ABSTRACTS

DEPARTMENT OF METALLURGY

1. Tempering of High Carbon Steels. E. G. Ramachandran and D. P. Antia, *Trans. Ind. Inst. of Metals,* 1949, **3**, 131.

Steel, on hardening, will consist of martensite and some retained austenite. The presence of both constituents is easily understood from the nature of the transformation of austenite. Tempering of the hardened steel is accompanied by structural changes in both constituents. Study of the changes by magnetometric, dilatometric, hardness and X-ray methods has enabled the following conceptions to be put forth. (1) The tetragonal martensite obtained on quenching yields on tempering in the range 80° C. to 160° C., a transition structure embedded within a ferritic matrix; (2) Retained austenite on tempering in the range 230° C. to 280° C. yields a product similar to that obtained in the first stage; (3) The transition structure progressively forms, on tempering in the range 260° C. to 360° C., Cementite, which on, further heating, reveals itself in its well known spheroidized form.

2. A Method for the Determination of Stress Produced on Electrodeposition by Using Electrical Strain Gauges. E. G. Ramachandran and K. V. Chinnappa, *Trans. Ind. Inst. of Metals,* 1950, **4**, 173 (Originally presented to the Societe Française de Metallurgie for its le Chatelier Centenary Commemoration Celebrations).

The stresses produced on electrodeposition have been for the first time, determined using electrical strain gauges. The strain gauges are mounted on one side of a thin metallic strip which is then electroplated. From a theory which has been developed relating the thickness of the deposit with the stresses produced in the metallic strip and its distortion, the stresses can be calculated. The theory has been developed to include the case of thick deposits.

Experiments on the deposition of nickel on steel were carried out and it was found that the values agreed to within 8% of those found by conventional methods.

3. ELECTRON MICROSCOPE AND METALLURGY. E. G. Ramachandran, *Metal Market Review*, Annual Number, 1951, 79.

The resolving power of an optical microscope using the most favourable conditions of observation is of the order of 1,500 Å units and the highest useful magnification is of the order of 5,000 diameters. Thus its inadequacy in the study of several important metallurgical problems like age-hardening, nature of martensite, etc., where the order of physical separation between the various constituents is 100–500 Å units. The study was rendered possible by the invention of the Electron Microscope, which was almost entirely due to the developments due to de Broglie and Busch, who respectively showed the wave nature of an electron beam and the focussing action of electrical and magnetic fields on an electron beam.

The electron microscope is of invaluable help in the study of (1) structure of hitherto unresolved constituents of steel; (2) age-hardening; (3) nature of grain boundaries in metals; (4) recrystallisation after cold work; (5) influence of additions of small amounts of aluminium and vanadium in 'Killing' of steels and of boron on hardenability; (6) 'Dislocations' and other contributory causes of slip.

4. A NOTE ON THE MOUNTING OF TUNGSTEN WIRE FOR MICROSCOPIC EXAMINATION. E. G. Ramachandran and others, *Indian Science Congress*, Eng. and Met. Section, Bangalore Session, 1951.

Tungsten wire is wound over a small rectangular block of a transparent thermoplastic material like lucite. The block, with the windings, is then mounted as usual, into a cylindrical block. By cutting suitably with a hacksaw, the desired section of the wire can be exposed. The section is then ground, polished and etched as usual for microscopic study.

The entire absence of staining, usually prevalent in older forms of mounting, is an advantage of this method.

5. HARD METAL CARBIDES. E. G. Ramachandran and M. V. Patankar, *Mechanical Engineer*, No. 1, October 1950.

A brief account of the manufacture of sintered tungsten carbide tools is given. The process consists in making the carbide powder and then mixing it with a specified amount of cobalt powder. The mixture is pressed and sintered and finally brazed to a mild steel shank for insertion in a tool holder.

Tungsten powder is first obtained by reducing tungstic oxide in a stream of hydrogen gas at about 900° C. The carbide is then obtained by carburising the tungsten powder with lamp black or other form of pure carbon in a furnace kept at 1,500° C. to 1,600° C. in an atmosphere of hydrogen. Rather higher temperatures are necessary to make the carbides of titanium and tantalum.

The size of the powder at each stage is of the utmost importance and the process has to be very finely controlled throughout to yield the optimum size of powder.

6. THE STRUCTURE OF COLD WORKED STEEL. E. G. Ramachandran. To be presented at the Indian Institute of Metals—Annual Meeting at Calcutta, January 1952.

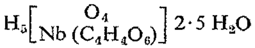
The variation, due to cold drawing, in some mechanical and physical properties of a wide variety of steels has been studied. In addition to using the dilatation, hardness, X-ray and magnetic testing methods of study, a new method of thermal analysis capable of accurate determinations of the specific heat and evolutions and absorptions of heat on progressive heating has been developed. Comparative studies on a few non-ferrous alloys have also been made.

