significantly to lower values, causing at the same time reduction of the maximum impact strength at the temperature higher than the NDT temperature. Ni fosters development of the fine-grained bainitic and martensitic structures of steel due to its strong effect on hardenability. Lowering the M_s and M_f temperatures – of the start and finish of the martensitic transformation – induced by Ni addition results in occurrence of the significant portion of the retained austenite in the heat treated steel structure, which decides the additional improvement of the steel impact strength An addition of Mn also results with the impact transition temperature shift improving the mechanical properties of steel including its impact strength, both at the room and lowered temperatures. Manganese in concentration above 0.8% may cause temper brittleness, which is counteracted by an addition of Mo, and also increased cooling rate after tempering. The C and N elements raise significantly the impact transition temperature t_k , similarly as S, O, and P. Heat treatment has a significant effect on the nil ductility transition temperature. Steels with the fine lathe type high tempered martensite structure, obtained with heat treatment, are characteristic of the lowest t_k temperature; slightly higher temperature is typical for steel with the bainitic structure; whereas, the highest one – for the normalised steels with the ferritic-pearlitic structure. For service at lowered temperature the unalloyed and low-alloy steels are used (they can be in service at temperature not lower than -50°C; they are subjected to the controlled rolling, normalising or heat treatment to refine their grains; they have an addition of Mn and small additions of Ni, Mo, Cr, Nb, and V with concentrations not exceeding 1%), nickel steels with concentration of 1.5 to 9% Ni – at the temperature from -50 to -200°C, chromium-nickel steels and chromium-nickel-manganese steel with the austenitic structure and the relatively low yield point, decreasing slightly along with reduction of the test temperature, the high-nickel alloys with the austenitic structure, including the so called inwar with the 36% Ni concentration, in which the impact transition temperature does not occur down to the He boiling point, i.e., to about -269°C.

Non-nickel steels are also used for service at the lowered temperature, including also the unalloyed steels with the ferritic-pearlitic structure, and the low-alloy ones, mostly Cr-Mo with the high tempered martensite structure. However, the minimum service temperatures of these steels are much higher than those of the high-nickel steels. Many other constructional and machine steels, especially those heat-treatable ones, can be also used for service at the lowered temperature. Steels with the austenitic structure feature a separate group for service at the lowered temperature. These are the high-alloyed Cr-Ni and Cr-Ni-Mo steels identical or very close to the austenitic corrosion-resisting- or creep-resisting steels. The "maraging" group of steel, consisting of the low-carbon iron-nickel alloys with the martensitic structure, precipitation hardened and characteristic of the significant strength and plasticity, other than steels containing carbon occurring in the solid solution or in carbides phases, strengthening by precipitation of the intermetallic phases, e.g., Ni_3Ti, Fe_2Mo, Ni_3Mo, $NiAl_2$ can also be used for service at the lowered temperature. This happens as the main alloying element in the "maraging" type steels is Ni with concentrations of 8÷25%. This element improves the steel hardenability making martensite transformation possible during hardening after austenitising, as it is air cooled. Nickel improves also the brittle cracking resistance and decides lowering the impact transition temperature, so that the yield point changes negligibly to the temperature of about -250°C. This element fosters inconsiderably strengthening of the steel during tempering; however, it originates the Ni_3Ti, Ni_3Mo, $Ni_3(Mo,Ti)$, NiTi, $(Fe,Ni)_2Mo$ intermetallic phases. The "maraging" type steels are used as the design material for making elements in service in a wide range of temperatures – lowered even to about -200°C. Cast steels with the compositions corresponding to the relevant steels may be used for service at the lowered temperature, this is also true for cast irons – especially the spheroidal ones with the impact strength specified in addition at the temperature lowered to -20 or -40°C. Some high-nickel asutenitic steels can be used for elements of machines and equipment in service at the lowered temperature.

The superconducting materials are characterised by the critical temperature T_k, above which the superconductive properties dwindle suddenly. Transition of metal from its normal state into the superconductive state is the reversible phenomenon. The fine monocrystalline metals demonstrate the very abrupt transition from their normal- to superconductive state, with the transition temperature zone width smaller than 10÷3 K; whereas the contaminated polirystalline metals, at the more gentle transition, demonstrate the wider temperature transition zone. Currently 38 elements are known demonstrating superconductivity and about 1000 alloys and compounds which are superconductors, and new ones are being discovered all the time. Organic matter occurs also among superconductors, like, e.g., aniline or pyridine as molecular layers. The cuperconductivity effect is demonstrated by the Be and Al metals of the main families, many transition metals, and some semiconductors. The Si and Ge semiconductors pass into the cuperconductivity state under high pressure, as then they assume the metallic state. Superconductivity is demonstrated also by P, As, Se, Sb, and Bi – in the form of the thin amorphous or policrystalline layers fabricated with the condensation on the cold substrate method. However, the monovalent Cu, Ag, and Au metals are not superconductors, neither the

