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Role of Tin and Zinc on the Proprietes of Liquid Copper

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Abstract: At the liquid state, on the diagrams (above the line of liquidus), an identical field of liquid solution is usually presented not depending on the type of the diagram of state of solid metal. However, these last years a series of works appeared which directly shows the well defined relation ship of the control of the liquid and the variation of these properties (viscosity, surface tension, conductibility electric and different) with the nature and the type of the diagram of state, these characteristics finds an image and emerges from the lines, dividing the common pole of the liquid state on various fields, which is characterized a dependent given energy with the particles of the components thus binding the various properties of liquid alloy. The properties of alloys containing copper in the liquid state are studied in several works. However, currently, the volume of information is not sufficient for all the characteristics of these alloys. The number of the data on the density, viscosity, surface tension, and other physicochemical properties of liquid copper alloys did not find for the moment of use practical. In this present work, we studied the most important physicochemical properties of principal liquid alloys containing copper (Cu-Sn, Cu-Zn).

Key words: Density, viscosity, surface tension, physicochemical

INTRODUCTION

The density of copper in the liquid state is determined by the method of the drop or that of the maximum pressure in the pores of gases. Figure 1 presents the data of various work on this subject[1-7], one distinguishes a linear dependence there density and temperature. The important dispersion of the absolute values of the density of liquid copper is related to the various levels of its purity. The density of copper without oxygen is measured by Guerassimov S.P.[8] roughly by the following equation:

$$\rho_{Cu} = 8.3 - 0.00073.(T - 1356K), [g\ cm3^{-1}]$$

Its viscosity is evaluated at various temperatures. On a level of the absolute values of the properties of pure metals show the influence[9] of the summary content of the impurities.

The influence of the temperature on the viscosity of pure copper (0.005%Fe; 0.002%Ni; 0.002%Sn; 0.001%Bi; 0.002%Sb) with the interval of 1373-1523K, obtained by the authors[10] Fig. 2 agree well while appearing with given other authors[10-14]. Values of the surface tension of copper[8] (nap of impurities 0.012%) in the interval of temperature 1100-1600°C is written by the relation:

$$\sigma_{Cu} = 1150 - 0.29.(T - 1473K)\ MJ/M2$$

The surface tension of extremely pure copper (nap of impurities 0.001%), has the highest values (1350-1370MJ/M2), according to other authors[15-17].

The copper, obtained in test-tubes casting in a sand and in a metal moulds has a flow which is presented in Fig. 3.

Alloys: Copper tin (Cu-Sn): The property of liquid alloys of the system Cu-Sn to various tin concentrations is of great interest, as shown in the Fig. 4 where we defer our

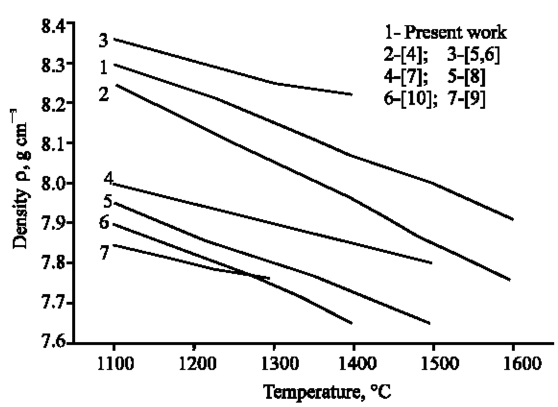

Fig.1 : Density of pure copper

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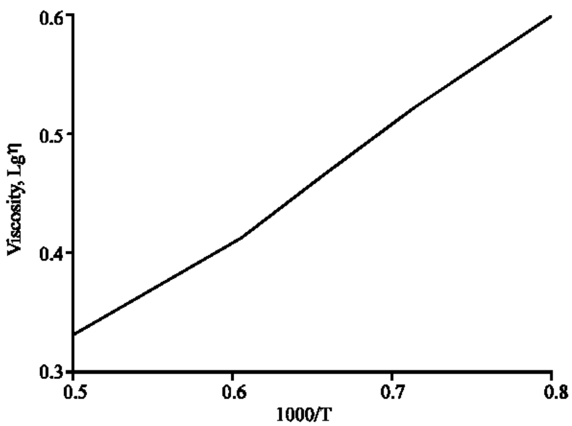

Fig. 2 : Influence temperature on the viscosity of liquid copper according to data's[10-14]