It has been found that the behaviour of nearly all steels investigated resembles that of a pure metal or single phase alloy in the early stages of cold work and that it is often quite different in the later stages of the cold work.

The effect of cold work in its early stages has been identified to be mainly on the ferrite grains in the steel, while the effect in its later stages has been identified to be mainly on the cementite. The mechanism of the cold working process on each of the two constituents has been considered and a theory covering both cases has been advanced.

7. STUDIES ON NIOBIUM AND TANTALUM—PART I. TARTRATONIOBIC ACID. N. R. Srinivasan, *Proc. Ind. Acad. Sci.*, 1950, **31**, 194.

The formation of a higher order compound of niobium with tartaric acid has been investigated. Freshly precipitated niobic acid reacts with tartaric acid to yield a definite complex compound. The conditions of its formation have been studied. It analyses to the composition $Nb_2O_5 \cdot (C_4H_4O_5)_2 \cdot 10\,H_2O$. It is a light straw coloured substance and is very soluble in water. Its properties have been investigated. Its electrical conductivity has been determined at a series of dilutions and its basicity has been determined by the Ostwald method. Molecular weight of the compound has been found out by the cryoscopic method. The optical rotation of its solution shows an enhanced rotation. Dehydration conducted in air and in vacuum has revealed some features regarding its structure. According to the Rosenhein-Miolati theory, it is formulated as a heteropoly acid being derived from metaniobic acid H_7NbO_6 by the replacement of oxygen atoms by a tartrate radical and is represented as



$$H_5\left[Nb\,\overset{O_4}{(C_4H_4O_6)}\right]2\cdot5\,H_2O$$

It is named as 2-tartrato-2-niobic acid 10-hydrate.

8. Studies on Niobium and Tantalum, Part II, Alkali Tartratoniobates. N. R. Srinivasan, *Proc. Ind. Acad. Sci.*, 1950, **31**, 315.

This paper details the work on a new class of compounds called the tartratoniobate. In an intensive investigation on the alkali niobates, some earlier data on the lithium niobates have been contradicted. Two new niobates, 2 *viz*., $3\,K_2O\cdot4\,Nb_2O_5\cdot20\,H_2O$ and $4\,Li_2O\cdot3\,Nb_2O_5\cdot15\,H_2O$ have been isolated. The reaction of tartaric acid on several niobates of lithium, sodium and potassium has been studied in detail and has resulted in the following tartratoniobates. $Li_2O\cdot Nb_2O_5\cdot(C_4H_4O_5)_2\cdot8\,H_2O$, $Na_2O\cdot Nb_2O_5\cdot(C_4H_4O_5)_2\cdot nH_2O$ and $K_2O\cdot Nb_2O_5\cdot(C_4H_4O_5)_2\cdot n\ H_2O\ (n = 6$ or $10)$. The properties of each of these compounds have been studied in detail and the difficulty in crystallisation and anomalous solubility have been adequately explained. Dehydration has been conducted in air and in vacuum. A heteropoly acid structure has been assigned to the tartratoniobates.

9. Studies on Niobium and Tantalum—Part III. Alkali Earth Tartratoniobates. N. R. Srinivasan, *Proc. Ind. Acad. Sci.*, 1950, **31**, 381.

The niobates of the alkaline earth and other metals are insoluble and hence the tartratoniobates of these metals are prepared by double decomposition of soluble metal salts with potassium tartratoniobates. The calcium-2-tartrato-2-niobate 10-hydrate of the formula $CaO\cdot Nb_2O_5\cdot(C_4H_4O_5)_2\cdot10\,H_2O$ has been prepared and studied. The strontium tartratoniobate prepared has the formula $SrO\cdot Nb_2O_5\cdot(C_4H_4O_5)_2\cdot10\,H_2O$. A copper compound of the formula $CuO\cdot Nb_2O_5\cdot(C_4H_4O_5)_2\cdot10\,H_2O$ has been prepared in a similar manner.

The barium and lead tartratoniobate are also prepared by the above method of double decomposition but they are obtained as basic salts of the formulæ $4\,BaO\cdot3\,Nb_2O_5\cdot(C_4H_4O_5)_6\cdot16\,H_2O$ and $5\,Pb\cdot0\cdot3\,Nb_2O_5\cdot(C_4H_4O_5)_6\cdot20\,H_2O$. It is significant that the dehydration of the barium salt gives a practically anhydrous compound. The calcium, strontium and copper compounds obtained are considered as the normal salts of the 2-tartrato-2-niobic acid whereas those of barium and lead are regarded as basic salts. Suitable heteropoly acid structures are assigned to these compounds.

