Comparative Study of Mechanical Properties Between Casting and Selective Laser Sintering (Sls) In Cobalt-Chromium Alloys

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Abstract

The aim of this study are compared the mechanical properties of yield strength, ultimate strength, transverse rupture strength and hardness of standard samples manufactured from the casting and selective laser sintering (SLS) techniques in cobalt-chromium alloys. Effects of the powder properties will be investigated such as the physical and mechanical properties and microstructural characterization are presented and discussed.

Materials and Methods

The Cobalt-Chromium (Co-Cr) alloys were been used in this study. The chemical composition of the cast alloy and the gas atomized powder were evalueted by X-ray fluorescence (see table 1). The flow chart of the process of this study is showed in figure 1.

Table 1 – Chemical compositions of the gas atomized Co-Cr alloy powder.

Alloy	Content of elements [%]						
	Co	**Cr**	**W**	**Nb**	**V**	**Mo**	**Fe**
Cast	63,0 ± 1,0	26,0 ± 1,0	7,0 ± 1,0	2,0 ± 0,2	1,5 ± 0,2	1,1 ± 0,1	0,4 ± 0,1
SLS	62,0 ± 1,0	25,0 ± 1,0	6,0 ± 1,0	< 0,2	< 0,2	7 ± 1,0	0,2 ± 0,1

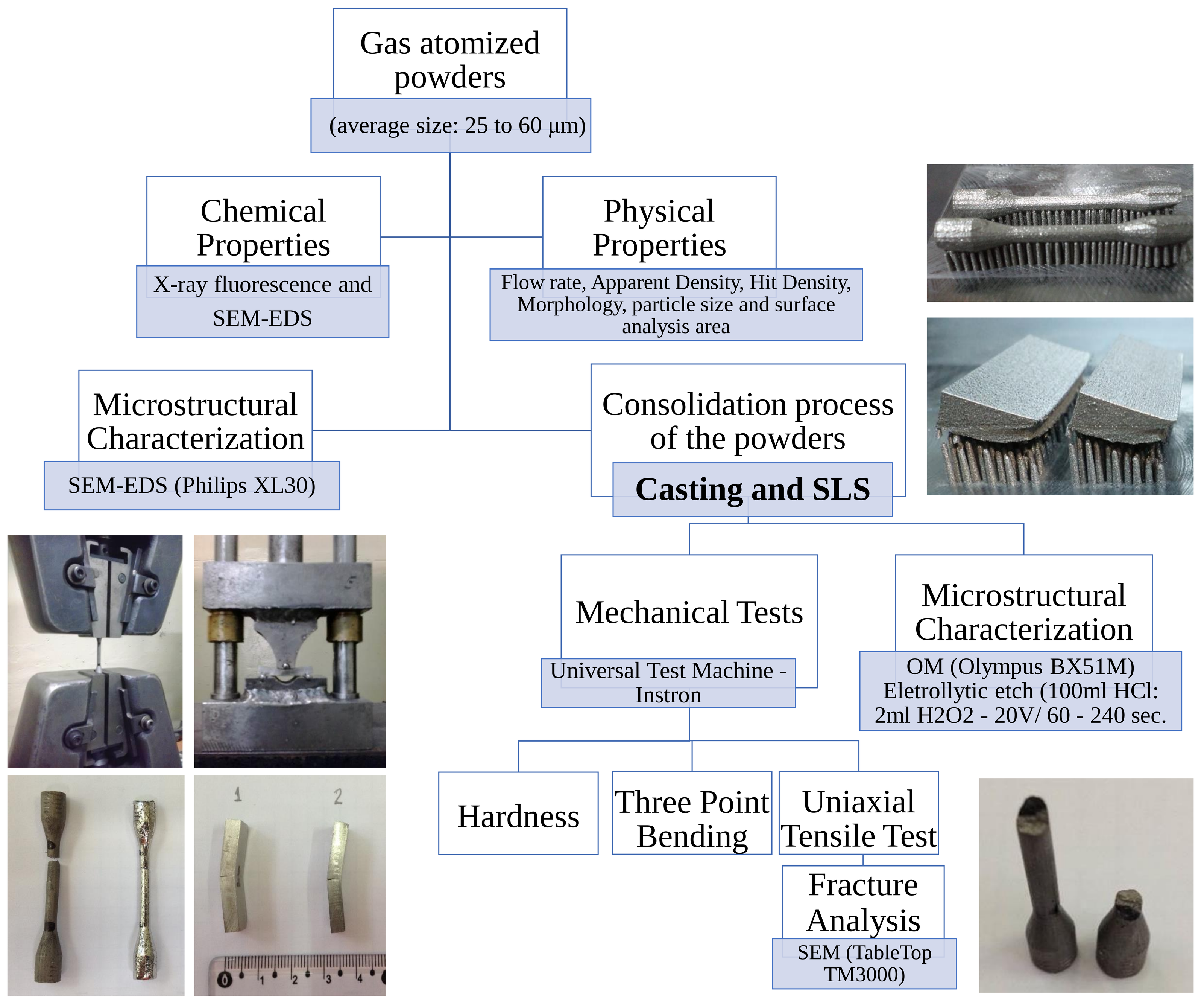

Figure 1 – Flow chart of the process of this study and images of tests and specimens.

