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SOME INVESTIGATIONS CONCERNING THE MECHANISM OF SWELLING IN BRASS, CAST IN SiO_2 BASED MOULDING SAND

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The present paper presents experimental study of the mechanism of swelling of Cu-base alloys, a problem faced by non-ferrous foundry of Karachi Shipyard and Engineering Works Pakistan.

In experimental study the influence of different factors i.e., casting-temperature, weight of flux, grade of ramming and different casting techniques on Swelling has been observed to understand the mechanism of swelling. The detailed theoretical and practical study has confirmed that a casting is susceptible to swelling when either the mold is weakly rammed i.e., below 30 dietert number or insufficient weight is placed on the cope or openpit casting technique is applied.

INTRODUCTION

The present paper summarises the research experiments carried out to study the influence of different factors on swelling and to develop a reliable explanation of mechanism of swelling in Cu-Zn alloy, cast in sand mold.

EXPERIMENTAL

General Procedure

For studying the influence of different factors on swelling in Cu-Zn alloy, a rectangular test bar of 4½ x 2″ x 2″ was used. For studying the influence of casting thickness, test bars of variable cross-sections eg: 3″ x 3″,4″ x 4″ ,5″ x 5″ and 6″ x 6″ were used.

Moulding. The test bars for each of the experiments, were cast in sand mold composed of 1 % molasses. A naturally bonded sand 10 % clay with 1 % molasses was prepared in laboratory sized muller of 200 Ib capacity operating with an electric motor of 2H.P. fitted with a paddle, working at 90 rpm and a milling wheel of 400 1b, revolving at 45 rpm. The mixing was carried out for 15 – 25 min. and for each experiment 75 Ib of moulding sand were prepared. Laboratory sized flasks of dimension 10″ x 6″ x 2″ were used for molding pulverized graphite was used as a parting material. The test bars were covered with facing sand (silica and 1 % molasses) and backed up with used screened backing sand).

Each of the mold cavity was provided with a circular sprue of appropriate size e.g., sprue of 1″ diamerer for the test bar 4½″ x 2″ x 2″ . The pouring cup and base were respectively of 3″ & 2″ diameter. The sprue base was joined with mold cavity by a parting line gate of 2½″leangth and ½″ depth while its width at the mold cavity is 1½″.

The grade of ramming for each of the experiment was measured with the dietert mold hardness tester. And was maintained in the appropriate limit of 85 No. on the mold cavity.

Melting. The melting was carried out in a crucible pit furnace of 18″ outer diameter 10″ inner diameter, and 30″ height, lined with firebricks, fitted with blower which supply, air (2 OZ/ in^2 z) and operating with the by-pro-

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duct coke with fixed carbon about 85 % and total ashes less than 5 %.

For studying influence of some factors, e.g. casting temperature deoxidizing agent, composition (70/30 brass), 35 – 40 lb of brass i.e. (21 – 24 lb of Cu, and 14 – 16 of lb Zn) was melted.

The melting was started by putting down the kindling wood on the bottom of the furnance covering it with thick layer of coke and igniting it with burning wood. 4 – 6" pieces of coke were put next to the kindling wood and then small pieces of 1 - 2" diameter were charged, when the initial coke is burned well the preheated clay-graphitc crucible of 40 lb capacity with required amount of metal, was placed in the red hot coke and more coke is added.

Casting. The Cu-ingot was first melted because it has the higher melting temperature, as compared to Zn, which melts at 41.9° The Cu-ingot took approximately 2 hr. to melt completely. The metal was then treated with the silica glass which forms a protective layer on the molten Cu-(and acts as strong deoxidizing agent approximately) 2 lbs of broken glass was found sufficient for deoxidizing approximately 40 lbs of alloy and forming a protective layer of ½ to ¾ on the molten alloy. When the Cu-was completely melted, pre-heated Zn was added and very little flaring of Zn was observed because molten metal was properly deoxidized. In actual practice borax (soda ash) common salt and other salt materials (e.g. suggi and sohaga) are used as deoxidizing agents for molten brass. Our research shows that silica glass is the most suitable and effective agent for brass because (it acts as strong deoxidizing agent as well as it) forms a protective layer on the molten bath which catches the impurities, slag particles and other immiscible materials from the bath and does not allow the molten metal to come in contact with atmospheric gases which can dissolve in the molten metal, creating porosity, swelling and other defects. After the addition of Zn, the crucible was taken out of the furnance with the tongs of 4ft length and the temperature of alloy was measured by hand thermo-couple (pt/pt-Rh range 0 – 1400°). Before pouring the alloy in the mold the layer of molten glass covering the molten mass was broken and glass was not allowed to enter in the mold cavity.

