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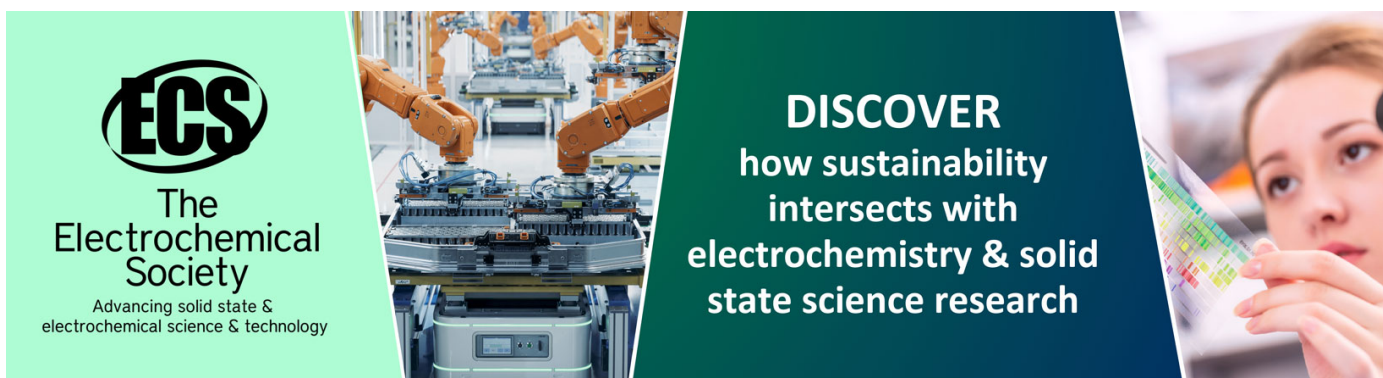
Differentiation of the material characteristics in an arandela muelle valvula

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Retraction

Retraction: Differentiation of the material characteristics in an arandela muelle valvula (*IOP Conf. Ser.: Mater. Sci. Eng.* **1145 012094)**

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[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:[2107.06751v1](#)

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Differentiation of the material characteristics in an arandela muelle valvula

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Abstract. Arandela Muelle Valvula (Valve Spring Washer) is a component used in valves for avoiding leakage while withstanding high pressure. In a manufacturing industry, these valve spring washers are produced as per the customer needs. Based on grades, four different grades of Muelle variants are used, they are UNS S15500 (15 – 5 pH), UNS S17400 (17 – 4 pH), INCONEL X-718, INCONEL X-750. In these variants, UNS S15500 (15 – 5 pH) and UNS S17400 (17 – 4 pH) have almost similar element composition, except the chromium level. From the raw material UNS S15500 (15 – 5 pH) Sheet, Arandela Muelle (Spring Washer) are cut by either Waterjet cutting process, Laser cutting or Wire cutting processes. While examining, some UNS S15500 (15 – 5 pH) grade Arandela Muelle (Spring Washer) are reported as UNS S17400 (17 – 4 pH) grade steel, in the Positive Material Identification Test (PMI). To properly identifies the differences, other chemical and mechanical tests are carried out.

Keywords: Valve spring washer, Material identification test, Mechanical Properties, Chromium.

1. Introduction

In a manufacturing industry, they develop and fabricate design-intensive sheet metal components [1-3]. The Industry manufactures the valve components like spring washer. From the raw material Sheet, spring washer can be cut in water jet cutting machine, laser cutting machine and Wire cutting machine. After cutting, Precipitation Hardening is done before it is dispatched to the customer. Arandela Muelle Valvula is a Spanish term which means valve spring washer. Arandela Muelle valvula (Valve spring washer) is a Belleville kind of spring washer [4-7]. This Belleville spring washer shape is like a small frustrum, but the spring washer manufactured here are like a normal disc spring washer, since the customer need the Belleville washer in that particular customized structure as like figure 1. So, the industry manufactures that particular Belleville spring washer as the customer required customized valve spring washer [8-11]. The industry manufactures the washer in four different grades. In those 4 variants, UNS S15500 and UNS S17400 have almost same element composition except the level of chromium [12-15]. The chromium level in UNS S15500 is in the range of 14.0 % to 15.5 %. Though, the range is between 14.0 % to 15.5 % usually the everyone uses the UNS S15500 Sheet with chromium level less than 15.0 %. The chromium level in the material UNS S17400 is 15.0 % to 17.4 %. Thus, there is an overlapping chromium level content which is 15.0 % to 15.5 %. In many researches works, the chromium level is taken less than 15.0 % even though the limit is up to 15.5% [1, 3, 5]. In very rare occasions researches done above 15.0% of chromium level in 15 – 5 pH material [5, 7]. This may be the reason for the irrelevance in the PMI test.