Results

The results of all physical properties are showed at the table 2.

Table 2 – Physical properties of Co-Cr powders.

Properties		Samples of powders	Standard
Granulometric Distribution [µm]	diameter of 10%	26,1	
	diameter of 50%	39,52	
	diameter of 90%	64,05	
	medium diameter	42,74	
Flow Time [s/50g]		20,598	MPIF 03
Apparent Density [g/cm³]		4,63	MPIF 04
Tap Density [g/cm³]		5,17	MPIF 46
Specific Surface Area [m²/g]	One Point	1,799	
	3 Points	2,644	

The analysis in MEV shows that the powders are spherical and presented satellites. The analysis with EDS in some particles indicate a possible oxidation in the powder surface (see figure 2).

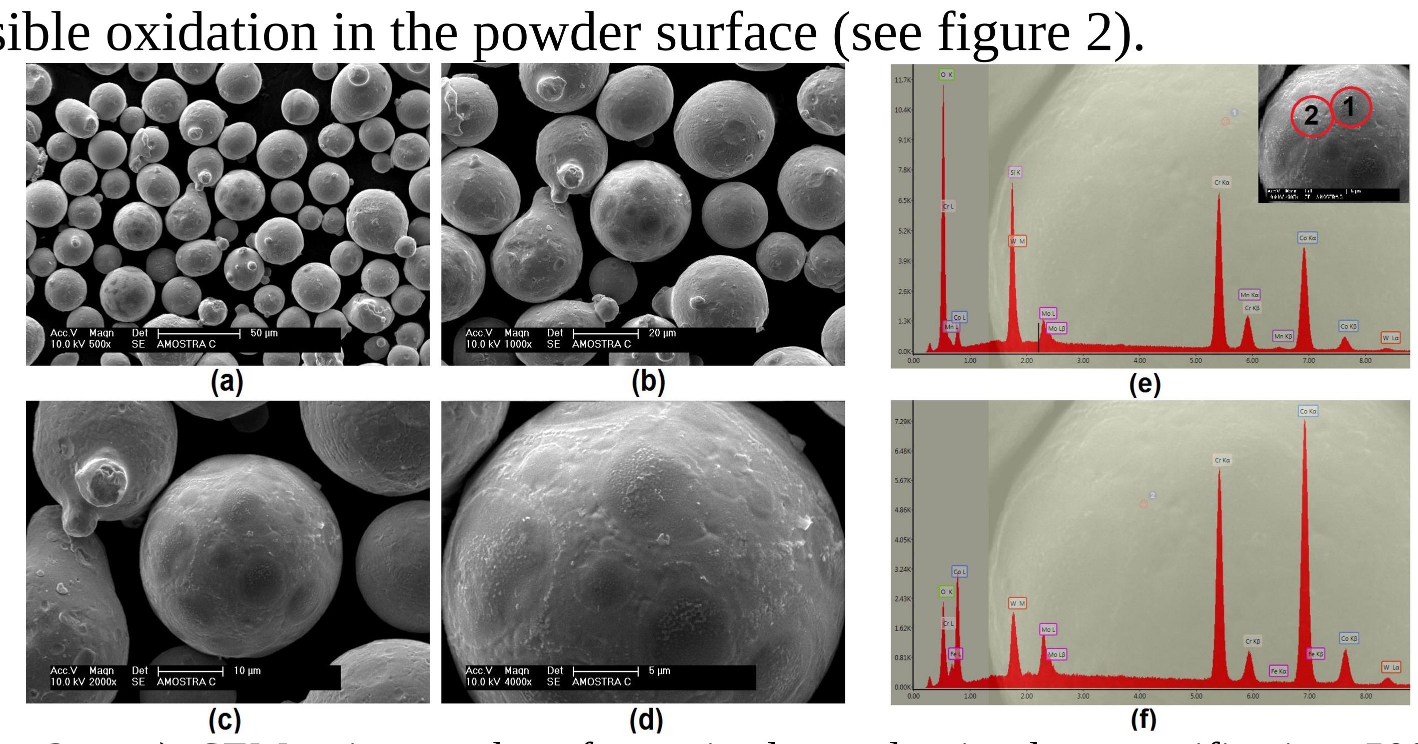

Figure 2 – a) SEM micrographs of atomized powder in the magnification 500x, b) magnification 1000x, c) magnification 2000x, d) magnification 4000x, e) spectroscopy of powder - area 1 and f) spectroscopy of powder – area 2.

