A REPORT ON

STAINLESS STEEL MATERIALS

SUBMITTED BY

G. SOWRYA KUMAR (17IMUH003)

R.S. MRITYUNJAYA AADITYAA (17IMUH007)

PRATEK KRISHNA (17IMUH009)

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LETTER OF TRANSMITTAL

OCTOBER 2019

TO

Dr M Kavitha

PSG college of technology

Coimbatore-4

Respected Madam,

The following report entitled “STAINLESS STEEL MATERIALS” is submitted in the partial fulfilment of the programme INDUSTRIAL METALLURGY. The report is based on my observation in the testing done on the material.

Your Faithfully,

(R.S. MRITYUNJAYA AADITYAA)

(G. SOWRYA KUMAR)

(PRATEK KRISHNA)

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ABSTRACT

Stainless Steel is a steel alloy that has good resistance to corrosion which has a minimum of 10.5% chromium by mass and maximum of 1.2 % carbon by mass in it. Our main objective is to investigate the surface topology of the SS – 316 which was conducted at PSGIAS Nanotechnology lab using Scanning Electron microscope and Digital microscope. We have therefore attached the pictures of our observation in this report. This report contains the important stainless steel and its categories. Stainless steel application is used in most of the fields in this world.

1.INTRODUCTION

In metallurgy, **stainless steel**, also known as **inox steel** or **inox** from French *inoxydable* (inoxidizable), is a steel alloy, with a minimum of 10.5% chromium content by mass and a maximum of 1.2% carbon by mass.

Stainless steels are most notable for their corrosion resistance, which increases with increasing chromium content. Additions of molybdenum increases corrosion resistance in reducing acids and against pitting attack in chloride solutions. Thus, there are numerous grades of stainless steel with varying chromium and molybdenum contents to suit the environment the alloy must endure. Resistance to corrosion and staining, low maintenance, and familiar luster make stainless steel an ideal material for many applications where both the strength of steel and corrosion resistance are required.

Stainless steel is rolled into sheets, plates, bars, wire, and tubing to be used in: cookware, cutlery, surgical instruments, major appliances; construction material in large buildings, such as the Chrysler Building; industrial equipment (for example, in paper mills, chemical plants, water treatment); and storage tanks and tankers for chemicals and food products (for example, chemical tankers and road tankers). Corrosion resistance, the ease with which it can be steam cleaned and sterilized, and unnecessary need for surface coatings has also influenced the use of stainless steel in commercial kitchens and food processing plants.

2.HISTORY

The corrosion resistance of iron-chromium alloys was first recognized in 1821 by French metallurgist Pierre Berthier, who noted their resistance against by some acids and suggested their use in cutlery. Metallurgists of 19th century were unable to produce the combination of low carbon and high chromium found in most modern stainless steels, and the high-chromium alloys they could produce were too brittle to be practical.

In 1872, the Englishmen John T. Woods and John Clark patented a "Water Resistant" alloy in Britain, that would today be considered a stainless steel. In the late 1890s, Hans Goldschmidt of Germany developed an aluminothermic (thermite) process for producing carbon-free chromium. Between 1904 and 1911 several researchers, particularly Leon Guillet of France, prepared alloys that would today be considered stainless steel.

In 1908, Friedrich Krupp Germaniawerft built the 366-ton sailing yacht *Germania* featuring a chrome-nickel steel hull in Germany. In 1911, Philip Monnartz reported on the relationship between chromium content and corrosion resistance. On 17 October 1912, Krupp engineers Benno Strauss and Eduard Maurer patented austenitic stainless steel as Nirosta.

3.PROPERTIES

PHYSICAL PROPERTIES:

Properties of a few common grades are listed below.

Physical Properties of Stainless steels								
Designations		Density	Modulus of elasticity	Mean coefficient of thermal expansion [$10^{-6} \cdot K^{-1}$]		Thermal Conductivity	Specific Heat	Electrical resistivity
EN [N°]	AISI/ASTM	at 20 °C [kg/dm^3]	at 20 °C [GPa]	20 °C 200 °C	20 °C 400 °C	at 20 °C [W/(m·K)]	at 20 °C [J/(kg·K)]	at 20 °C [($\Omega \cdot mm^2$)/m]
Austenitic stainless steels								
1.4301	304	7,9	200	16,5	17,5	15	500	0,73
1.4401	316	8,0	200	16,5	17,5	15	500	0,75
Duplex stainless steels								
1.4462	2205	7,8	200	13,5	14,0 (g)	15	500	0,80
1.4362	2304	7,8	200	13,5	14,0 (n)	15	500	0,80
1.4501		7,8	200	13,5	(n.r.)	15	500	0,80
Ferritic stainless steels								
1.4512	409	7,7	220	11,0	12,0	25	460	0,60
1.4016	430	7,7	220	10,0	10,5	25	460	0,60