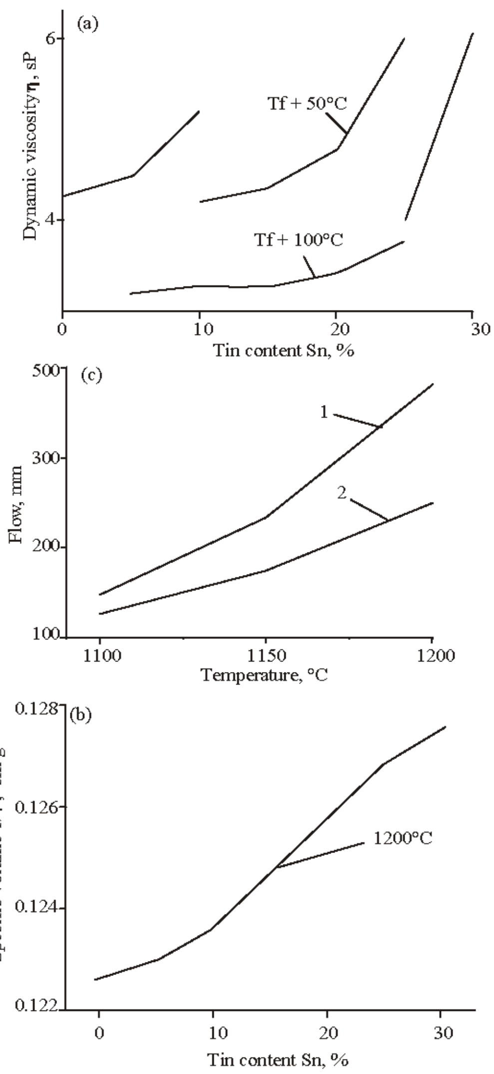

Fig. 3: Flow of copper at various temperatures: 1 - run in the sand moulds, 2-run in the shell

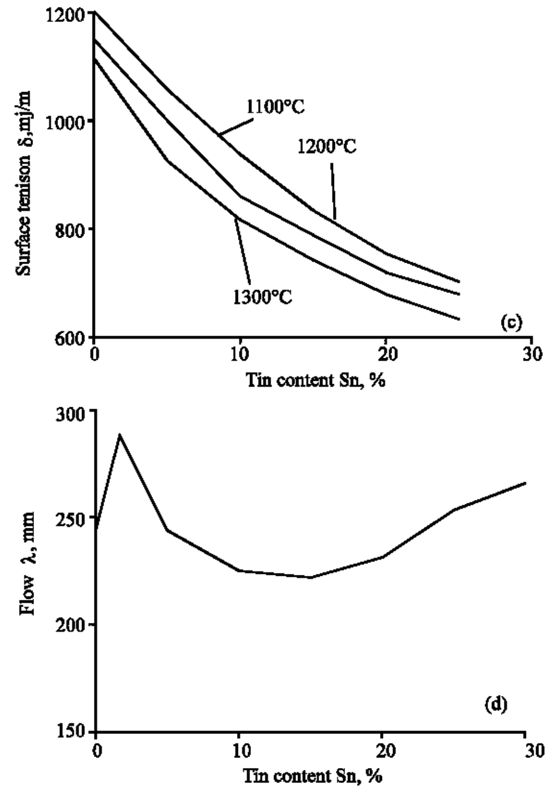

Fig. 4: Properties of alloys liquidate copper-tin

data and those of the literature as comparison. According to the classification of the authors[8], these alloys belong to the systems, of which the structures in the liquid state show a series of intermetallic combinations. They are characterized of a negative enthalpy of mixture (at temperature 1423 with the tin content of 38,37% in mass).

The variation of the viscosity of this liquid alloy at identical temperatures indicates that tin is shown of a negative activity for viscosity[9]. In the isotherms of the viscosity of liquid alloys of the type $Cu_{31}Sn_8$ and Cu_3Sn with strong chemical bonds, certain authors[11-13] find values maximum of viscosity. These data correlated with the maximum known the curve (ΔH^m-Composition)[11]. On the Fig. 4a are built the data Chelekov A.V and Tchoursine V.M.[10] and also Iones W.[12] according to the viscosity of the alloys Cu-Sn, with a Sn concentration up to 25% near the temperatures with the same values of overheating which are above the line of liquidus. The nature of the curves viscosity composition shows that the relation of the concentration of the viscosity of the various alloys Cu-Sn, while appearing with lines of overheating and isotherms equal is interpreted various ways. One distinguishes with equal overheating a less large activity from positive viscosity from tin in the copper, which tends towards a maximum value in the points, which answer the composition of the intermetallic compounds $Cu_{31}Sn_8$ and Cu_3Sn. In this way, one can note, that in the studied interval of the Sn concentration in Cu, the influence of the temperature was prevalent, which makes the impression of a negative viscosity due to the activity of Sn in Cu[11,13].

