Effect of recasting of nickel–chromium alloy on its porosity

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Abstract

Statement of Problem: As per the review of literature very few studies have been carried on recasting of dental casting alloy and in particular its effect on occurrence of porosities. **Purpose of Study:** This study was designed to find out occurrence of porosities in new alloy and recasted alloy using a scanning electron microscope. **Materials and Methods:** Different percentage combinations of new and once casted alloy were used to produce twenty five samples. Castings obtained from new alloy were used as control group. All the samples were scanned under scanning electron mocroscope and photographs were taken from three specific sites for comparison. **Results:** There is no significant difference in occurrence of porosities in casting obtained by using new alloy and recasted alloy. **Conclusion:** With in the limitations of the study it is conducted that the prorosities will not be affected by recasting of neckel-chromium alloy. **Clinical Implication:** Porosities in dental casting alloy can alter physical and mechanical properties of the mental which inturn may lead to failure of crown and bridge, and also cast partial denture prosthesis.

Keywords: Base metal alloys, dental casting alloys, porosity, recasting

Introduction

In our current economy, it is obligatory that dentists and technicians be cost conscious about the materials they use for fixed prosthesis. Cast gold alloy is in use since a long time as restorative materials in dentistry. The alloy's properties like resistance to tarnish and corrosion, hardness, strength, percentage elongation, castability, burnishability and capacity to take high polish have made it as an ideal restorative material. However, it has two main disadvantages: one is its highly distinguishable color and the other is high cost. The preferential use of the precious metal alloys like gold alloy has almost been eliminated by the elevated cost and resulted into subsequent demand for semiprecious and nonprecious base metal alloys in dental procedures. In 1930s, base metal alloys were introduced to dentistry by Eardle RW and Prange CH.[1] The properties of this alloy satisfy with that of gold alloy with the additional advantage of its reduced specific gravity and low cost. Due to this superiority over gold alloy, cobalt, chromium and nickel alloy and its allies have become immensely popular in the field of restorative dentistry.[2] This popularity of these alloys can be gauged by the varieties of the alloys available in the market. It is a point of commercial concern that the present demand for the base metal alloys has resulted in a substantial increase in the price of these once insignificant alloys.

Due to nobility of the contents of the gold alloys, it has been possible to recast the material again and again without losing any of its required properties. However, the same cannot be said about base metal alloys, due to lack of research work and literature available. Invariably, the manufacturers of base metal alloys instruct to use the alloy only once. Therefore, it will be of great advantage, both economically and environmentally, to recycle or to recast the alloy again and again with or without adding new alloy.

Very few references in dental literature are available regarding recasting of the base metal alloys. Few have tested the properties of the alloy by casting the used material and others have tested by adding new material to the casted alloy. It will be of definite scientific advantage if the properties of the recast alloys are studied in detail and directions given to prosthodontist and laboratory technicians.

Therefore, this study has been undertaken to find out the porosities in the new alloy, different percentage combinations of new alloy and once casted alloy and recasted alloy.

Materials and Methods

Samples were casted using Whitlock's method.[3] Acrylic-

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wax mesh (Klett-O-flex, Renfert, Hilzingen, Germany) of dimensions 11 mm × 11 mm with 100 square shaped spaces of 1 mm × 1 mm and filament diameter of 0.3 mm was selected. Samples were casted by using nickel–chromium alloy (G-Soft, Dentaurum,Ispringen, Germany, with a chemical composition Ni 65%; Cr 27%; Mo 5%; Si 1.5%; other elements C, Mn, B less than 1%). For the first group of castings, totally new alloy was used, i.e., 100% new alloy; this group was designated as group A. The buttons of these castings from group A were separated from its sprue. These buttons were cut into different portions so as to mix it with new alloy by weight in proper proportions. In this study, the following groupings [Table 1] were made based on different combinations of new alloy and once casted alloy:

Three samples from each group were selected randomly for the measurement of porosities. These selected samples were embedded in clear epoxy resin powder. Clear epoxy resin and formaldehyde were mixed in a ratio of 1:1 and poured into a standard mould over the samples and allowed to set. Three samples of the same group were embedded in one mould. Same procedure was followed for the other four groups. The embedded specimens were recovered and ground flat using belt emery grinding machine. It was then further smoothened with grade "0" and finished with grade "000" emery paper. Care was taken to produce uniform, scratch-free surface and to have a mirror finish. Final polishing was done on a motor driven revolving disk. The disk was covered with a velvet polishing cloth which was kept moist with slurry of various gradations of aluminium oxide powder. The specimens were cleaned with ethanol.