Martensitic stainless steels								
1.4021	420	7,7	215	11,0	12,0	30	460	0,60
1.4418		7,7	200	10,8	11,6	15	430	0,80
Precipitation hardening stainless steels								
1.4542	630	7,8	200	10,8	11,6	16	500	0,71

Courtesy: Google

ELECTRICITY AND MAGNETISM:

Like steel, stainless steels are relatively poor conductors of electricity, with significantly lower electrical conductivity than copper.

Ferritic and martensitic stainless steels are magnetic.

Annealed austenitic stainless steels are non-magnetic. Work hardening can make cold-formed austenitic stainless steels slightly magnetic.

Galling:

Galling, sometimes called cold welding, is a form of severe adhesive wear which can occur when two metal surfaces are in relative motion to each other and under heavy pressure. Austenitic stainless steel fasteners are particularly susceptible to thread galling, although it also occurs in other alloys that self-generate a protective oxide surface film, such as aluminium and titanium. Under high contact-force sliding this oxide can be deformed, broken and removed from parts of the component, exposing bare reactive metal. When the two surfaces are the same material, these exposed surfaces can easily fuse together. Separation of the two surfaces can result in surface tearing and even complete seizure of metal components or fasteners.[23][24]

Galling can be mitigated by the use of dissimilar materials (bronze against stainless steel), or using different stainless steels (martensitic against austenitic). Additionally, threaded joints may be lubricated to provide a film between the two parts and prevent galling. Also, Nitronic 60, made by selective alloying with manganese, silicon and nitrogen, has demonstrated a reduced tendency to gall.

4.STAINLESS STEEL FAMILIES:

There are four main families, which are primarily classified by their crystalline structure: austenitic, ferritic, martensitic and duplex.

4.1.Austenitic stainless steel

Austenitic stainless steel is the largest family of stainless steels, making up about two-thirds of all stainless steel production. They possess an austenitic microstructure, which is a face-centered cubic crystal structure. This microstructure is achieved by alloying with sufficient nickel and/or manganese and nitrogen to maintain an austenitic microstructure at all temperatures from the cryogenic region to the melting point. Thus austenitic stainless steels are not hardenable by heat treatment since they possess the same microstructure at all temperatures.

Their yield strength is low (200 to 300MPa), which limits their use for structural and other load bearing components. Duplex stainless steels tend to be preferred in such situations because of their high strength and corrosion resistance.

Their elongation is high, which allows very important deformation in fabrication processes (such as deep drawing of kitchen sinks)

They are weldable by all processes. The most frequently used is electric arc welding.

Thin sheets and small diameter bars can be strengthened by cold working, with an associated reduction of elongation. However, if they are welded, the welded area will return to the low strength level of the steel before cold working. This limits the use of cold-worked austenitic stainless steels.

They are essentially non-magnetic and maintain their ductility at cryogenic temperatures.

They can be further subdivided into two sub-groups, 200 series and 300 series:

- 200 Series are chromium-manganese-nickel alloys, which maximize the use of manganese and nitrogen to minimize the use of nickel. Due to their nitrogen addition they possess approximately 50% higher yield strength than 300 series stainless steels. Type 201 is hardenable through cold working; Type 202 is a general purpose stainless steel. Decreasing nickel content and increasing manganese results in weak corrosion resistance.
- 300 Series are chromium-nickel alloys, which achieve their austenitic microstructure almost exclusively by nickel alloying; some very highly alloyed grades include some nitrogen to reduce nickel requirements. 300 series is the largest group and the most widely used. The best known grade is Type 304, also known as 18/8 and 18/10 for its composition of 18% chromium and 8%/10% nickel, respectively. The second most common austenitic stainless steel is Type 316. The addition of 2% molybdenum provides greater resistance to acids and to localized corrosion caused by chloride ions.