After complete solidification the bars were taken out from the mold, cleaned, and risers and gates are separted from casting.

Factors Studied

The experiments were carried out to study the influence of following factors on swelling in brass:

1. Casting temperature (T)
2. Amounts of flux added (D).
3. Grade of raming (R).

For studying each of the factors all other factors remained constant, also melting and casting condition remains the same. In this way the swelling was observed as the function of one factors at a time.

Exp. 1. Influence of Casting Temperature : In order to study the influence of casting temperature, four samples were cast in four cavities, each practerised? seperately in six molds. Casting temperature in six cavities was, 190°, 1100°, 1000° and 935°. measured with hand thermo-couple.

The hand thermocouple fitted at one end with Cu – Ni steel nozzle containing the Pt/Rh tip, is dipped in the molten metal, approximately 4", below the molten glass layer.

Exp. 2. Influence of Fluxing: In order to observe the influence of flux, different ratios of flux were added to molten metal in the furnance and rates of swelling were studied. The flux was added by wt 0.0, 1.5,3.0, and 4.5, lb in each mold.

All other factors temperature (1120°), grade of ramming (85 D. No), composition of alloy (70/30 brass) and composition of moulding sand remained constant.

Exp. 3. Effect of Ramming. Ramming of sand plays an important role in swelling of casting. The influance of grade of ramming was studied in three molds which were rammed to different degrees. The bars were cast vertically in the molds of length 10" width 12½" and height 8" while the vertical mold cavity was provided with sprue base of 1" diameter. 2½" length sprue cup of 1½" diameter. The grade of ramming was measured inside the mold cavity, on the cope side and at the four sides of cavity with the dietert green hardness tester and was recorded as 44, 37, and 30:

Casting temperature = 1250°
Time of pouring = 18 sec.
Composition of molding sand and brass (70/30) remains same.

Exp. 4. The above mentioned experiments did not indicate any authentic cause for the swelling of Cu-base alloys. It was therefore decided to cast the brass in a mold cavity which was not provided with cope, so that the mechanism of swelling was shown openly. All other factors, for example, casting temp. (1250°), rate of pouring (18 sec.) composition of molding sand and brass (70/30) were kept constant.

Qualitative and Quantitative Determination

The bars cast were used to analyse the experimental results. The swelling was measured by graphical method. The results are tabulated in Chart No. 1.

Chart 1.

Sample No.	Parameters/variable factors	Constant factors	Analysis of experimental results	Observations
T_1	Casting temperature 1190°	Brass composition: 75/25	Casting without swelling.	Sound casting
T_2	1100°	Casting size 4½" x 2" x 2"	–do–	–do–
T_3	1000°	Grade of ramming 85 D. No.	–do–	–do–
T_4	935°	Composition of moulding sand = 98% SiO_2, 2% molasses	–do–	–do–
D_1	Flux (Glass) 0.0 (lb)	Brass composition 75/25	Casting without swelling	Sound Casting
D_2	1.5	Casting size = 4½" x 2" x 2"	–do–	–do–
D_3	3.0	Grade of ramming= 85D. No	–do–	–do–
D_4	4.5	Comp. of moulding sand- 98%SiO_2 2% molasses	–do–	–do–
		casting temperature = 1120°C.	–do–	–do–
G_1	Grade of ramming. 44 D. No.	Brass composition 75/25 Casting size 4½" x 2" x 2"	Casting without swelling.	Sound casting with some pitting on the surface.
G_2	37 D. No.	Composition of moulding sand = 85% natural bonded sand 3%	–do–	–do–
G_3	30 D. No.	Casting temperature = 1250°	Test for slightly swelled at lower portion, 15% swelling.	Swellen casting.
	Surface area of casting open to air.			
P_1	Half area.	Brass composition = 75/25 Casting size = 4½" x 2" x 2" Grade of ramming 85D. No.	Uncovered half portion swelling 12.5%	Swelled casting portion without any surface defect.
P_2	All area covered.	Casting temp=1250° Comp. of moulding sand=85% SiO_2, 3% graphite, moisture = 5 %	No swelling.	Sound casting.