Mechanical curves of uniaxial stress and three point bending are presented at Figure 3. For more explanations about the mechanical properties values is apresented the table 3 with the tests results of standard samples.

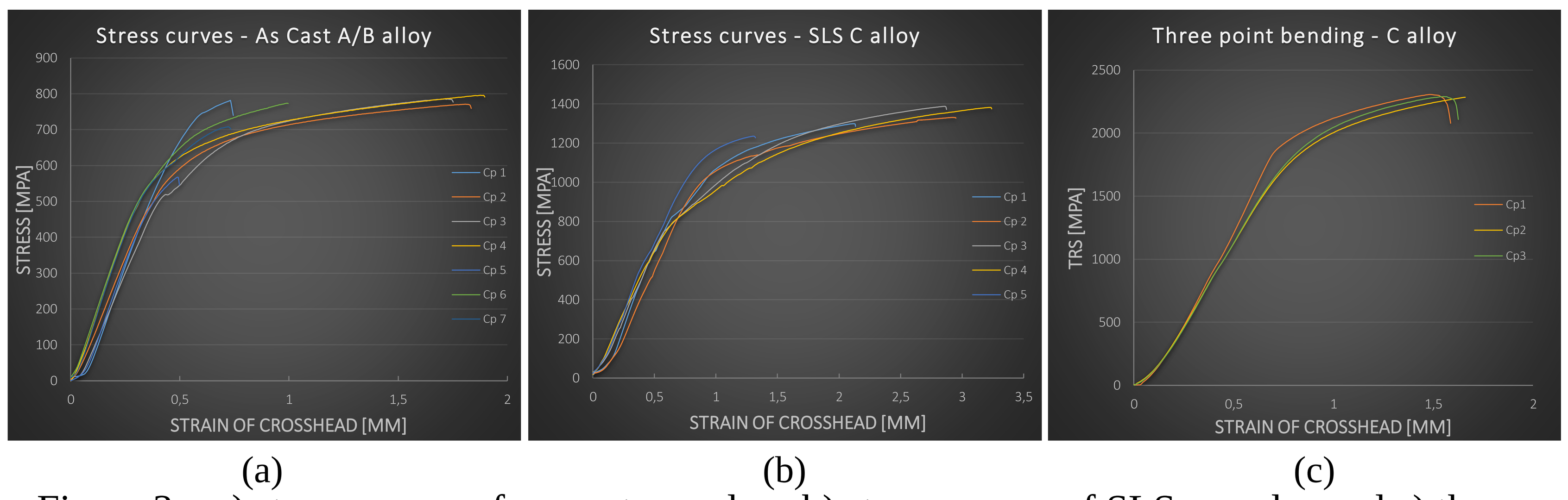

Figure 3 – a) stress curves of as cast samples , b) stress curves of SLS samples and c) three point bending curves of SLS samples.

Table 3 – Mechanical properties of the specimens manufactured by casting and SLS process (medium values and desviations).

Mechanical Properties		Consolidation Process				Standard
		As Cast		SLS		
Yield Stress (Rp 0,2%)	[MPa]	516,4 ± 27,34		788,4 ± 158,12		ISO 22674: 06
Rupture Stress	[MPa]	715,0 ± 94,27		1312,4 ± 67,67		
Max. Stress	[MPa]	740,6 ± 80,68		1327,4 ± 63,40		
Elongation	[%]	5,58 ± 3,17		7,68 ± 0,80		
Transverse Rupture Stress	[MPa]	-		1790,0 ± 91,94		ASTM B528:12
Sample		Cp7fH	Cp7fV	Cp1sH	Cp1sV	ISO 14577-1
MicroHardness	HV	430,01±25,04	446,69±31,03	509,91±20,54	551,55±20,03	

The microstructure of the specimens were evalueted by OM and the fractures analyzed by SEM as shown in Figure 4 and Figure 5.