Low-carbon versions, for example 316L or 304L, are used to avoid corrosion problems caused by welding. The "L" means that the carbon content of the alloy is below 0.03%.

4.2.Ferritic stainless steels:

Ferritic stainless steels possess a ferrite microstructure like carbon steel, which is a body-centered cubic crystal structure, and contain between 10.5% and 27% chromium with very little or no nickel . This microstructure is present at all temperatures, due to the chromium addition, and like austenitic stainless steels these are not hardenable by heat treatment. They cannot be strengthened by cold work to the same degree as austenitic stainless steels. They are magnetic like carbon steel.

As they do not contain Nickel, they cost less than austenitic grades and are now present in a wide range of industries.

Common grades are 409 and 409Cb (Cb is the US name for Nb) with about 10.5%Cr, the latter being used mostly for automobile exhaust pipes in North America, 430 (17%Cr) for architectural applications, for kitchenware, sinks, slate hooks, roofing, etc...). Additions of Nb, Ti, Zr to grade 430 allow a good weldability and such grades are used for automotive exhaust pipes, for white goods (dishwashers, refrigerator doors, chimney ducts, solar water heaters etc..

Higher Cr ferritics (22%Cr) are now used for power plates for Solid Oxide Fuel Cells (SOFC) operating at temperatures around 700°C.

Electrical resistance ferritic grades Fr-Cr-Al are not included in these groups, as they are designed for oxidation resistance at elevated temperatures.

4.3.MARTENSITIC STAINLESS STEEL:

Martensitic stainless steels offer a wide range of properties and are used as stainless engineering steels, stainless tool steels, and creep resisting steels. They fall into 4 categories (with some overlap):

1. Fe-Cr-C grades: They were the first grades used and they are still widely used in engineering and wear-resistant applications.
2. Fe-Cr-Ni-C grades: In these grades, some of the carbon is replaced by nickel. They offer a higher toughness and a higher corrosion resistance. Grade EN 1.4303 (Casting grade CA6NM) with 13%Cr and 4%Ni is used for most Pelton, Kaplan and Francis turbines in hydroelectric power plants [41] because it has good casting properties, a good weldability and a good resistance to cavitation erosion.
3. Precipitation hardening grades: Grade EN 1.4542 (a.k.a. 17/4PH), the best known grade, combines martensitic hardening and precipitation hardening. It achieves high strength and good toughness and is used in aerospace among other applications.
4. Creep-resisting grades: Small additions of Nb, V, B, Co increase the strength and creep resistance up to about 650 °C.

4.3.1.Heat treatment of martensitic stainless steels:

Martensitic stainless steels form a family of stainless steels that can be heat treated to provide the adequate level of mechanical properties.

The heat treatment typically involves three steps:

- Austenitizing, in which the steel is heated to a temperature in the range 980 - 1050 °C depending on the grades. The austenite is a face centered cubic phase.
- Quenching (a rapid cooling in air, oil or water). The austenite is transformed into martensite, a hard body-centered tetragonal crystal structure. The as-quenched martensite is very hard and too brittle for most applications. Some residual austenite may remain.
- Tempering, i.e. heating to around 500 °C, holding at temperature, then air cooling. Increasing the tempering temperature decreases the yield strength and ultimate tensile strength but increases the elongation and the impact resistance.

4.3.2.Nitrogen-alloyed martensitic stainless steels:

Replacing some of the carbon in martensitic stainless steels by nitrogen is a fairly recent development. The limited solubility of nitrogen has been increased by the pressure electroslag refining (PESR) process in which melting is carried out under a high nitrogen pressure. Up to 0.4% nitrogen contents have been achieved leading to higher hardness/strength and higher corrosion resistance. As the PESR is expensive, lower but significant nitrogen contents have been achieved using the standard argon oxygen decarburization (AOD) process.

They are magnetic. They are not as corrosion resistant as the common ferritic and austenitic stainless steels due to their low chromium content.

4.4.Duplex stainless steel:

Duplex stainless steels have a mixed microstructure of austenite and ferrite, the aim usually being to produce a 50/50 mix, although in commercial alloys the ratio may be 40/60. They are characterized by high chromium (19–32%) and molybdenum (up to 5%) and lower nickel contents than austenitic stainless steels. Duplex stainless steels have roughly twice the yield strength of austenitic stainless steels. Their mixed microstructure provides improved resistance to chloride stress corrosion cracking in comparison to austenitic stainless steels Types 304 and 316.