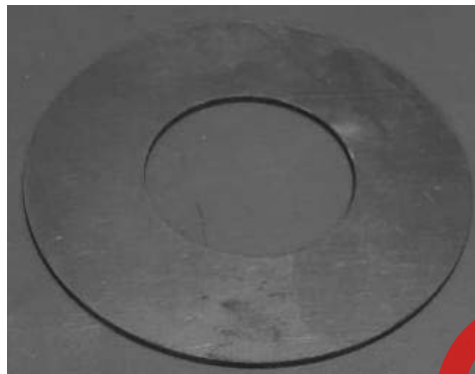


Figure 1. Arandela Muelle Valvula.

2. Materials and methods

The material used in the industry was stainless steel. The grades of stainless steel used are UNS S15500 and UNS S17400. The basic element composition in UNS S15500 is Iron – 75 %, Carbon up to 0.07 %, Manganese up to 1.00 %, Silicon up to 1.00 %, Sulphur up to 0.030 %, Phosphorous up to 0.040 %, Nickel may consist of 3.5 % to 5.5 %, Chromium may consist of 14.0 % to 15.5 %, Niobium and Tantalum may consist of 0.15 % to 0.45 % and finally, Copper may consist of 2.5 % to 4.5 % [7, 9, 11, 16-18]. In the same way, the basic element composition in UNS S17400 is Iron – 75 %, Manganese up to 1.00 %, Carbon up to 0.07 %, Silicon up to 1.00 %, Phosphorous up to 0.040 %, Sulphur up to 0.030 %, Niobium and Tantalum may consist of 0.15 % to 0.45 %, Chromium may consist of 15.0 % to 17.4 %, Nickel may consist of 3.0 % to 5.0 % and Copper may consist of 3.0 % to 5.0 % [10]. The test coupons are collected from the scrap of the UNS S15500 (15 - 5 pH) stainless steel sheet from which the wrongly resulted Arandela muelle were cut. Also, Test coupon from UNS S17400 (17 - 4 pH) sheet also cut. Initially, Test coupon will be examined for Positive material Identification Test (PMI). Figure 2 shows the scrap sheet. Figure 3 shows UNS S15500 and UNS S17400 test coupons

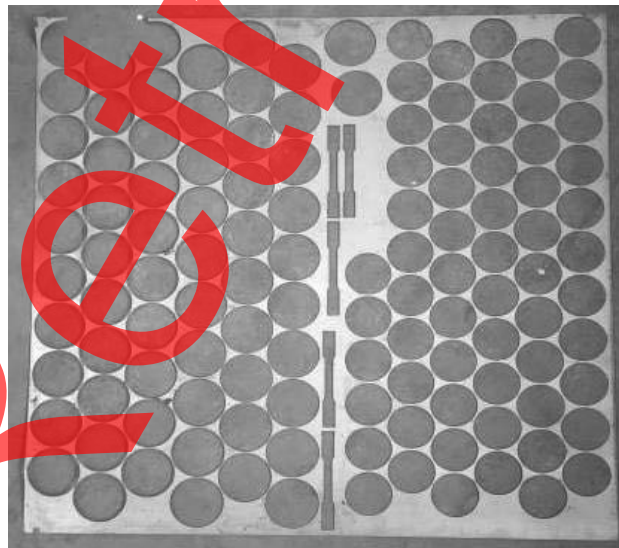


Figure 2. UNS S15500 Scrap sheet.



Figure 3. UNS S15500 and UNS S17400 test coupons.

3. Experimentation

The PMI test is done to find the exact problem faced by the customer of the industry. The same test coupon which is tested for the PMI test, will be tested with some other chemical and mechanical tests to find the difference between the UNS S15500 and UNS S17400 grade steels. To recheck the 15 – 5 pH material, the other chemical composition test Optical Emission Spectroscopy test was done to find the difference between the 15 – 5 pH and 17 – 4 pH test coupons. Also, Mechanical tests such as Tensile strength, Yield stress, Elongation and Hardness were done. Only these mechanical tests were done to find the difference. Since, the customer of the industry requires the 15 – 5 pH Arandela Muelle should satisfy the standards of ASTM A693 TYPE XM-12 in those previously mentioned mechanical tests. Also, the 17 – 4 pH Arandela Muelle should satisfy the standards of ASTM A693 TYPE 630 in those previously mentioned mechanical tests. So that, those mechanical tests were preferred for experimentations.