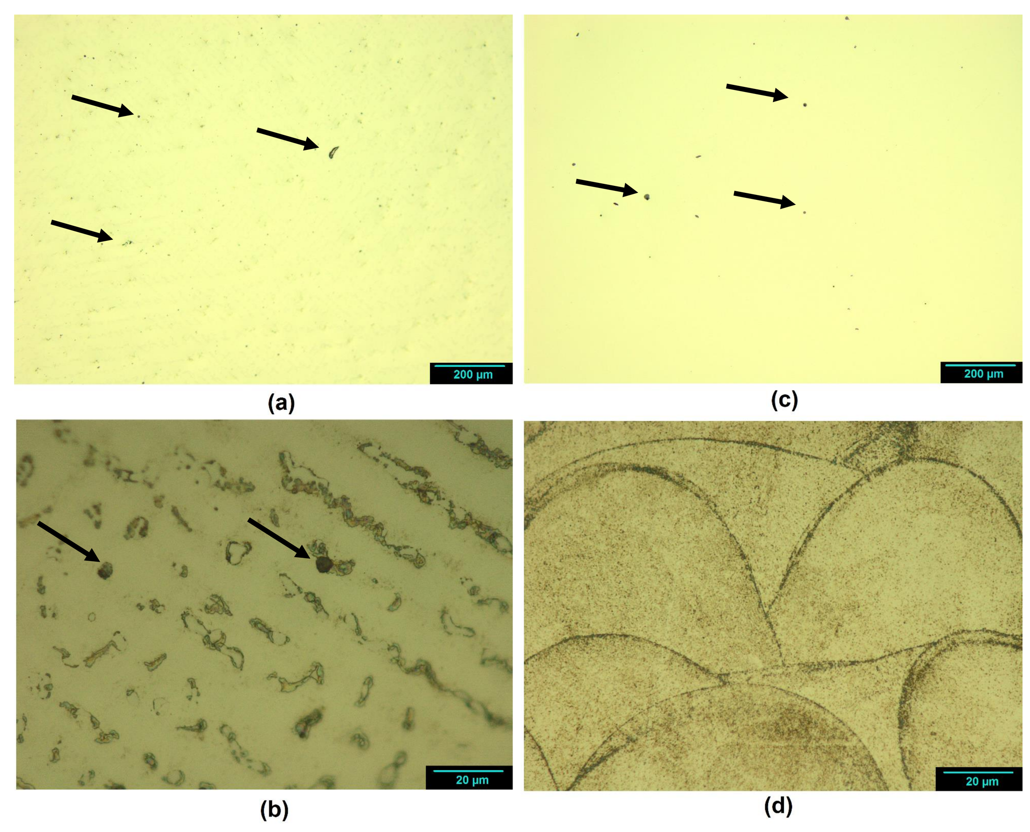

Figure 4 – OM micrographs of CoCr specimens and the arrows indicate the pores, a) as cast before eletrollytic etch, b) as cast after eletrollytic etch, c) as cast after eletrollytic etch, d) SLS before eletrollytic etch, d) SLS after eletrollytic etch and e) SLS after eletrollytic etch.

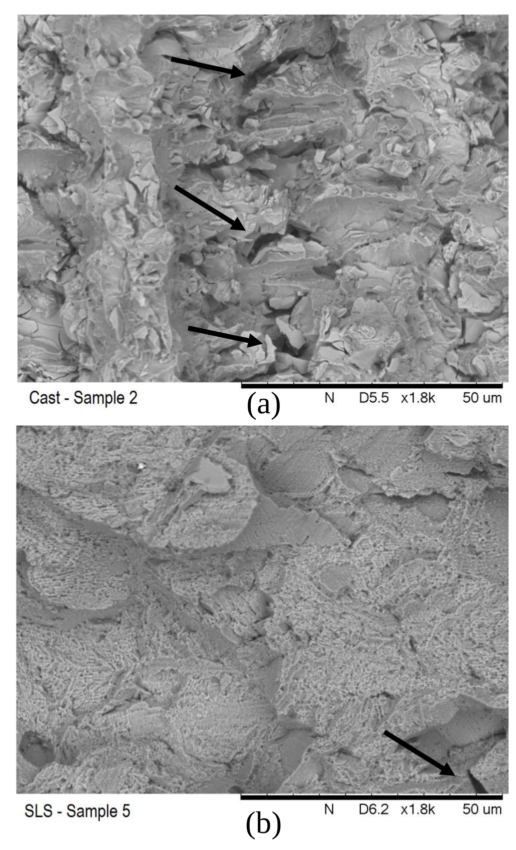

Figure 5 - SEM micrographs of samples fractured and the arrows indicate the pores, a) cast sample and b) SLS sample.

Conclusions

1. The mechanical properties as yield stress, rupture stress, maximum stress, elongation and hardness in the SLS technique are better than casting technique. The addition of Molybdenum element at the SLS samples shows a improvement in the mechanical properties.

2. The microstructure in the samples represent the characteristics phases in the manufacturing processes. The casting specimens are characterized by the dendritic phases and the SLS specimens are characterized by the solidification morphologies of the laser beam melting.

3. The fracture analysis by SEM shows that the microstructure presents more pores in the casting technique than the SLS technique. The SLS fracture represents a ductile fracture, showing the presence of dimples. This is one of the evidences in the low values at the results of uniaxial tensile tests in the casting samples.

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