Duplex grades usually divided into three sub-groups based on their corrosion resistance: lean duplex, standard duplex and super duplex.

The properties of duplex stainless steels are achieved with an overall lower alloy content than similar-performing super-austenitic grades, making their use cost-effective for many applications.The pulp and paper industry was one of the first ones to use extensively duplex stainless steel. Today, the oil and gas industry is the largest user and has pushed for more corrosion resistant grades, leading to the development of super duplex and even so-called hyper duplex grades. More recently, the less expensive (and slightly less corrosion-resistant) lean duplex has been developed, chiefly for structural applications in building and construction (concrete reinforcing bars, plates for bridges, coastal works) and for the water industry.

4.5.Precipitation hardening stainless steels:

Precipitation hardening stainless steels have corrosion resistance comparable to austenitic varieties, but can be precipitation hardened to even higher strengths than the other martensitic grades.

There are based on 3 types:

- Martensitic 17-4 PH, (AISI 630 EN 1.4542) contains about 17% Cr, 4%Ni, 4%Cu and 0.3% Nb.

Solution treatment at about 1040°C followed by quenching results in a relatively ductile martensitic structure. Subsequent ageing treatment at 475°C precipitates Nb and Cu-rich phases that increase the strength up to above 1000 MPa yield strength. This outstanding strength level finds uses in high tech applications such as aerospace (usually after remelting to eliminate non-metallic inclusions and thereby to increase fatigue life). Another major advantage of this steel is that ageing, unlike tempering treatments, is carried out at a temperature that can be applied to (nearly) finished parts without distortion and discoloration.

- Semi Austenitic 17-7PH (AISI 631 EN 1.4568) contains about 17%Cr, 7.2% Ni and 1.2%Al.

Typical heat treatment involves first solution treatment and quenching. At this point, the structure remains austenitic. Martensitic transformation is then obtained either by a cryogenic treatment at -75°C or by severe cold work (over 70% deformation, usually by cold rolling or wire drawing). Ageing at 510°C, which precipitates the Ni_3Al intermetallic phase, is carried out as above on nearly finished parts. Yield stress levels above 1400 MPa are then reached.

- A286 (ASTM 660 EN 1.4980) has the following typical analysis Cr 15%, Ni 25% Ti 2.1% Mo 1.2% V 1.3% and B 0.005%

The structure remains austenitic at all temperatures.

Typical heat treatment involves solution treatment and quenching, followed by ageing at 715°C. Ageing forms Ni_3Ti precipitates and increase the yield strength to about 650MPa at room temperature. Unlike the above grades, the mechanical properties and creep resistance of this PH steel remain very good at temperatures up to 700°C.

A286 is in fact a Fe-based superalloy, used in jet engines and gas turbines, turbo parts, etc.

The designation "CRES" is used in various industries to refer to corrosion-resistant steel. Most mentions of CRES refer to stainless steel, although the correspondence is not absolute, because there are other materials that are corrosion-resistant but not stainless steel.

4.6.GRADES:

There are over 150 grades of stainless steel, of which 15 are most commonly used. There are a number of systems for grading stainless and other steels, including US SAE steel grades.

5.STANDARD FINISHES:

316L stainless steel, with an unpolished, mill finish

Standard mill finishes can be applied to flat rolled stainless steel directly by the rollers and by mechanical abrasives. Steel is first rolled to size and thickness and then annealed to change the properties of the final material. Any oxidationthat forms on the surface (mill scale) is removed by pickling, and a passivation layer is created on the surface. A final finish can then be applied to achieve the desired aesthetic appearance.

- No. 0: Hot rolled, annealed, thicker plates
- No. 1: Hot rolled, annealed and passivated
- No. 2D: Cold rolled, annealed, pickled and passivated
- No. 2B: Same as above with additional pass through highly polished rollers
- No. 2BA: Bright annealed (BA or 2R) same as above then bright annealed under oxygen-free atmospheric condition
- No. 3: Coarse abrasive finish applied mechanically
- No. 4: Brushed finish
- No. 5: Satin finish
- No. 6: Matte finish (brushed but smoother than #4)
- No. 7: Reflective finish
- No. 8: Mirror finish
- No. 9: Bead blast finish

- No. 10: Heat coloured finish—offering a wide range of electropolished and heat coloured surfaces.