Embedded specimens were mounted on a metallurgical microscope (Invertoscope, LABO, Ambala, India) for evaluation of porosities in the sprue and runner bar region.[4] The porosity analysis was carried out by thorough scanning of sprue and runner bar under a magnification of 100×. Then, photographs were taken with SLR camera (Pantex, Tokyo, Japan) under 100× magnifications. But these photographs were not of a satisfactory quality. So, a repeat porosity study was carried out under scanning electron microscope (JEOL, JSM T330 A). The embedded specimens were removed from the embedding of epoxy resin material as this material was not accepted by scanning electron microscope [Figure 1].

Then, all the samples were scanned thoroughly in the region of runner bars and the sprue, under scanning electron microscope. For comparison between different samples from different groups, three particulars sites from each group were selected. Those were two apex portions of two runner bars and the junction of two runner bars and the sprue. These sites were photographed and compared for analysis.

Results

The results are shown in Tables 2–6. On photographic comparison, porosities were seen in the one of the samples in group D [Figure 5d]. Every sample from group E exhibited porosities in one out of three sites. [Figures 6b, 6d]

Table 1:Different groups and its %combinations

Group	Percentage of new alloy (by weight)	Percentage of once casted alloy (by weight)
A	100	—
B	75	25
C	50	50
D	25	75
E	—	100

Table 2: Occurrence of porosity in group A

Sample	Apex of runner bars	Junction of sprue and runner bars	Sprue
1	No porosities	No porosities	No porosities
2	No porosities	No porosities	No porosities
3	No porosities	No porosities	No porosities

Table 3: Occurrence of porosity in group B

Sample	Apex of runner bars	Junction of sprue and runner bars	Sprue
1	No porosities	No porosities	No porosities
2	No porosities	No porosities	No porosities
3	No porosities	No porosities	No porosities

Table 4: Occurrence of porosity in group C

Sample	Apex of runner bars	Junction of sprue and runner bars	Sprue
1	No porosities	No porosities	No porosities
2	No porosities	No porosities	No porosities
3	No porosities	No porosities	No porosities

Table 5: Occurrence of porosity in group D

Sample	Apex of runner bars	Junction of sprue and runner bars	Sprue
1	Porosities found	No porosities	No porosities
2	No porosities	No porosities	No porosities
3	No porosities	No porosities	No porosities

Table 6: Occurrence of porosity in group E

Sample	Apex of runner bars	Junction of sprue and runner bars	Sprue
1	No porosities	No porosities	Porosities found
2	Porosities found	No porosities	No porosities
3	No porosities	No porosities	Porosities found

Discussion

The dental gold alloy contains all noble metals except copper. Sprues and buttons remaining after casting were used again for casting with addition of lost copper. Since

Figure 1: Photograph showing scanning electron micorsope

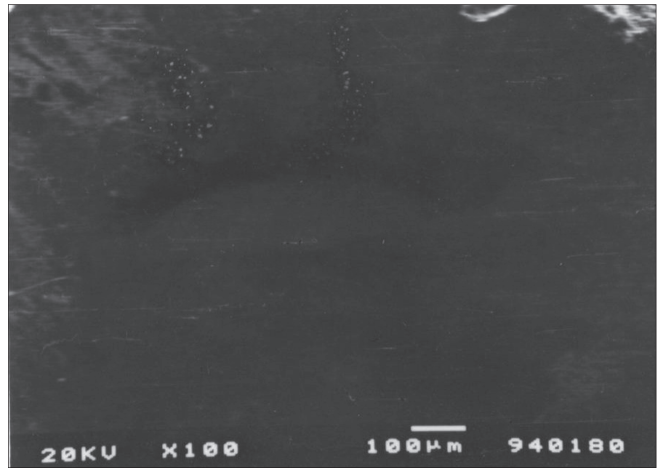

Figure 2a: Porosity free micrograph of apex of the runner bar (Group A)