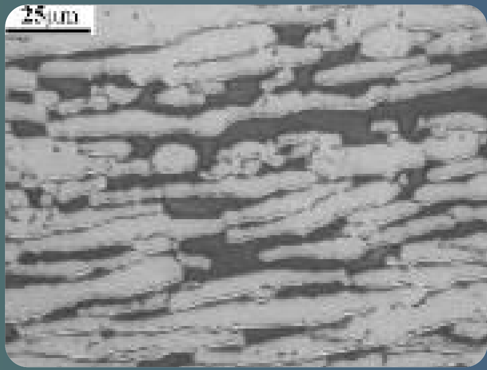
Fe, Co, and Ni ones, as their strong ferromagnetism does not allow superconductivity to occur. Therefore, the superconductive elements are Al, Hgβ, Pa, Ti, Sb, Be, In, Pb, Tl, Ba, Se, Bi, Cd, Ir, Re, Uα, Si, Mo, Ga, Laα, Ru, Uγ, Ce, Te, Laβ, Sn, V, Cs, Y, W, Gaγ, Ta, Ge, Hf, Nb, Tc, Zn, Hgα, Os, Th, Zr, P. From among the most important alloys and superconductive compounds one may mention Nb-Ti superconductors. Currently the NbTi46,5 alloy is used most commonly, albeit in certain applications the NbTi50 alloy is preferred. The Nb-Ti-Ta and Nb-Ti-Hf alloys and the Nb-Ti-Ta-Zr quaternary alloy exhibit slightly bigger critical magnetic field. The most common use of the Nb-Ti superconductors is in the MRI magnetic resonance equipment used for examinations and diagnostics of brain, kidneys, and liver, of whose more than 1700 are installed yearly in the world. However, the HEP high-energy physics is the biggest receiver of superconductors. The first in the world Fermilab's Tevatron high-energy superconductive accelerator with the 6 km long ring, containing 774 superconductive dipoles and 216 magnet quadropoles, was set to work in July 1983; whereas the main ring of one of the later SSC in Texas, US, has already 83 km perimeter and contains 7680 dipoles and 1776 magnet quadropoles. The Nb-Ti superconductors have also found applications in the thermonuclear synthesis equipment, mostly in tokamaks, producing a toroidal magnetic field, in LCT large coil test in Oak Ridge National Laboratory in US, in which as much as five coils out of six were made using superconductors from the Nb-Ti alloys, each of 8T magnetic field peak at the electric current of 10÷19 kA. The Nb-Ti superconductors were also used in the power generation installations, in the NMR nuclear magentic resonance, chemical spectroscopy, in the MHD magnetohydrodynamic power generators, power transmission, magnetic levitation and in the proton beam therapy, as well as in the magnetoplan- magnetica levitating train designed in Japan and reaching speed of 400÷500 km/h. Other most commonly used superconductor groups include those containing the A_3B phases with the A15 type lattice structure (from among 76 known phases of this type as much as 49 are superconductors). Superconductors containing the A15 type phases are used in the NMR nuclear magnetic resonance equipment, alternating current motors and generators in service below 18 K, as energy transfer cables, in the high-energy physics, and in the thermonuclear synthesis. The US-DPC coil is the prototype of a cable for the central tokamak solenoid. In the NET next European torus its PF poloidal- and TF toroidal field coils were designed with Nb_3Sn, and a system designed with Nb_3Sn is planned in the ITER international thermonuclear experimental reactor being the European-American-Japanese-Russian joint project. Moreover, Nb_3Sn was used in the international LCT installation with six D type coils and in the Westinghouse coils in the ICCS internally cooled cable in conduit. Moreover, superconductors with Nb_3Sn, V_3Ga, $Nb_3(Al,Ge)$, and Nb_3Al are used in the magnetic field bigger than 10 T and at temperature lower than 15 K. A class of materials with the general formula $M_xMo_6X_8$, where M is a c cation and X is a chalcogen (S, Se or Te), where Mo may be also substituted with Re, Rn or Rh, called R. Chevrel phases, demonstrate the superconductive properties. Because of the big critical magnetic field, the practical use found the $PbMo_6S_8$ chalcogenes (designated as PMS), $SnMo_6S_8$ (designated as SMS), and $LaMo_6S_8$, which are characteristic of the critical magnetic fields of 60, 34, and 45 T respectively at temperature of 0 K. PMS wires are used in devices which require high magnetic field in the high-energy physics for nuclear synthesis and in the NMR nuclear magnetic resonance. Discovery of superconductivity in the La-Ba-Cu-O system at the temperature of 30 K in 1986 by J.G. Bednorz and K.A. Müller, and next in the Y-Ba-Cu-O (YBCO) system at the temperature of 93 K in 1987 by M.K.Wu et al., in the Bi-Sr-Ca-Cu-O (BSCCO) system at the temperature of 110 K in 1988 by H. Maeda, Y. Tanaka, M. Fukutomi, and T. Assano, and next in the Tl-Ba-Ca-Cu-O (TBCCO) system at the temperature of 125 K in 1988 by Z.Z. Sheng and A. Herman, attracted attention to the very big importance of the thin superconductive layers. Electron beam evaporation, sputtering both from the composite disks and from various electrodes, and laser ablation technologies are used to this end. Saphire crystals (monocristal Al_2O_3), $SrTiO_3$, $LaAlO_3$ or $LaGaO_3$ are used as substrate. These superconductive materials have found many applications or it is expected that they will find them in the nearest future, as converters of analogue signals into digital ones, for signal processing and analogue electronics, with the high resolution and low energy dissipation, for parametric amplifiers and tunnel connections superconductor/insulator/SIS superconductor operating at the very low noise level, in sensory applications as detectors of infrared radiation and visible light, and also in the SQUID superconducting quantum interference device magnetometres. Transmission lines operating at the microwave frequencies require amplification with low losses, and then – apart from gold and silver – superconductors can be used.