6.PRODUCTION PROCESS AND FIGURES

6.1.Production process:

Most of the world stainless steel production is produced by the following processes.

- EAF (Electric Arc Furnace) in which stainless steel scrap, other ferrous scrap and ferro alloys (Fe Cr,Fe-Ni, Fe Mo, Fe Si ...) are melted. The molten metal is then poured into a ladle and transferred into the AOD
- AOD (Argon Oxygen Decarburization) allows the removal of carbon in the molten steel and other composition adjustments to achieve the desired chemical composition of the steel
- CC (Continuous Casting) in which the molten metal is solidified into slabs (typical section is 20 cm thick and 2 m wide) for flat products or blooms (sections vary widely but 25cmx25cm is about the average).
- HR (Hot Rolling): The slabs and blooms are reheated in a furnace and then hot rolled. Hot rolling reduces the thickness of the slabs to produce about 3mm thick coils. Blooms on the other hand are hot rolled into bars (that are cut into lengths at the exit of the rolling mill) or wire rod which is coiled.
- CF (Cold finishing): This is a very simplified overview.

Hot rolled coils are pickled in acid solutions to remove the oxide scale on the surface, then subsequently cold rolled (Sendzimir rolling mills), annealed in a protective atmosphere, until the desired thickness and surface finish is obtained. Further operations such as slitting, tube forming, etc. can be carried out in downstream facilities.

Hot rolled bars are straightened, then machined to the required tolerance and finish.

Wire rod coils are subsequently processed to produce

- cold finished bars on drawing benches
- fasteners on boltmaking machines
- wire on single or multipass drawing machines

Further information can be obtained on the websites of most producers. An example is provided here.

6.2Production figures

World stainless steel production figures re published every year by ISSF.

Overall stainless steel production (flat and long products):

Stainless steel meltshop production in 1000 metric Tons						
Year	**European Union**	**Americas**	**China**	**Asia without China**	**Other countries**	**World**
2018	7386	2808	26706	8195	5635	50729
2017	7377	2754	25774	8030	4146	48081
2016	7280	2931	24938	9956	672	45778
2015	7169	2747	21562	9462	609	41548
2014	7252	2813	21692	9333	595	41686
2013	7147	2454	18984	9276	644	38506

The stainless steel production in China accounted for more than 50% of the world production in 2017.

The 630-foot-high (190 m), stainless-clad (type 304) Gateway Arch defines St. Louis's skyline

Breakdown of production by families of stainless steels in 2017:

- Austenitic stainless steels Cr - Ni (also-called 300*-series): 54%
- Austenitic stainless steels Cr - Mn (also called 200*-series): 21%
- Ferritic and martensitic stainless steels (also called 400*-series): 23%

This breakdown is quite stable over the years.

- 300, 200 and 400 refer to the ASTM/AISI grade numbering system for stainless steels

7.APPLICATIONS

The pinnacle of New York's Chrysler Building is clad with *Nirosta* stainless steel, a form of Type 302[54][55]

An art deco sculpture on the Niagara-Mohawk Power building in Syracuse, New York

7.1.Architecture:

Stainless steel is used for buildings for both practical and aesthetic reasons. Stainless steel was in vogue during the art deco period. The most famous example of this is the upper portion of the Chrysler Building (pictured). Some diners and fast-food restaurants use large ornamental panels and stainless fixtures and furniture. Because of the durability of the material, many of these buildings still retain their original appearance. Stainless steel is used today in building construction because of its durability and because it is a weldable building metal that can be made into aesthetically pleasing shapes. An example of a building in which these properties are exploited is the Art Gallery of Alberta in Edmonton, which is wrapped in stainless steel.

Type 316 stainless is used on the exterior of both the Petronas Twin Towers and the Jin Mao Building, two of the world's tallest skyscrapers.

The Parliament House of Australia in Canberra has a stainless steel flagpole weighing over 220 metric tons (240 short tons).

The aeration building in the Edmonton Composting Facility, the size of 14 hockey rinks, is the largest stainless steel building in North America.

La Geode in Paris is a nearly spherical building. The dome is composed of 6433 polished stainless steel equilateral triangles that form the sphere that reflects the sky.

7.2.Bridges:

Stainless steel is quite frequently used for pedestrian and for road bridges. Product forms are tubes (Helix bridge), plates (Cala Galdana bridge), or reinforcing bar [56](Champlain Bridge).