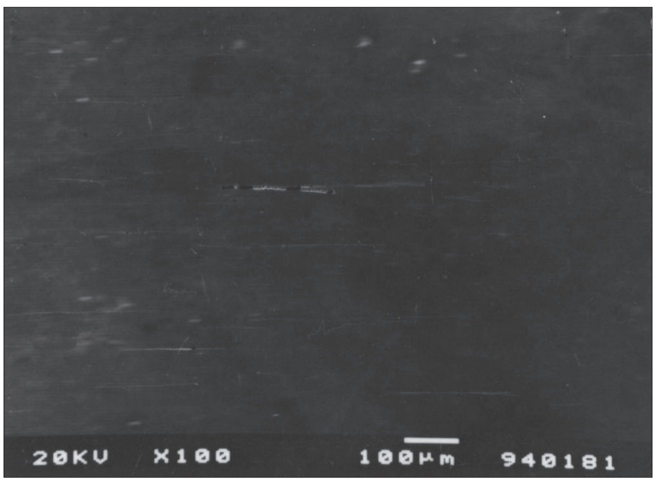

Figure 2b: Porosity free micrograph of the junction of two runner bars and sprue (Group A)

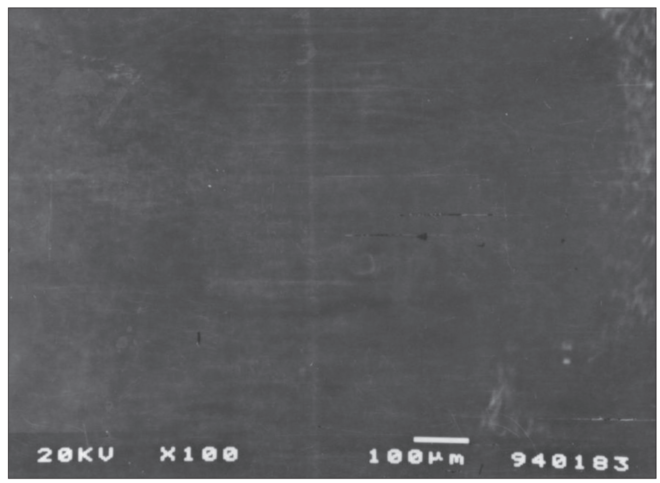

Figure 2c: Porosity free micrograph of the apex of runner bar (Group A)

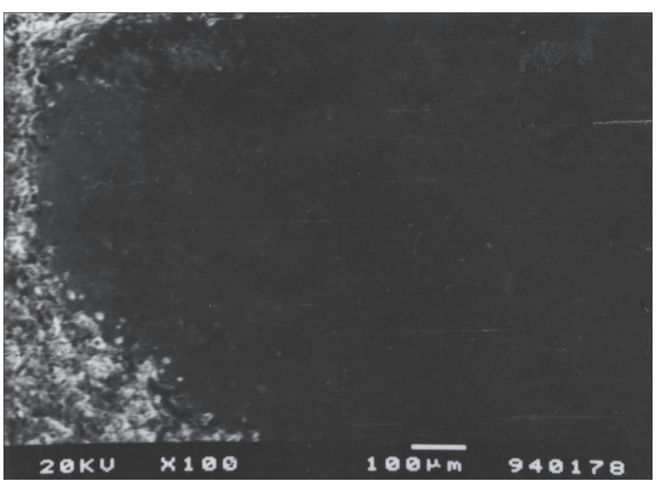

Figure 3a: Porosity free micrograph of the junction of two runner bars and the sprue (Group B)