The pace of the isotherm of the surface tension (σ) of the alloys Cu-Sn Fig. 4b shows that Sn superficially behaves like the active element in copper. This behaviour, one can explain it by "the incompatibility" of the particles of copper and tin because of their difference in atomic dimensions. Dimensional factor F.D. according to the author[15] constitutes 21%, because of that occurs a kind of "repression" of the particles of tin (to the weak concentrations) or many groupings Cu_m Sn_n on surface of liquid alloy (according to the increases in the concentrations of tin in copper). The density (ρ) of these alloys liquidate Cu-Sn decreases with the increase in the content of the tin and the growth of the temperature. On the Fig. 4b are quoted the data[8] on the variations of the density of the system Cu-Sn in the co-ordinates (composition-1/ρ) at the temperature 1200°C. The comparison of the experimental data and the theoretically calculated values of specific volumes 1/ρ of alloys and according to the law of additively, show, that in the system Cu-Sn a compression of the volume takes place which gradually increases and approaches certain maximum values. Thus with contents 23.8% Sn (mass) the values of the compression of the volume of liquid alloy constitutes Δv = -2% while appearing with the ideal solutions.

Adding up the nature of the variation of the appreciably structural properties of liquid alloys of copper with tin, one can note that the alloys Cu-Sn belong to the systems, in which take place of the negative variations compared to the ideal solutions and or appears in the various stages, an influence of the bonding strengths between copper and tin. With the high concentrations of tin (up to 5%) in liquid alloys at the temperatures with the top of the line of liquidus, these connections are shown in less important degrees.

The flow of these liquid alloys to same overheatings (+60°C) above the line of liquidus is presented on the Fig. 4d. The nature of the variation of the flow is in agreement with the diagram of state and the interval of crystallization. The characteristic of the data obtained appears by stability because of considerable increase of the flow of copper (according to the test piece) during the relatively weak addition of the concentration of tin. The similar image is practically noted in all studied binary alloying of copper and presents cavity their specification. This one distinguishes them from alloys containing iron, aluminium, magnesium and others, or this regularity was not revealed. The increase in the flow of copper to the high additions of the combined elements is explained by the variation of the whole of its thermodynamic properties (thermal conductibility, heat-storage capacity and different). The direct correlation enters viscosity, tension surface and the flow on alloys of this system practically was not revealed.

Alloys: Copper-zinc (Cu-Zn): These alloys belong[18] to the systems containing an electronic connection. The diagrams Cu-Zn are characterized by the presence of a wide field of the solution α of Zn in Cu, because of a small relative difference of atomic dimensions of these components: r^a_{Cu}=1.28A°; r^a_{Zn}=1.39A° (dimensional factor F.D.= 6.8%). In alloys liquidate Cu-Zn are established[19] an important variation negative compared to the ideal (until 0.7N_{Zn}, or N_{Zn} is the atomic fraction of Zn in Cu) with gradually the passage in the field of the positive variations in alloys, rich in zinc (0.7-1.0 N_Z). The alloys Cu-Zn belong to the ideal solutions, however the alloys rich in copper (N_{Zn}<5) and pertaining to the single-phase current α-brass, can, according to[19], is written within the frameworks of the quasi-chemical theory of the reciprocal action of the heterogeneous atoms. The bibliographical data on viscosity and the surface tension of alloys liquidate Cu-Zn could not be revealed. On Fig. 5 are brought the data expérimentables of these properties. The alloys are prepared starting from pure metals: zinc (nap of the impurities = 0.025%) and coppers it (nap of the impurities = 0.06%).

The viscosity of alloys of copper with zinc at the same temperatures (isotherms of viscosity) decreases harmonically until the zinc content close by 32% (mass), i.e., within the limits of concentration corresponding to α-brass. In the passing to the composition of the alloys β-brass (solid solution containing the electronic connection Cu-Zn with stronger of interaction of the forces inter particulate of the atoms) the viscosity of liquid alloys increases by with blow. This increase is observed at the alloys whose Zn concentration is about 48-49% (mass). Superior with this concentration, the alloys were not studied. The nature of the variation of kinetic viscosity to same overheatings Fig. 5a and others: the reduction in the viscosity of the alloys Cu-Zn is observed only until the concentration of zinc 15% (mass).

Then in the interval of the concentration 15-35% Zn viscosity appreciably does not change but then increases abruptly with the compositions, which correspond to the concentrations of zinc at the time of the passage of the α-brass field in β-brass.