3.1. Positive material identification test

Positive Material Identification test is a kind of analysis test of a material. This test is generally used for the analysis of the metallic alloys to give the composition of the material by finding the percentage of the elements present in the alloy [11-18]. PMI test is an instant result giving test. So, many uses this test to find the grade of the material. When the test coupon of UNS S15500 is tested. The chromium level in the UNS S15500 is 15.82 %, 15.81 % and 15.72% in three trails as in figure 4, figure 5, figure 6 and figure 7 respectively. It is found that the chromium level is beyond the range of the chromium level should be in UNS S15500. Though the chromium level is beyond the range, the result in trail 1 is shown as 15 – 5 pH. The trail 2 also resulted as 15 – 5 pH. The trail 3 is resulted as 17-4 pH. Thus, there is an irrelevance in the result of PMI test of UNS S15500 and is shown in Table 1.

Table 1. Result of UNS S15500 in PMI with respect to chromium level.

UNS S15500	Trail 1	Trail 2	Trail 3
Chromium %	15.82 %	15.81 %	15.72 %
Result	15-5 pH	15-5 pH	17-4 pH

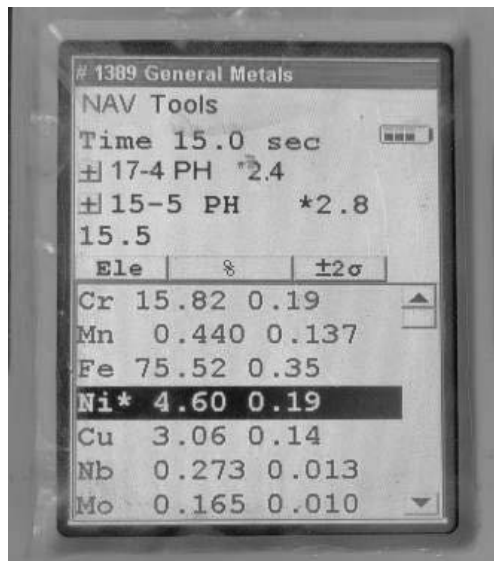


Figure 4. 15-5 pH Test coupon trail 1.

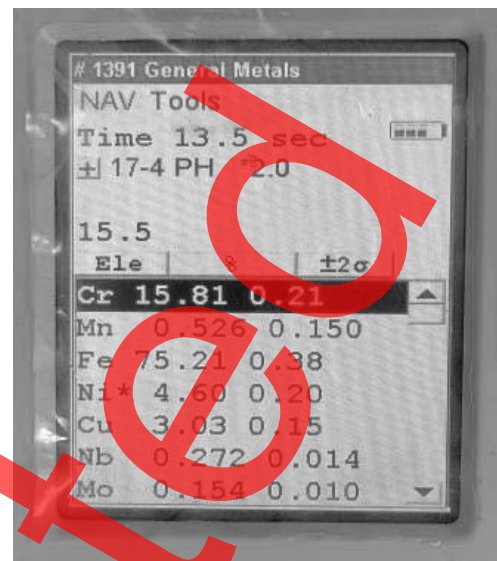


Figure 5. 15-5 pH Test coupon trail 2.

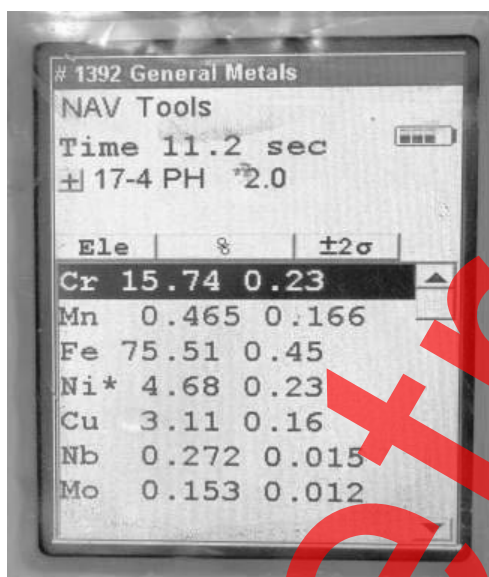


Figure 6. 15-5 pH Test coupon trail 3.