10. ELECTROPLATING OF METALS FROM FLUOBORATE BATHS. J. Balachandra, *Journal, Electro-Chemical Society*, Jan. 1951, **98**, No. 1, 17 C.

Fluoborate baths have been found to present a combination of features hitherto not realized in most of the present-day plating baths. These baths have all the desirable qualities of the acid type bath, *viz.*, high conductivity, good cathodic and anodic current efficiencies, non-poisonous nature on the one hand, and good throwing power of the cyanide bath on the other. They are superior to the other types of baths in respect to high metal content that can be employed, ready solubility in water, satisfactory deposition even at high current densities, ease of maintenance, and stability.

Copper, zinc, tin and nickel fluoborate baths are compared with other plating baths, with special reference to preparation, maintenance, and operating characteristics. Work done by the author and his co-workers on cadmium, zinc, and nickel fluoborate baths are referred to, pointing out the special advantage of these baths over other types.

11. ELECTRODEPOSITION OF COPPER-TIN ALLOYS FROM FLUOBORATE BATH. J. Balachandra, *Curr. Sci.*, 1951, No. 4, 99.

Bright and adherent deposits of copper-tin alloys have been obtained from the stannate-cyanide bath. The stannate cyanide bath requires careful control of bath composition and anode current densities when separate anodes are employed. From the fluoborate bath containing both the metal fluoborates in solution, deposits similar to those obtainable from the stannate cyanide bath have been obtained. The bath is stable over long periods of operation in the presence of excess of free fluoboric acid.

The deposits obtained from the bath are fine adherent and are easily polished. The throwing power of the bath is satisfactory. Satisfactory deposits of any composition between 17·3% Sn–82% Cu and 90% Sn–9·5 Cu can be readily obtained. Deposits obtained beyond the range of c.d. studied are coarse and non-adherent. No appreciable change in composition of the deposit from that obtained at room temperature has been observed when the bath is operated at temperatures up to 60° C. Mild agitation has no influence on the composition of the deposit.

12. METHODS OF WIRE PRODUCTION. K. V. Aiyer. To be presented at the Indian Institute of Metals—Annual Meeting at Calcutta, January 1952.

The paper makes a survey of some recent trends in the practice of wire drawing, with special emphasis on drawing of high tension transmission cable wires of aluminium. The design features of slip and accumulation type wire drawing machines are first considered and it is observed that in spite of the adverse effect of slip, if present in excessive amount, on the surface quality of the wire drawn, these types are in general use for non-ferrous work. The usual velocity of slip between wire and capstan for aluminium is indicated to show the method of slip calculations, and it is observed that a constant slip is preferred to a constant slip ratio.

The operation of a typical machine is next briefly considered to show the method of controlling both the speed and tension of the wire during the drawing process. D.C. motors are used for the drive and spooling, and the two machines are kept in sequence by the expedient of having their armatures supplied in series from a common source. Individual shunt field rheostats allow the tension of the wire to be adjusted within certain limits, and the rheostats are operated both manually and automatically for coarse and fine settings.

The lubricants used for the process, their viscosity ranges and their compositions are then discussed and mention is made of ready-mixed oils available in India, marketed by oil companies like Standard Vacuum and Shell, which have been found to work satisfactorily for the drawing of conductor grade aluminium. The usual lubricant is mineral oil compounded with fat and fatty acids to cut down boundary friction, and the temperature of drawing for aluminium is around 140°–180° F.

As to a large measure, good dies determine successful drawing, standard practice for lapping and polishing them are outlined. The abrasives used and the method of suspending them in suitable media, as also the usual angles to which the bell, approach, bearing and relief portions of the die are shaped, are given.

The fabricating schedules employed for drawing four alloy metals, *viz.*, steel aluminium, duralumin for knitting needle wire and an aluminium alloy for nail wire, are presented in order to illustrate how the drawing procedures can be so altered as to suitably develop the mechanical and physical properties that may be demanded of the final products: judgment, and thorough understanding of alloy characteristics are essential to specify the optimum conditions during drawing.

A short discussion of plasticity theory for wire drawing then follows in order to evaluate the drawing tension. This theory requires a knowledge of the flow and strain-hardening characteristics of the material, and to illustrate its application to the drawing of conductor grade aluminium, its flow curve is derived. From experimental data obtained by drawing wires through various sizes of dies with semi-angle of 8° and with the lubricant at 140° F., the true-stress, true-strain equation is obtained as:

$$\sigma = 20{,}300\ (5\ \text{Log Strain})^{\cdot 101}\ \text{pounds/sq. in.}$$

Finally, a simple method is indicated for calculating the power absorbed during drawing, using flow curves, and this is illustrated by examples taken from typical plant practice.