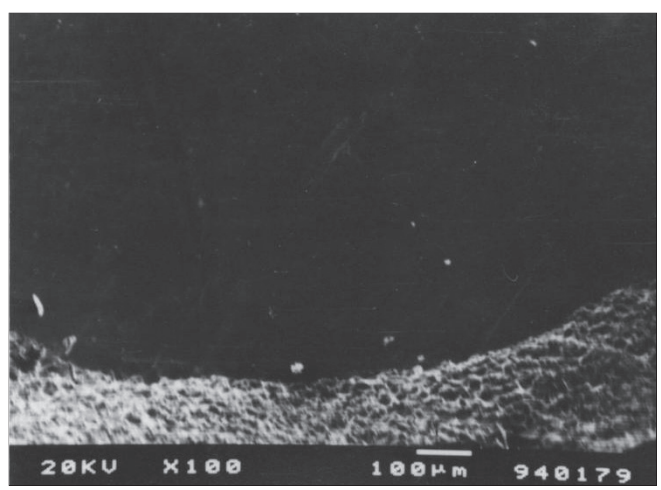

Figure 3b: Porosity free micrograph of the apex of the runner bar (Group B)

1930s, base metal alloys like cobalt–chromium (Co–Cr) and nickel–chromium (Ni–Cr) are in use as indirect restorative materials, as they were cost effective. In 1930s and 1940s, the cost of these base metal alloys was affordably low, so the

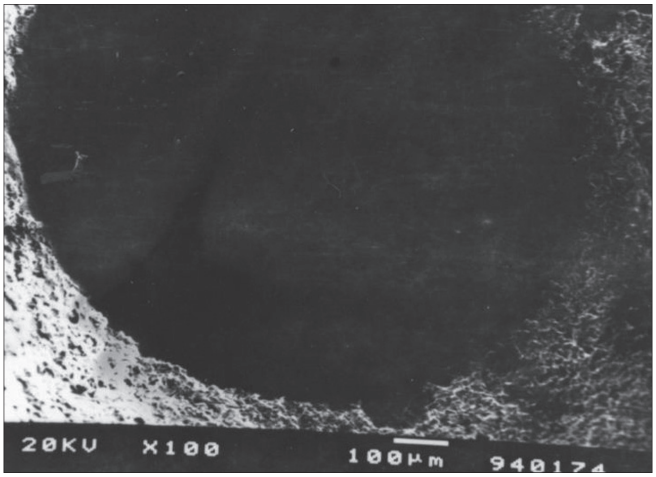

Figure 4a: Porosity free Micrograph of the runner bar (Group C)

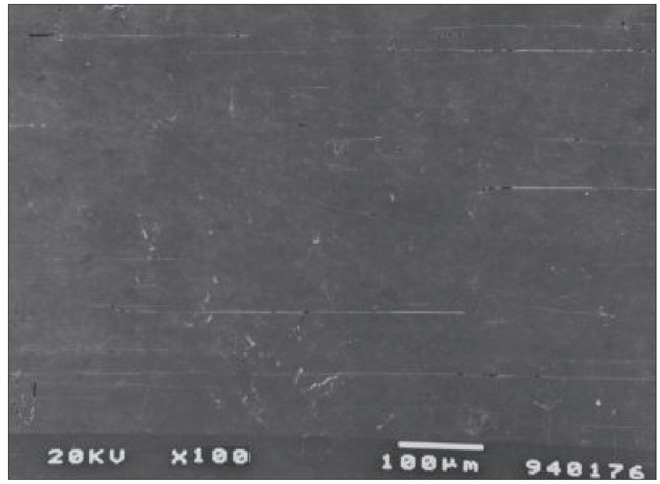

Figure 4b: Porosity free micrograph of the apex of runner bar (Group C)

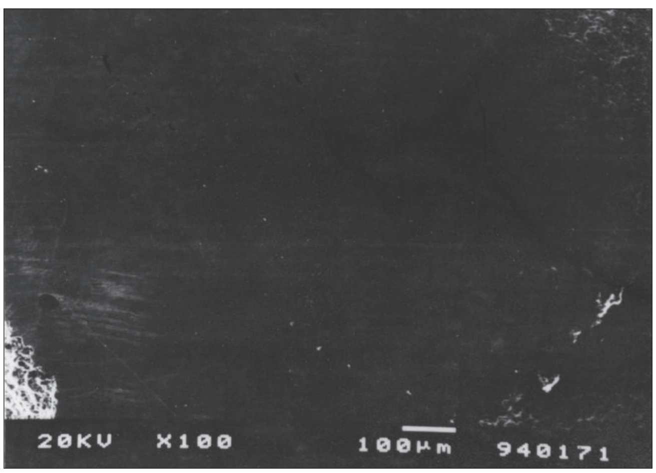

Figure 5a: Porosity free micrograph of the apex of runner bar (Group D)