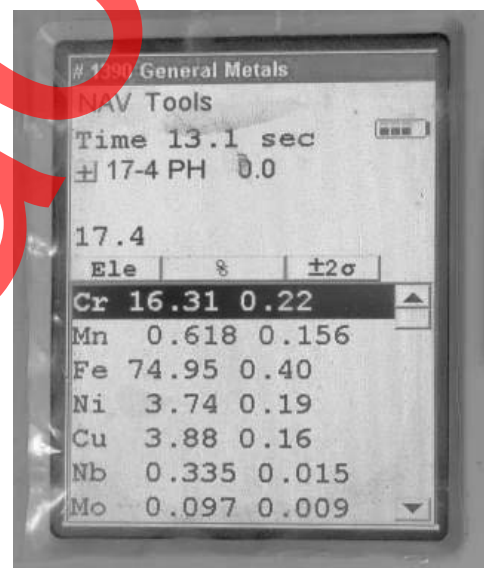


Figure 7. 17 – 4 Ph Test coupon trail.

3.2. Optical emission spectroscopy test

Optical emission spectrometer test is a kind of elemental composition determining test of metals and alloys. This test is a rapid method of analysis and comparatively more accurate than the PMI test. The equipment used for testing is OES – Foundry Master – Pro. The test is carried out in room temperature which is 24°C. From the table 2, it is clear that the UNS S15500 test coupon has 15.45 % chromium content. The table 2 compares the actual values to the specifications of ASTM A693 type XM – 12 standards. This clearly shows that the chromium level is within the range of the chromium level as per the standards. From the table 3, it is proven that UNS S17400 test coupon is absolute 17 – 4 pH grade steel. Since, the chromium level in UNS S17400 steel is 16.13 %. As the UNS S17400 test coupon's actual value is compared with the specifications of the ASTM A693 type 630 standards [19-21].

Table 2. Result of UNS S15500 in the OES test.

Elements	Minimum Value	Maximum Value	Actual Value
Carbon	-	0.07 %	0.040 %
Manganese	-	1.00 %	0.470 %
Silicon	-	1.00 %	0.272 %
Sulphur	-	0.030 %	0.008 %
Phosphorous	-	0.040 %	0.020 %
Nickel	3.50 %	5.50 %	4.503 %
Chromium	14.00 %	15.50 %	15.45 %
Copper	2.50 %	4.50 %	3.046 %
Niobium + Tantalum	0.15 %	0.45 %	0.263 %

Table 3. Result of UNS S17400 in the OES Test.

Elements	Minimum Value	Maximum Value	Actual Value
Carbon	-	0.07 %	0.033 %
Manganese	-	1.00 %	0.919 %
Silicon	-	1.00 %	0.497 %
Sulphur	-	0.030 %	0.007 %
Phosphorous	-	0.040 %	0.023 %
Nickel	3.00 %	5.00 %	3.550 %
Chromium	15.00 %	17.50 %	16.13 %
Copper	3.00 %	5.00 %	3.908 %
Niobium + Tantalum	0.15 %	0.45 %	0.314 %

Since, table 2 also clears that the actual values of UNS S15500 test coupon satisfies ASTM A693 type XM-12 standard element composition range. Especially, the deciding element chromium is just behind the maximum level of the predefined standard. Hence, this might be the reason to the deviation in the results of PMI test. The UNS S15500 test coupon is clearly proved as 15 – 5 pH grade material from the optical emission spectroscopy test. Also, table 3 clears that the ASTM A693 type 630 standard element composition range is satisfied by the actual values obtained from the UNS S17400 test coupon. Hence, UNS S17400 test coupon is proved as 17 – 4 pH grade material from the OES test. From the table 2 and table 3, it is clearly differentiated that the UNS S15500 test coupon not UNS S17400 grade material in the optical emission spectroscopy test.

