"Comparative Analysis of SS 301 with Current Scenarios of Gas Turbine Disc Material for Possible use in Gas Turbine Disc"

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Abstract— SS 301L (S30100), SS301 LN which contains up to 8 % of Nickel, and 18 % of chromium is most familiar and most frequently member of stainless steel family and a key limiting factor in early jet engines was the performance of the materials available for the hot section (disc) of the engine. The need for better materials spurred much research in the field of alloys and developing method and that research resulted in a long list of new materials and methods that make modern gas turbines possible.

Key words: SS 301, IN 718, IN 706, A 286, Gas Turbine Disc

I. INTRODUCTION

Gas turbines disc is used to produce mechanical power in industrial applications or thrust, when those machines are used for aeronautical purposes. The basic operation of gas turbine is similar to that of the steam power plant except that air is used in place of water. Atmospheric air passes through a compressor that converts it to higher pressure. A gas-turbine is composed of a number of discs, mounted onto a shaft. Gas turbine consists of several components working together and running in order to achieve mechanical power or thrust [1], [2].Gas turbine disc has to be subjected high pressure, high temperature, and vibration condition inside gas turbine. All this factors are responsible for failure of gas turbine disc and blades, harm of engine. So the alloy which is used in gas turbine disc material has to be high melting point. Melting temperature of SS 301 is comparatively near and so called high then current scenarios but also cheaper in cost and availability is easier. SS301 contains up to 6-8 % Ni, and 16-18% Cr which makes Stainless steel good corrosion resistance .SS 301 is engineering material with good corrosion resistance, strength and fabrication characteristics. They can be meet a wide place of design limits, such as load, cycle life and maintenance cost. Austenitic stainless steels have a complicated mechanical property at room temperature, behavior differences are fluctuated to a higher or lower stability related to martensite transformation.

II. CURRENT SCENARIOS

The alloys require for gas turbine disc are generally high performance super alloys .These alloys can be strengthened by various hardening techniques. Super alloys contain good oxidation and creep resistance and are available in different shapes. These alloys can work under very high mechanical stress and high temperature and at places which require high surface stability.
List of turbine DISC materials:

A. Alloy 718 Nickel-Based Alloy

Inconel 718 is nickel chromium alloy used at -253 to 760˚C. This alloy contains basically Ni, Fe,Cr with an FCC structure. This super alloy widely used in aircraft engine is applied for super plastic forging and forming. An alloy 718 consist high quantity of alloying elements and is therefore difficult to manufacture large ingot size needed for the large frame size type turbine wheel and spacer Forging. Super alloys or high performance alloys have an ability to function at temperature range above 540ºC with resistive nature and high surface stability. As they have better creep resistance, super alloys can be easily forged, rolled to produced in various shapes. Iron-base, nickel-base alloy are the major part of super alloys.

Elements	Content (%)
Ni+Co	50-55%
Cr	17-21%
Fe	BAL
Nb+Ta	4.75-5.5%
Mo	2.8—3.3%
Ti	0.65-1.15%
Al	0.2-0.8%

Table 1: Chemical Composition of Inconel 718

B. Alloy 706 Nickel-Based Alloy

Inconel Alloy 706 (IN 706) is an important super alloy material for large, commercial forgings utilized in several critical applications including power generation. super alloy Inconel 706 extends at a temperature range of 925°C to 1150°C. The hot workability of IN 706 in relatively large ingot shapes makes this alloy easily fabric able. Super alloys are also called as super performance alloy. They have good creep and oxidation resistance, and are formed in various shapes.

Elements	Content (%)
Ni	39-44
Fe	38
Cr	14.5-17.5
Nb	2.50-3.30
Co	≤1
Ti	≤0.40
Cu	≤0.35
Mn	≤0.35
Si	≤0.35
C	≤0.30
Al	≤0.060
P	≤0.020
S	≤0.015
B	≤0.0060

Table 2: Chemical Composition of Inconel 706

C. A286 Alloy

Use of A 286 started, when technological advances made the production of large ingots sufficient in size to produce make it possible. These Super alloys contain good oxidation and creep resistance and are formed in varied shapes. These

alloys can work under higher mechanical stress and high temperature range where high surface stability needed.
The chemical composition of super alloy A-286 is listed in the following table-