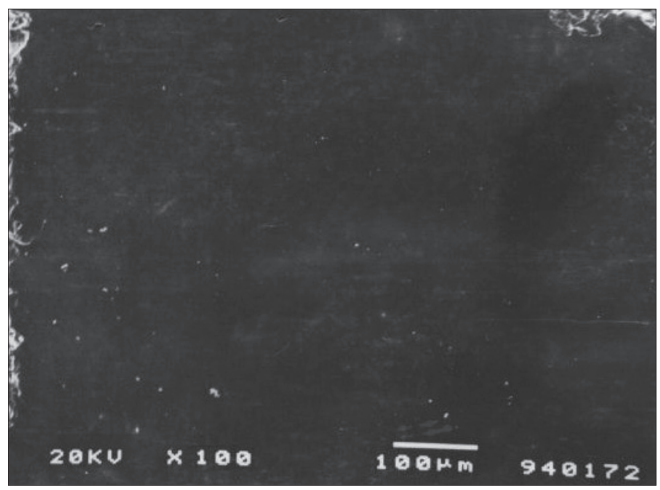

Figure 5b: Porosity free micrograph of the apex of the runner bar (Group D)

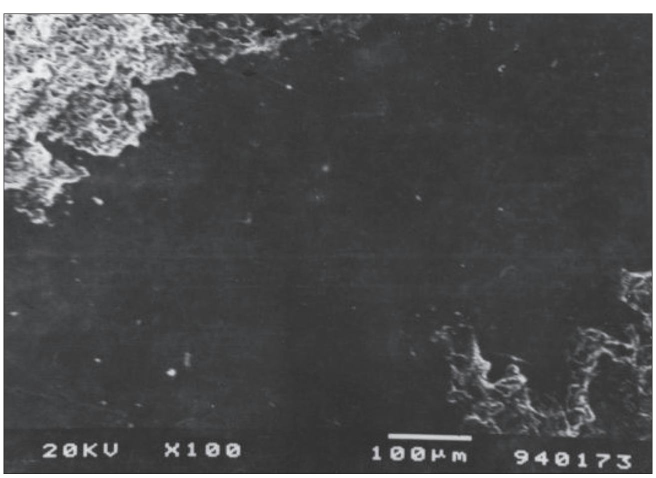

Figure 5c: Porosity free micrograph of the juction of two runner bars and the sprue (Group D)

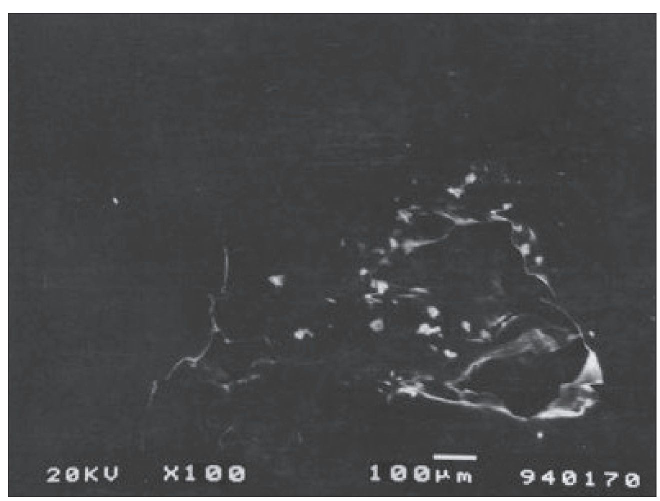

Figure 5d: Micrograph showing porosities (white dots) in the region just below the apex of runner bar (Grooup D)