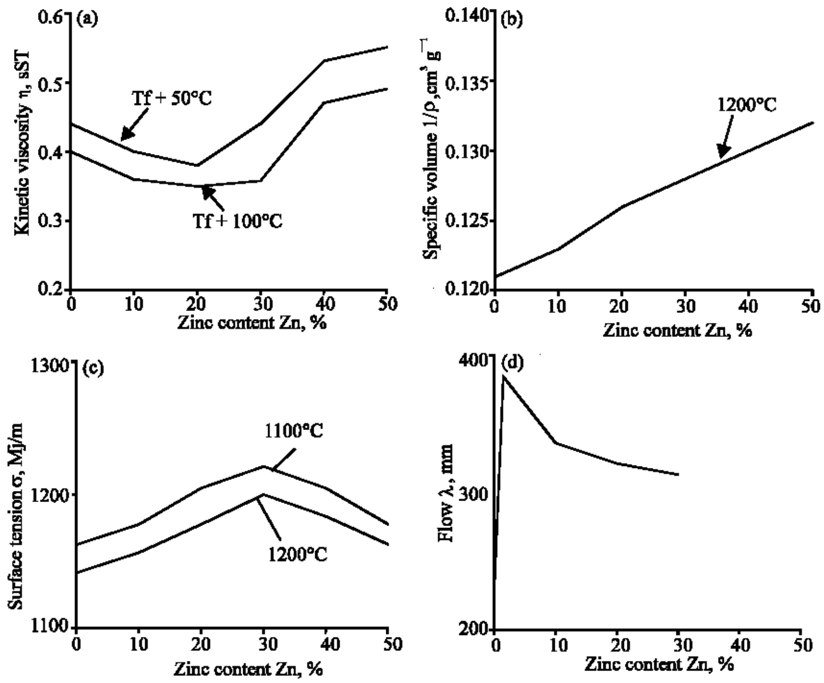

Fig. 5: Properties of alloys liquidate Copper-Zinc a) Viscosity; b) Specific volume; c) Surface Tension; d) Flow (casting in the sand moulds)

However, it is appropriate, especially to say, that for the moment, it is impossible to characterize the control of zinc in copper with important overheating, when the elasticity of its vapour becomes relatively high, the mobility of the atoms increases, certainly, is felt on these properties, like viscosity and the surface tension.

Measurements of the surface tension of the alloys Cu-Zn, carried out by Guerassimov S.P.[8], at relatively high temperatures, show Fig. 5c that with the zinc content up to 30% practically does not change. In alloys containing 32% more one distinguishes a point from curve and the surface tension of liquid alloys starts to decrease. The considerable variation of the surface properties of the system Cu-Zn compared to the direct additive (the eigenvalue σ of the zinc relatively large of its overheatings is less important than that of Cu and between 700 - 750MJ/m2 constitutes), one can explain it to the first place by a high mobility of the particles of zinc in liquid alloy Cu-Zn conditioned by great plasticity of these vapors, and in second place by the presence in liquid alloys of the CuZn groupings, which with regard to Cu and of Zn shows inactive properties. In the studied interval of the concentrations of the content of zinc the value of the temperature coefficient of the surface tension is negative.

The density of alloys liquidates Cu-Zn Fig. 5b decreases with the increase in the content of zinc in alloys. While appearing the experimental points of the curve ((composition-1/ρ) with the line, built by the rule of additive, shows the compression of alloys liquidate Cu-Zn which confirms the fact of the negative variations of these liquid alloys of those of the ideality. Relative variation of the volume (Δv) =3.1%, which is well harmony with the data mentioned by Vilson[15].

The flow of copper Fig. 5d with weak addition of zinc (0.5-1.0%) appreciably increases, but then one progressively distinguishes a harmonious reduction the length of the test-tube with the content of zinc and in accordance with the interval of crystallization (with the minimum with the zinc 15-20% concentrations). The flow then starts to increase with measurement of the approach of the compositions

CONCLUSION

At the beginning we studied influence of the temperature on the properties of pure copper, then we compare inter alias the density with other study.

The pace of the isotherm of the surface tension of the alloys Cu-Sn shows that Sn superficially behaves like the active element in copper. The density of these liquid alloys decreases with the increased content's tin and the growth of the temperature. The nature of the variation of the flow is in agreement with the diagram of state and the interval of crystallization. The particularity of the data obtained appears by stability because of considerable increase of the flow of copper during a weak addition of the concentration of tin. The viscosity of the alloys Cu-Zn at the same temperatures harmonically decreases until the zinc content close to 32%. In the interval of the studied concentrations of the content of zinc, the value of the temperature coefficient of the surface tension is negative. The density of alloys liquidates Cu-Zn decreases with the increased content of zinc in alloys. The flow of copper with weak addition of zinc (0.5-1.0%) appreciably increases, but then, we progressively distinguish a harmonious reduction of length of technological specimen with zinc content decreases.

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