- Cala Galdana Bridge in Menorca (Spain) was the first stainless steel road bridge.
- Champlain Bridge, Montreal, Canada
- Oudesluijs bridge in Amsterdam, a 3D printed stainless steel bridge using Construction 3D printing
- Padre Arrupe Bridge (Bilbao, Spain) links the Guggenheim museum to the University of Deusto.
- Sant Fruitos Pedestrian Bridge (Catalonia, Spain), arch pedestrian bridge.
- Stonecutter's bridge, Hong Kong, China
- The Helix Bridge is a pedestrian bridge linking Marina Centre with Marina South in the Marina Bay area in Singapore.

7.3.Arts and monuments:

- Atomium was renovated with stainless-steel cladding in a renovation completed in 2006; previously the spheres and tubes of the structure were clad in aluminium (Brussels, Belgium)
- Cloud Gate sculpture by Anish Kapoor (Chicago, Illinois)

7.4.Automobiles:

The Allegheny Ludlum Corporation worked with Ford on various concept cars with stainless steel bodies from the 1930s through the 1970s to demonstrate the material's potential. The 1957 and 1958 Cadillac Eldorado Brougham had a stainless steel roof. In 1981 and 1982, the DMC DeLorean production automobile used Type-304 stainless steel body panels over a glass-reinforced plastic monocoque. Intercity buses made by Motor Coach Industries are partially made of stainless steel.

The largest use of stainless steel in cars is the exhaust line. Environment protection requirements of reducing pollution and noise for whole life of cars led to the use of ferritic grades typically AISI409/409Cb in North America, EN 1.4511 and 1.4512 in Europe. They are used for collector, tubing, muffler, catalytic converter, tailpipe. Heat resisting grades typically EN1.4913 or 1.4923 are used in parts of turbochargers, other heat resisting grades for EGR (Exhaust gas recirculation) and for inlet and exhaust valves. In addition, common rail injection systems and particularly the injectors rely on stainless steels.

Stainless steel has proved to be the best choice for miscellaneous applications, such as stiffeners for windshiel wiper blades, balls for seat belt operation device in case of accident, springs, fasteners, etc.

The aft body panel of the Porsche Cayman model (2-door coupe hatchback) is made of stainless steel. It was discovered during early body prototyping that conventional steel could not be formed without cracking (due to the many curves and angles in that automobile). Thus, Porsche was forced to use stainless steel on the Cayman.

Some automotive manufacturers use stainless steel as decorative highlights in their vehicles

8.SUSTAINABILITY – RECYCLING AND REUSING:

The average carbon footprint of stainless steel (all grades, all countries) has been estimated to be 2.90Kg CO_2 per Kg of stainless steel of which 1.92 are emissions from raw materials (Cr, Ni, Mo...); 0.54 from electricity and steam, and 0.44 are direct emissions (i.e; by the stainless steel plant). As this is an average, countries that have low CO_2 emissions in their electricity production (such as France with nuclear energy) will have lower figures. Ferritics without Ni will have a lower CO_2 footprint than asutenitics with 8%Ni or more.

Stainless steel is 100% recyclable. An average stainless steel object is composed of about 60% recycled material of which approximately 40% originates from end-of-life products and about 60% comes from manufacturing processes. What prevents a higher recycling content is the availability of stainless steel scrap, in spite of a very high recycling rate. According to the International Resource Panel's Metal Stocks in Society report, the per capita stock of stainless steel in use in society is 80–180 kg in more developed countries and 15 kg in less-developed countries. There is a secondary market that recycles usable scrap for many stainless steel markets. The product is mostly coil, sheet, and blanks. This material is purchased at a less-than-prime price and sold to commercial quality stampers and sheet metal houses. The material may have scratches, pits, and dents but is made to the current specifications.

Carbon footprint must not be the only factor for deciding the choice of materials:

- over any product life, maintenance, repairs (when possible) or early end of life (planned obsolescence) can increase the overall footprint way beyond the difference between materials only. In addition loss of service (typically for bridges) may induce large hidden costs (queues, wasted fuel, loss of man-hours;..)

- how much material is used to provide a given service varies with the performance, particularly the strength level, which allows lighter structures and components.