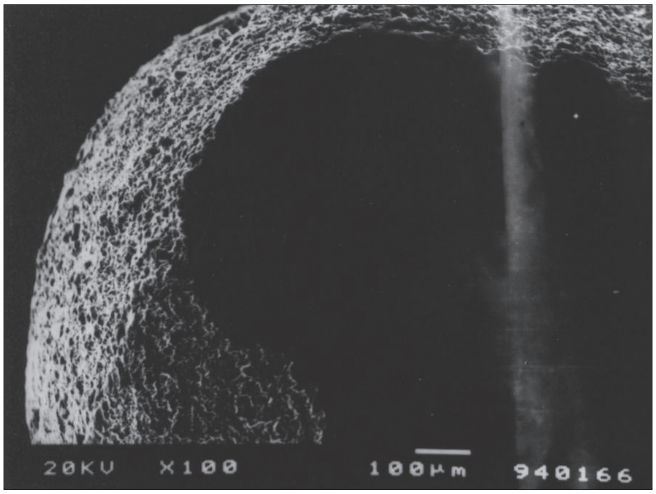

Figure 6a: Porosity free micrograph of the apex of runner bar (Group E)

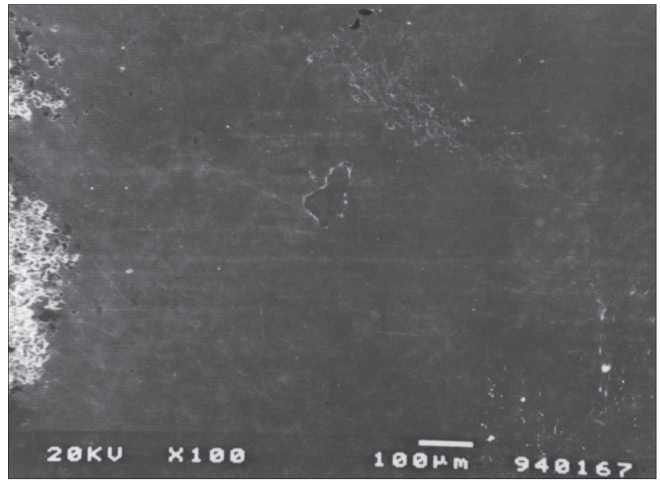

Figure 6b: Micrograph of the apex of the runner bar showing porosity in the center (Group E)

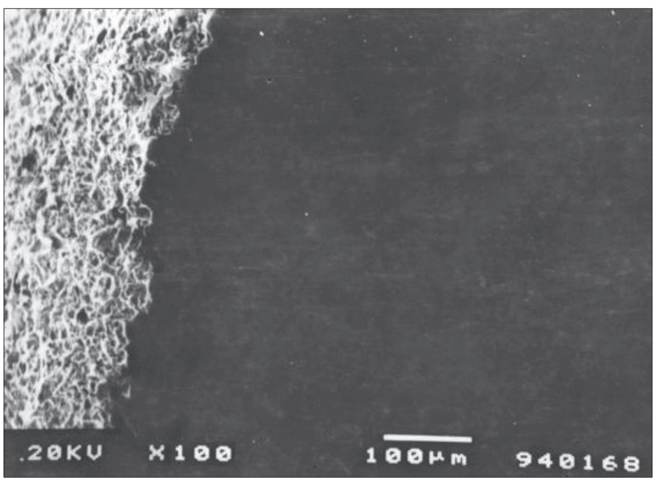

Figure 6c: Porosity free micrograph of the junction of two runner bars and the sprue (Group E)

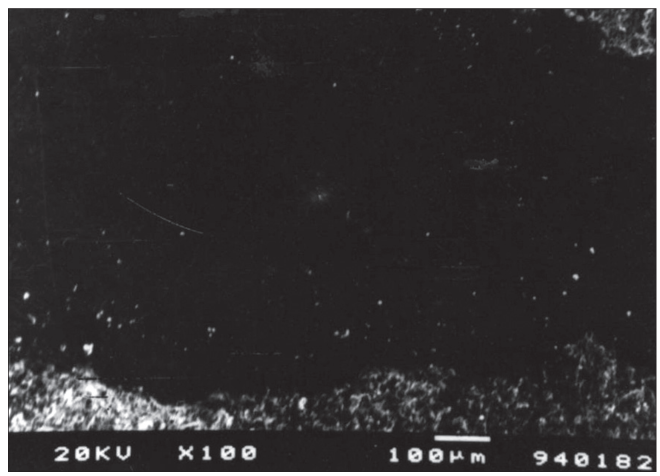

Figure 6d: Micrograph showing porosities (white dots) in the sprue region (Group E)