Elements	Content (%)
Fe	54
Ni	25.5
Cr	14.8
Ti	2.13
Mo	1.30
Mn	1
Si	0.50
V	0.30
Al	0.18
C	0.040
P	0.020
S	0.015
B	0.0060

Table 3: Chemical Composition of A-286

III. Stainless steel grade 301

Stainless steel 301 is highly corrosion resistant due to higher amount of chromium (minimum of 16%) content in it which provides SS301 both oxidation and corrosion resistance. These steel also contains of other essential elements in it such as manganese, nickel and molybdenum in order to improve its corrosion resistance property. Stainless steel grade 301 is manufactured in the form of strips and wires, to produce tempers ranging from 1/16 Hard to Full Hard.

A. Types of SS 301

1) SS 301 L

Grade 301L, which contains less amount of carbon in it. This is the ideal choice for applications that requires good ductility. It is used in heavy gauge components for improved weld ability.

2) SS 301LN

Grade 301LN, which is another variant of SS 301 contains a higher amount of nitrogen and it shows higher hardening capability than the SS 301 grade.

%	301	301L	301LN
C	0-.15	0-.03	0-.03
Mn	0-2.0	0-2.0	0-2.0
Si	0-1	0-1	0-1
P	0-0.045	0-0.045	0-1
S	0-0.3	0-0.3	0-0.015
Cr	16-18	16-18	16.5-18.5
Ni	6-8	6-8	6-8
Fe	Balance	Balance	Balance

Table 4: Chemical composition of stainless steel 301

IV. Properties comparison of SS 301 with already used metals in gas turbine disc

SS301 have a excellent corrosion resistance. The resistance to corrosion offered by stainless steel grade 301 is similar to that offered by SS 304. SS301 grade exhibits good resistance to corrosion in mildly corrosive environments at ambient temperatures. This Grade of Stainless Steel have low carbon variants of this grade are predominantly used as high strength stainless steel.

There are various application of SS301 for Domestic and Industrial field but here we analysis about the application in Gas turbine industry.

Here we comparative Analysis the SS301 and other material, which are also used in Gas turbine Disc.
The comparative chart is given below:-

PROPERTIES	Stainless Steel			IN 706	IN 718	A 286
	301 (1/4)	301 (1/16)	301 (FULL)			
Density (g/cm3)	7.88	7.88	7.88	8.05	8.19	7.92
Melting Point (°C)	1421	1421	-	1360	1336	1399
Tensile strength (MPa)	862	620	1276	757	1035 (PLATE)	1035
Yield strength (MPa)	517	310	965	383	725 (PLATE)	759
Elongation	25 %	40%	9%	47 %	31%	25 %
Thermal conductivity (W/m.K)	-	16.2	-	12.5	11.1	-

Table 5: Comparison table of SS 301 with already used metals in gas turbine disc

V. Criteria for selection

Once the design parameter have been establish, the engineer may then evaluate the materials that appears to be capable of meetings the design strength requirements for service at elevated temperature the first factor is to be considered is hot strength, thermal Stability is second physical properties may also be significant in certain cases[24].

VI. Short time tensile properties

upto a temperature of about 482°c, the short time tensile properties are most important .these are property value that can be used where parts are not exposed to high service temperature for extended periods of time. The standard test for these properties are conducted after the test specimen have been held at a temperature to insure constant temperature throughout normally about 30 min. the data do not reflect any effect of long time exposure to high temperature[24].

VII. Conclusion

Stainless steel 301 has multiple applications in various fields. By comparative analysis of SS 301 with various alloy already used in gas turbine disc found that the properties of SS 301 is quite similar to the current scenarios but cost much more cheaper than others. In the short to medium term continued development of new existing materials will be needed however in the long term as new materials are introduced for possible uses in Gas turbine Disc and their associated technologies will have to be developed as an integral part of delivering of the overall materials system solution. Finally we conclude the analysis of Mechanical Property of SS301 improve the Property and efficiency and

comparing Gas turbine disc used Material are higher in cost as compare to SS301 and SS301 is can be possibility to use in Gas turbine Disc for various heat treatment process increases the property.

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