Table 1.

Constituents	Sand–1 %	Sand–2 %
Natural bonded sand	98	90
Containing 10% clay	=	xx
Graphite	–	4
Moisture	–	6
Molasses	2	–

Analysis of the Experimental Results

The results of experiments carried out have shown that the tendency of swelling in Cu-Zn alloy (70/30) bars cast in molding sand (composition shown in Table 1), slightly increases with decreasing grade of ramming but it is negligibly influenced by casting temperature and the flux used. The authors think that swelling in casting is connected, with mold hardness (factor influencing the grade of ramming) gases dissolved in molten metal and deoxidizing agent. Our research experiments indicate that swelling starts appearing at D.No. below 30 and disappears at D.Nó. above 35: Experiments conducted with the loose pattern of test bar molded in green sand have shown that swelling of casing is most likely observed in those pieces which were cast in the mold cavities not provided with cope and.metal is directly poured in to the cavity in which the metal solidifies in the open atmosphere (open pit pouring).

Application in Industry

The experimental results were verified by applying them on a typical casting used frequently in the industry. The coupling shaft, was cast in the molding sand composed of natural bonded sand containing 10 % clay, and 7 % molasses. The brass containing 7 % Zn, was melted in a gas fired furnance and was poured at a temperature of 1150^{o} in an open pit mold, the cavity was completely filled and the alloy was allowed to solidify in the open air, the authors clearly observed the swelling of the metal which ultimately resulted in shrinkage and uneven surface of the casting. The swelling was due to the upward-thrust of metal (physical swelling) while shirnkage was due to the solidification. By principle the liquid metal should keep its level perfectly horizontal in the cavity or should solidify in the same position but simultaneous effect of swelling and contraction resulted in an uneven surface.

Conversely the same alloy was cast at the same pouring temperature in the same mold cavity provided with the cope, weight of 18 kg was placed on it and a sound casting was obtained. This consequently confirms that swelling is most frequently in those sections which are cast in the open pit or if they are covered with the cope but proper weight is not placed on the cope surface.

DISCUSSION AND CONCLUSION

The detailed theoretical and experimental study of physico-mechanical aspects of swelling in brass casting has suggested that no intense mechanism takes place during swelling but some molding and casting factors have great influence on the degree of swelling. The authors think that the prominant factors which influence swelling are the high upward thrust of the liquid metal in the mold cavity ramming and gases dissolved in the liquid metal. In the light of the present facts deduced from the experiments conducted to study the influence of different factors on swelling have led to catagorize swelling in three types.

Mechanical Swelling. Like every other liquid, the liquid metal also exhibits upward thrust. When the liquid metal fills the mold cavity, it exhibits ups-ward thrust depending upon specific gravity, Fluidity of molten metal and the area of mold cavity. This phenemenon is practically observed in the open pit pouring in which the swelling is being observed in those portions which were not covered with the cope or some other weight.

This type of swelling is termed as mechanical "Swelling and it is observed usually in flate portions.

Physical Swelling. In sufficient ramming is also considered as a prominant source of swelling. In this case the metallostatic pressure due to the high column of metal plays an important role and the portions where liquid metal exerts high metallostatic pressure, the swelling is observed. This is usually observed in the high vertical sections cast in molds, rammed to lower Dietort number. This type of swelling is termed as physical swelling.

Chemical Swelling. Besides physical and mechanical swelling in which metal respectively exerts pressure downward and upward, other type of swelling is also observed. It is characterized by enlargement of casting in the form of the cake and if the test casting is broken blowholes and gas holes are observed.

The blow holes are created by the absorption of the gas during melting and casting of metals. This type of swelling is termed as "chemical swelling."

The practical evidences have also suggested certain measures which may be taken to eliminate the swelling. Mechanical swelling may be avoided by putting proper weight on the cope surface so that the cope surface is not slipped by the upward thrust of the liquid metal. The weight recommended 2.5. lb/cm^2 (min) of the mold cavity for avoiding mechanical swelling.

Physical swelling is eliminated by maintaining proper mold hardness while chemical swelling is avoided by deoxidzing the brass with the adequate weight of deoxidizer and flux.