The high-temperature superconductivity was discovered in the $(La_{2-x}Sr_x)CuO_4$ material designated often as 214 from the numbers of La, Cu, and O atoms in this compound; concentration of Sr corresponds to $0<x<0.3$. At a higher temperature transformation of the tetragonal phase described as the T type structure into the rhombus phase occurs. Structure of the Nd_2CuO_4 compound called the T' structure is related closely with the T type structure. Combination of the lower part of the elementary T' type cell with the upper part of the T type elementary cell produces the structure characteristic of the $(Nd_{2-x-y}Ce_ySr_x)Cu_2O_4$ type compounds called the T* structure. The main types of the high-temperature superconductors used currently are YBCO ($YBa_2Cu_3O_7$) designated as Y (123) with the critical temperature of 93K, BSCCO ($Bi_2Sr_2CaCu_2O_8$) as Bi (2212) (92K) or ($Bi_2Sr_2Ca_2Cu_3O_{10}$) as Bi(2223) (110K), TBCCO ($TlBa_2Ca_2Cu_3O_{10}$) as Tl (1223) (122K), and HBCCO ($HgBa_2Ca_2Cu_3O_{10}$) as Hg (1223) (133K). Superconductivity was discovered recently also in materials based on fullerens doped with the alkali metals and higher alkali fullerides. The highest confirmed so far critical temperature of 133 K is observed in the $HgBa_2Ca_2Cu_3O_8$ mercury superconductors discovered by Anitopov in 1993. In 1993 Chu obtained under high pressure the critical temperature of 150 K in these materials. The organic superconductors were discovered at the turn of seventies and the 1980s among the so called Bechgaard salts, e.g., $(TMTSF)_2ClO_4$, where TMTSF stands for Tetramethyl Tetraselena Fulvalene. Superconductivity was discovered also in the β-$(BEDT\text{-}TTF)_2I_3$ compound. The BEDT-TTF stands for Tetrathia Methyl Tetrathiafulvalene.

I do not doubt that the constructional and functional materials mentioned herein belong to interests of Readers and Authors of our Journal. Delivering the current issue to our Readers I hope for further fruitful co-operation, to which I would like to invite you sincerely.

Gliwice, in January 2009

Prof. Leszek A. Dobrzański, M. Dr H.C
Editor-in-Chief of the JAMME
President of the WAMME
President of the ACMSSE



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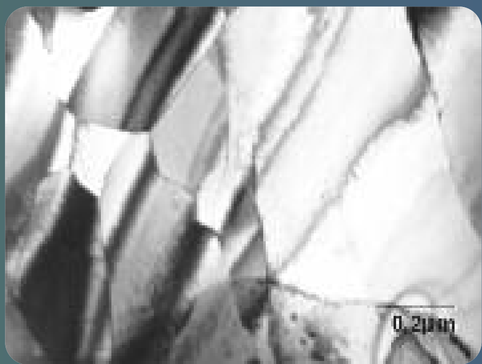
The Research Monograph entitled "Ferritic-austenitic steel and its weldability in large size constructions" by J. Nowacki on a **page 115** demonstrates the influence of selected aspects of welding technology, including welding heat input and between-bead temperature, additional materials on microstructure transitions and properties of welded joints. In the described work, experiments were conducted to welding tests for selected joints, visual examinations, non-destructive testing of welded joints, X-ray examinations, and metallographic testing of welded joints. On the basis of sources and own experiments, the analysis of microstructure, properties, applications as well as material and technological problems of ferritic-austenitic steel welding were carried out. The area of welding applications, particularly welding of large-size structures, on the basis of example of the FCAW method of welding of the UNS S3 1803 duplex steel in construction of chemical cargo ships was shown. An original value of the paper is to prove that a usage of high value welding heat input provides the best joints quality.



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In the paper entitled "Technological plasticity and structure in stainless steels during hot-working" by D. Kuc and G. Niewielski on a **page 154** the investigations provided referring to the influence of the hot plastic deformation process on the microstructure and the substructure as well as technological plasticity of steels of an austenitic, ferritic and ferritic-austenitic structure is presented. The high-temperature plastic deformation is coupled with dynamic processes of recovery influencing the structure and properties of alloys. One of crucial issues is to find the interdependence between the hot plastic deformation process parameters, the structure and properties. The research carried out enabled the understanding of the phenomena taking place during deformation and annealing of the investigated alloy. The results will constitute the basis for modelling the structural changes. The obtained results are vital for designing an effective thermo - mechanical processing technology for the investigated steels.