Fabrication of 304L Stainless Steel by Powder Metallurgy Route

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ABSTRACT

SS304L stainless steels have been widely used in Food processing equipment, Architectural trim and molding, Automotive and aerospace structural use, Heat exchangers, Nuts, bolts, screws, and other fasteners in the marine environment. These steels are well known for their good mechanical properties like strength and corrosion resistance. However, still there is a hope to improve properties of these steels. In this paper, the fabrication of 304L steel by powder metallurgy has been investigated. The power was green compacted at different pressures and then sintered at 1100°C for 60 min under protective atmosphere. Microstructure was measured by optical microscopy (OM). Hardness was measured by Rockwell hardness testing machine. The results are discussed in this paper.

KEY WORDS: 304L steel, Microstructure, Hardness, Density, Powder Metallurgy.

1. INTRODUCTION

Steel is the alloy of Fe and other elements by weight percent. The primary element in steel is carbon (C) and is widely used in construction and other applications because of its high mechanical properties and cost effective (Eisenhüttenleute, 1992). The carbon (Wt. %) may contribute up to 2.0% of in steel. Extensive use of steel began after more efficient production methods were devised in the 18th century (Bugayev, 2001). With the creation of the Bessemer process in the 19th century, a new era of massive steel began (Barraclough, 2001). Mild steel replaced wrought iron with their introductions. Today, steel alloys are one of the most collective materials in the world, with the production of 1.5 billion tons produced annually. It is a major component in machines, construction, tools, automobiles, ships, and weapons. Recent year's steel is generally recognized by various grades defined by associated standards organizations (Warren, 2001). Stainless steel is an alloy of steel which contains iron, minimum of carbon and other elements (Smith, 2006). Stainless steel is prominent for its corrosion resistance, and it is widely used for food handling and many other applications (Mariappan, 2015).

SS304L is a 300 series austenitic stainless steel, which has a minimum of 17-18% chromium and 8-12% nickel. This steel has a carbon maximum is 0.03. It is the typical 18:8 stainless that is usually found in cooking tools. SS304L is the most versatile and widely used alloy in the stainless steel. It is perfect steel for a wide variety of home and commercial applications. The alloy 304L has excellent corrosion resistance and outstanding formability (Woei-Shyan, 2004). In this paper, the fabrication of SS304L steel by powder metallurgy process has been investigated.

2. MATERIALS AND FABRICATION

A stainless steel powder of 304L (Table.1) with 30 gm. of powder was chosen. The floating die of 20 mm diameter with punch was manufactured and is shown in Fig.1. The powder was placed in this die and pressed at different pressures of 450MPa, 500MPa and 550MPa at room temperature using a uniaxial press.

Table.1. Composition of 304L steel

Element	Weight
Carbon	0.030
Manganese	2.00
Chromium	18.0 to 20.0
Nickel	8.0 to 12.0
Nitrogen	0.10

Figure.1. Die used for this study

Graphite of small quantity (lubricator) was used as the lubricant in the process. The green compacted SS 304L steel billets were sintered at 1100°C for 60 min under protective atmosphere. Green and sintered densities of 304L billets were measured. Microstructures of 304L sintered billets were studied by using Optical Microscope (OM). Hardness of SS 304L steel billets was measured by means of Rockwell hardness testing machine. Three specimens were tested for obtaining average value of density and hardness.

3. RESULTS AND DISSCUSSIONS

Density: The green density values of 304L steel powder is shown in Table.2. The green compacted density plots of 304L steel powder compacted at various pressures are shown in Fig.2. The average green density of 75% was observed for 304L steel. When the pressure increases then green density increases.

Table.2. Green density values of 304L steel

Sample-1	Sample-2	Sample-3	Pressure
71	72.03	71.94	450
72.93	73.14	72.93	500
74.13	75.12	75.89	550

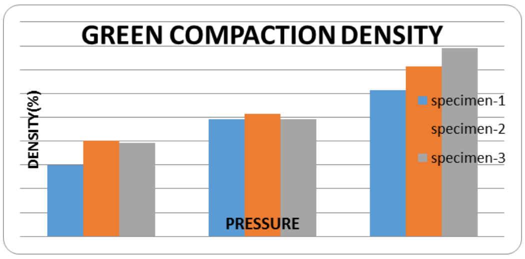

Figure.2. Green Compaction Density plots of 304L steel

The sintered density values of 304L steel powder is shown in Table 3. The sintered density plots of 304L steel powder sintered at 1100^{0}C are shown in Fig.3. The average sintered density of 85% was observed for 304L steel. When the pressure increases then sintered density increases.

Table.3. Sintered density values of 304L steel

Sample1	Sample2	Sample3	pressure
85	82	81	450
84	86	83	500
84	87	82	550

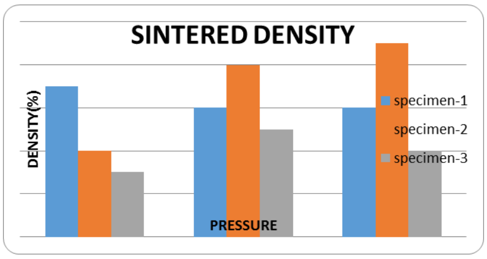

Figure.3. Sintered Density plots of 304L steel

The green and sintered density values of 304L stainless steel increase with increase in compaction pressure. This is due to differences in porosity levels obtained from the material.