sprues and buttons remaining after casting were discarded. However, at present, the cost of these base metal alloys has become very high. In spite of this, manufacturers give the instruction that alloy should be used only once for casting. Very few manufacturers advocate part addition of new alloy to the sprue and buttons for recasting. Apart from the cost due to environmental factors and deprivation of the resources, every material is being tried to reuse for various purposes. It is desired that the base metal alloy must also be reused for casting. Good restoration requires certain optimum properties. These properties should remain constant not only during various laboratory procedures but also in the oral environment. Therefore, it is very clear that recasting should not be done at the expense of the properties of the alloy.

Since 1962, studies regarding recasting of base metal alloys have been conducted by various researchers, namely, Harcourt,[5] Hesby,[6] Hong,[7] Nelson[4] and Presswood.[8] Mainly, they have studied properties of recast alloy, such as tensile strength, ultimate tensile strength, percentage elongation, modulus of elasticity, mean yield strength, microstructure and microhardness. However, as per the review of literature, there have been very few studies regarding the porosities in recasted nickel–chromium alloy.[4] Therefore, this study was undertaken to study porosities in the nickel–chromium alloy.

So far, the study on properties of recast alloy has been done either by casting the same alloy again and again up to 13 generations or by studying the properties of the castings with the addition of new allow to the recasted alloy in various proportions.

It is easy and scientific to compare the properties of the only new alloy, with various percentage combinations of new alloy and once casted alloy and with only recasted alloy. In this study, the following groups [Table 2] were made:

Perfect casting should be not only accurate but also free of porosities. Presence of porosities reduces the strength of the casting.[1,4,9-11] Hence, it is one of the criteria to study the change in the properties of the recasted alloy. As mentioned earlier, as per review of literature, only Nelson[4] has studied the porosities in recasted nickel–chromium alloy by using metallurgical microscope. In this study, embedded samples were mounted on a metallurgical microscope and photographs were obtained; but as the photographs obtained were not of satisfactory quality, the study was reconducted by using scanning electron microscope.

Porosities are always studied at the thickest portion of the castings and in the area which is farthest away from the junction of the sprue and the patterns. As the mesh filaments were very thin, it was not an ideal region to study the porosities. Hence, the farthest ends of the runner bar, i.e., the apex of the runner bars, the junction of the two runner bars and the sprue, were subjected for microscopic studies. These three particular sites were selected for photographic comparison between specimens of different groups.

All the microscopic photographs of the specimens from group A [Figures 2a, 2b, 2c], Group B [Figure 3a and 3b], Group c [Figures 4a and 4b] and Group E [Figure 6a and 6c] (indicate the absence of porosities in all the specimens except in one belonging to group D [Figure 5d]. It should be noted that even in group D, two samples did not show any porosities among the three samples observed. [Figures 5a, 5b and 5c].

In group E, all the three samples showed porosities at only one site in each sample, as shown in Figure 6b and 6d One sample out of three samples showed porosity at the one apex of the runner bar [Figure 6b], and in other two samples, porosities were seen in the sprue region of the sample [Figure 6d]. But it is to be noted that the micro-porosities were detected in small amounts. This finding is almost similar to the findings of Nelson[4] where microporosity was not readily apparent. But the occurrence of porosities in the sprue region[12,13] is bound to take place and has been already proved.

Based on this study it can be advocated that recasted alloy can be used at least once again. As per the studies of Harcourt,[5] recasting can be done up to 13th generation without losing any properties of the alloy.

It can also be advocated that completely cleaned and deoxidized casted alloy need not be added with new alloy in any proportion. This finding is of great significance in view of the cost involved and maintaining the level of available resources.

Conclusion

1. The porosity will not be affected by recasting the nickel–chromium alloy.
2. It is not necessary to add new alloy in any proportion to the once casted alloy to minimize porosities in the alloy.
3. We have studied only till the second generation of the recasted alloy. It is suggested to recast the alloy for a number of generations and study its effect on the properties of the alloy.

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