9.NANOSCALE STAINLESS STEEL:

Stainless steel nanoparticles have been produced in the laboratory. These may have applications as additives for high performance applications. For examples, sulfurization, phosphorization and nitridation treatments to produce nanoscale stainless steel based catalysts could enhance the electrocatalytic performance of stainless steel for water splitting.

10.HEALTH EFFECTS:

Stainless steel is generally considered to be biologically inert, but some sensitive individuals develop a skin irritation due to a nickel allergy caused by certain alloys. Stainless steel leaches small amounts of nickel and chromium during cooking.

11.LITERATURE SURVEY

Study of corrosion behaviour of SS-316 cladding deposited by shielded metal arc welding by Vedant Singh, Virender Singh and Narender Anand Mohan.

The present work deals with the study of microstructure and to examine the effect of sensitization on the corrosion resistance of the Stainless Steel 316 cladding deposited by using SMAW process. Literature explains the susceptibility and resistance of SS316L at ambient temperatures and higher temperatures to examine the corrosion rate of the steel after immersion in the corrosive media. This work reveled that with one layer have less amount of precipitated chromium carbide as compared to the specimen B and C. The result shows that the Austenitic Stainless steel has the best layer thickness to highest corrosion resistance rates. Huey's test gives the microstructure results and through that we have concluded the corrosion rate goes at the maximum value of 2.88 mm by boiling the fresh nitric acid at 67 percentile. By focusing on the future various grades like SS309L, SS304L and materials such as cobalt alloys, copper alloys, manganese alloys, alloy steels, ceramics and composites are employed for weld cladding applications.

12.AIM

The aim of this project is analysis a stainless. Here we have chosen SS – 316, and conducted an analysis using Scanning Electron Microscope (SEM) and using Digital microscope 1000x.

13.EXPERIMENTAL WORK

We bought SS – 316 nuts from the market which is readily available. Our objective was to check the surface topology and composition in it. So first we cleaned the surface of the nut to be experimented and etched with concentrated hydrochloric acid for 30 seconds. Then it was tested under Digital microscope and SEM with the help of experts at the Nanotechnology lab, PSGIAS.

14.PROJECT OBSERVATIONS

We did observation on stainless steel of Grade – 316 nuts using Scanning Electron Microscope (SEM) and using Digital Microscope 1000x at PSGIAS Nanotechnology Lab. The observed pictures are listed below.

14.1.Digital Microscope 1000X:

A **digital microscope** is a variation of a traditional optical microscope that uses optics and a digital camera to output an image to a monitor, sometimes by means of software running on a computer. A digital microscope often has its own in-built LED light source and differs from an optical microscope in that there is no provision to observe the sample directly through an eyepiece. Since the image is focused on the digital circuit, the entire system is designed for the monitor image. The optics for the human eye are omitted.

The etchant used for this SS – 316 is concentrated hydrochloric acid. The image that we got from this microscope after etching is shown below,