3.3. Mechanical tests

Mechanical test such as tensile strength, yield stress, elongation and hardness are done to find the difference between the test coupon grades. Also, it finds whether the actual values of the test coupons satisfy the customer given standards. The customer of the industry needs that UNS S15500 should satisfy the ASTM A693 type XM-12 standard and UNS S17400 should satisfy the ASTM A693 type 630 standard. Since, both the standards ASTM A693 type XM-12 and ASTM A693 type 630 minimum values are same for the preferred mechanical tests. These tests are done in COND – H900 and the room temperature 27°C. From the table 4, it is clear that the tensile strength of both test coupons is higher than the standard value 1310 MPa. The tensile strengths of UNS S15500 and UNS S17400 are 1402 MPa

and 1426 MPa respectively. There is 24 MPa difference between both test coupons tensile strength. The standard yield stress should be minimum 1170 MPa for both the grades. The yield stress of test coupons UNS S15500 and UNS S17400 are 1370 MPa and 1393 MPa respectively. The difference between both the grades is 23 MPa. These test coupons should withstand 5% minimum elongation in GL of 50 mm to satisfies the standards preferred by the customer of the industry. The elongation of UNS S15500 and UNS S17400 test coupons are 5% and 6% respectively. The difference between the elongation of test coupons is 1%. The required hardness for the component as per the standards of both UNS S15500 and UNS S17400 is minimum 38 HRC in Rockwell C. The actual hardness in Rockwell C of UNS S15500 and UNS S17400 are 44 and 45 respectively. The difference between the hardness of the test coupons is 1 HRC. From the table 4, it is clear that the both the test coupons UNS S15500 and UNS S17400 satisfies the customer required standards and there the difference in their actual values proves that both the test coupons are not same grade.

Table 4. Mechanical test results (UNS S15500 vs UNS S17400).

Mechanical Tests	Minimum Value	Actual Value for UNS S15500 Test Coupon	Actual Value for UNS S17400 Test Coupon
Tensile Strength in MPa	1310	1402	1426
Yield Stress in MPa	1170	1370	1393
Elongation in GL of 50 mm	5 %	5 %	6 %
Hardness, Rockwell C	38	44	45

3.4. Microstructure test

In addition to these mechanical tests, Microstructure test is done to both test coupons UNS S15500 and UNS S17400 to find the difference in the microstructure of the test coupons. The equipment used for the test is metallurgical microscope – Dewinter Tech. The observation is done by using etchant Vilella's reagent. The equipment and etchant are same for both UNS S15500 and UNS S17400 test coupon. The microstructures are taken at 200X /50 μ m. Heat treatment provides better microstructure breakage and increases mechanical properties. [10]



Figure 8. UNS S15500 microstructure.



Figure 9. UNS S17400 microstructure.

Microstructure breakage provides better hardness and better spring reaction to the Arandela muelle. From the figure 8 and figure 9 while comparing both the microstructures, it is evident that the comparatively the UNS S17400 test coupon has better microstructure breakage than the UNS S15500 test coupon. This shows there is a difference in the grade of the material. Since, the hardness is nearly

equal but the breakage has difference in it. Also, comparatively UNS S17400 grade material is stronger than the UNS S15500. From the figure 8 and figure 9, the more breakage in microstructure of UNS S17400 test coupon shows that there is a difference in the material grade.

4. Conclusion

In the PMI test, it is clear that there is a deviation in the result when the chromium level is between the overlapping chromium range which is 15.0 % to 15.5%. The deviation in the result from the PMI test is reanalysed with some other tests like Optical emission spectroscopy test, Tensile strength, Yield stress, Elongation test, Hardness and the microstructure test. In optical emission spectroscopy test, the UNS S15500 is proved as 15 – 5 pH grade material and also compared with the result of UNS S17400 test coupon. In the mechanical tests, the results clearly show the difference between the grade of the material and also satisfies the standards provided by the customer of the industry. In tensile strength test, the difference between the UNS S15500 and UNS S17400 test coupons is 24 MPa. In yield strength test, the difference between the UNS S15500 and UNS S17400 test coupons is 23 MPa. In elongation test, the difference in the result of UNS S15500 and UNS S17400 test coupons is 1%. Also, the microstructure test clearly shows the difference in the microstructure breakage of the test coupons. The UNS S17400 has comparatively high breakage than UNS S15500 test coupon and shows that the UNS S17400 is stronger than the UNS S15500 test coupon. From all the previous aspects, the result is clear that the UNS S15500 is wrongly resulted in PMI test and in all other tests, it is evident that the UNS S15500 test coupon is 15-5 pH grade material steel and not 17 – 4 pH grade steel.

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