Optical Microstructure: The optical microstructure of SS304L for three specimens is shown in Fig.4, Fig.5 and Fig.6. It is observed that the better microstructure has been observed for the billet compacted at 550MPa pressure. Similar microstructure has been observed for three specimens. The grain size is more for the billet compacted at 550MPa pressure. The dark zone with irregular shape and rough texture was identified as a ferritic phase. The lightest zone in a microstructure was an austenitic phase.

Specimen 1:

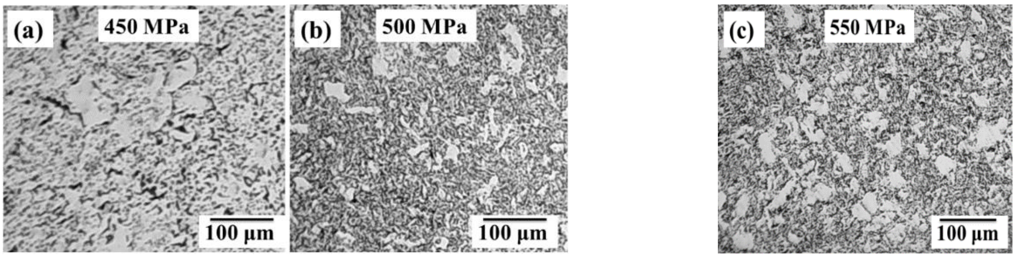

Figure.4. Optical Microstructure of 304L Steel

Specimen 2:

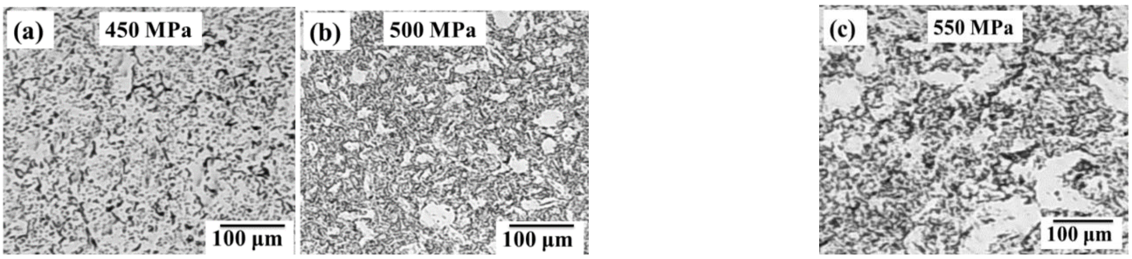

Figure.5. Optical Microstructure of 304L Steel

Specimen 3:

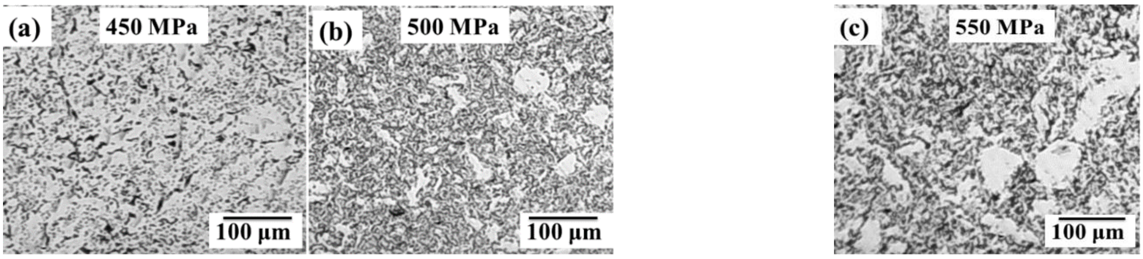

Figure.6. Optical Microstructure of 304L Steel

Hardness: The hardness plots of 304L steel compacted at three different pressures and sintered at 1100^{0}C are shown in Fig.7. The hardness values of 304L steel is shown in Table 4. The average hardness of 77 HRB was observed for 304L steel. When the compaction pressure increases then hardness increases.

Table.4. Sintered density values of 304L steel

Sample 1	Sample2	Sample3	pressure
76	74	72	450
75	78	74	500
75	79	74	550

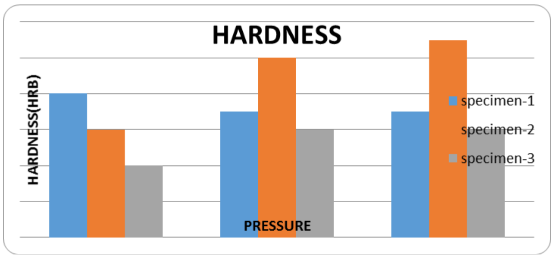

Figure.7. Hardness plots of 304L steel

The hardness (HRB) of sintered 304L stainless steel increases with increase in compaction pressure. This phenomenon is due to improvement in sintered density of steel (Table 3).

4. CONCLUSIONS

304L steel materials were prepared from powder metallurgy method. The powder was compacted at different pressures and sintered under protective atmosphere. Microstructures and properties of the SS304L were characterized and tested. The following points were appeared from present study.

- The green density of 75% was obtained for 304L steel compacted at different pressures
- The sintered density of 85% was obtained for 304L steel sintered at 1100^{o}C in protective atmosphere.
- Both ferrite and austenite structure was observed for 304L steel.
- The hardness of 77HRB was obtained for 304L steel which is compacted at different pressures sintered at 1100^{o}C in protective atmosphere.

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