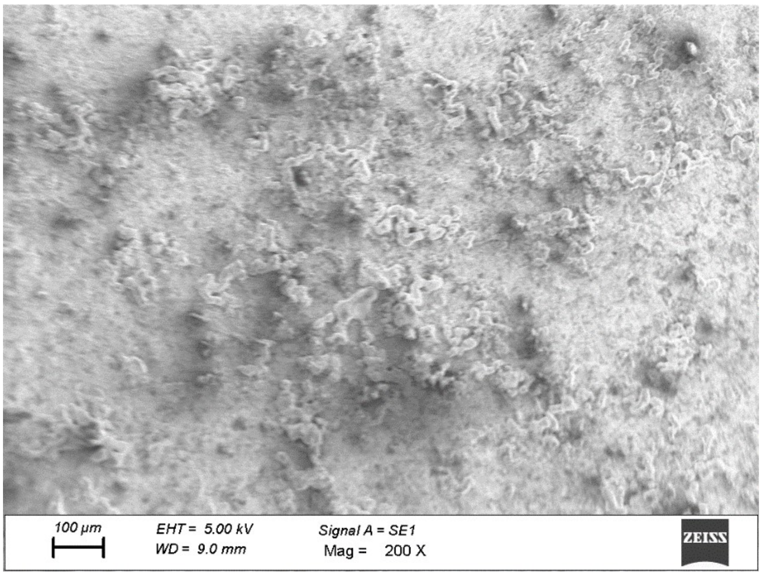
Before Etching

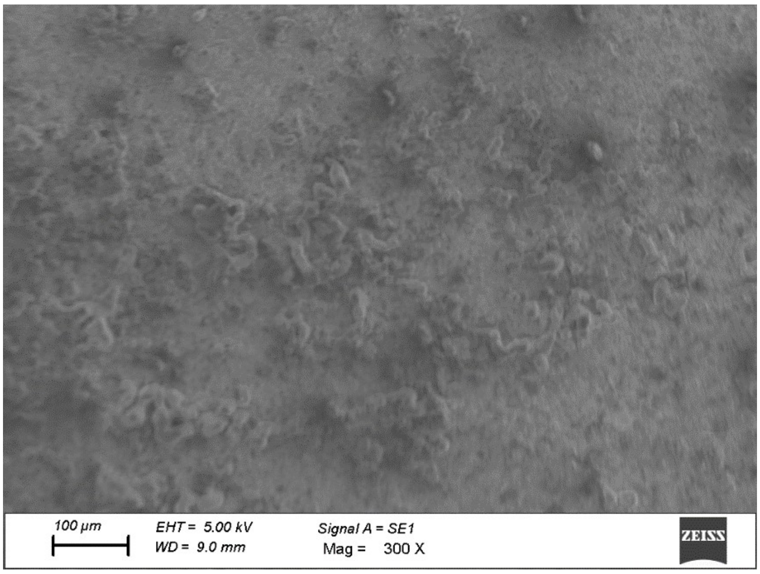
After Etching

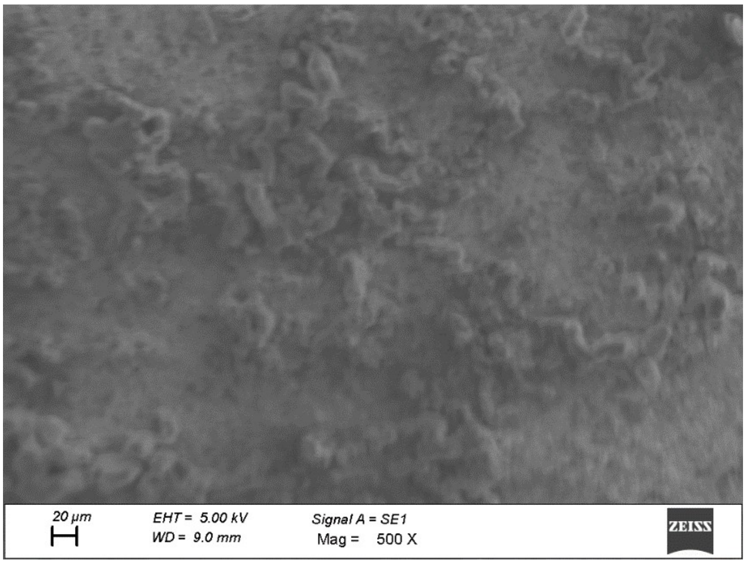
14.2.Scanning Electron Microscope:

A **scanning electron microscope** (**SEM**) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample. The electron beam is scanned in a raster scan pattern, and the position of the beam is combined with the intensity of the detected signal to produce an image. In the most common SEM mode, secondary electrons emitted by atoms excited by the electron beam are detected using an Everhart-Thornley detector. The number of secondary electrons that can be detected, and thus the signal intensity, depends, among other things, on specimen topography. SEM can achieve resolution better than 1 nanometre. Specimens are observed in high vacuum in conventional SEM, or in low vacuum or wet conditions in variable pressure or environmental SEM, and at a wide range of cryogenic or elevated temperatures with specialized instruments.

The resultant that we got from SEM is shown below,


100 µm
EHT = 5.00 kV
WD = 9.0 mm
Signal A = SE1
Mag = 200 X
ZEISS


100 µm
EHT = 5.00 kV
WD = 9.0 mm
Signal A = SE1
Mag = 300 X
ZEISS


20 µm
EHT = 5.00 kV
WD = 9.0 mm
Signal A = SE1
Mag = 500 X
ZEISS

15.CONCLUSIONS

By conducting this project, we were able to understand the standards, characters, types, grades, microstructures, surface topology, application of stainless steel. As a part of our project we have studied about SS – 316. As we with the help of the experts in nanotechnology lab, we were able to gain the knowledge about SEM and Digital microscope. Hence, we had a good experience by conducting this experiment.

16.REFERENCE

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