

# Tribological and Fatigue Behaviour of Liquid Nitriding SS304

H.Kishore<sup>-1</sup>, T.Vivekkumar<sup>-2</sup>, M.Vignesh<sup>-3</sup>

Assistant Professor, Department of Mechanical Engineering, Professional Group of Institutions (Tirupur Dist),  
Tamilnadu, India <sup>1</sup>

UG Student, Department of Mechanical Engineering, Professional Group of Institutions (Tirupur Dist),  
Tamilnadu, India <sup>2,3</sup>

**ABSTRACT:** Stainless steel 304 exhibit excellent mechanical properties, which have made them the material of choice in various applications, defence and corrosion resistant applications. The present work focuses on the processing of stainless steel 304 through of liquid nitriding process. Then liquid nitriding process of stainless steel 304 will be tested for its wear resistance on sliding condition using pin on disk apparatus, and test for the tensile test, fatigue test and hardness test for given parameters then Compared with stainless steel 304 which exhibits comparatively better mechanical properties.

**KEYWORDS:** nitriding, fatigue, wear, tensile, hardness

## I.INTRODUCTION

### STAINLESS STEEL

The material we know as stainless steel (also commonly referred to as "Inox" or "Rostfrei") is such a common feature of 21st century living that there can be few of us who have not seen or handled articles made from it. Like all types of steel, stainless steel is not a single metal but an alloy that is a material made from two or more separate elements alloyed or "melted" together. What all steels have in common is that their major "ingredient" (alloying element) is the metal iron, to which a small amount of carbon has been added. Stainless steel is a generic term for a family of corrosion resistant alloy steels containing 10.5% or more chromium.

All stainless steels have a high resistance to corrosion. This resistance to attack is due to the naturally occurring chromium-rich oxide film formed on the surface of the steel. Although extremely thin, this invisible, inert film is tightly adherent to the metal and extremely protective in a wide range of corrosive media. The film is rapidly self-repairing in the presence of oxygen, and damage by abrasion, cutting or machining is quickly repaired.

### NITRIDING

THE NITRIDING PROCESS, first developed in the early 1900s, continues to play an important role in many industrial applications. Along with the derivative nitro carburizing process, nitriding often is used in the manufacture of aircraft, bearings, automotive components, textile machinery, and turbine generation systems. Though wrapped in a bit of "alchemical mystery," it remains the simplest of the case hardening techniques.

The secret of the nitriding process is that it does not require a phase change from ferrite to austenite, nor does it require a further change from austenite to martensite. In other words, the steel remains in the ferrite phase (or cementite, depending on alloy composition) during the complete procedure. This means that the molecular

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structure of the ferrite (body-centered cubic, or bcc, lattice) does not change Its configuration or grow into the face-centered cubic (fcc) lattice characteristic of austenite, as occurs in more conventional methods such as carburizing. Furthermore, because only free cooling takes place, rather than rapid cooling or quenching, no subsequent transformation from austenite to martensite occurs. Again, there is no molecular size change and, more importantly, no dimensional change, only slight growth due to the volumetric change of the steel surface caused by the nitrogen diffusion. What can (and does) produce distortion are the induced surface stresses being released by the heat of the process, causing movement in the form of twisting and bending.

## II. METHODOLOGY

### MATERIAL SELECTION

- Easily available in the market.
- Cost is very low compared to the other grads.
- Liquid nitriding process for available in the market.

### STAINLESS STEEL 304

The background of stainless steel 304 types 1.4301 and 1.4307 are also known as grades 304 and 304L respectively. Type 304 is the most versatile and widely used stainless steel. It is still sometimes referred to by its old name

18/8 which is derived from the nominal composition of type

304 being 18% chromium and 8% nickel.The chemical composition SS304 as shown in table 2.

Stainless steel 304 is an austenitic grade that can be

severely deep drawn. This property has resulted in 304 being the dominant grade used in applications like sinks and saucepans. The mechanical properties of SS304 as show in table

### MECHANICAL PROPERTIES OF SS304

S.NO	SS 304	VALUES
1	TENSILE STRENGTH (min)	500-700Mpa
2	YIELD STRENGTH (min)	190Mpa(0.2% offset)
3	ELONGATION (min)	45%(A50 mm)
4	HARDNESS(Rockwell B)(max)	95 HR B
5	HARDNESS(Brinell)(max)	215HB

Table No 1 Mechanical Properties Of SS304

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## CHEMICAL COMPOSITION OF SS304

S.NO	MATERIAL	%
1	Columbium	0.0-0.07
2	Manganese	0.0-2.0
3	Silicon	0.0-1.00
4	Phosphorous	0.0-0.05
5	Sulfur	0.0-0.03
6	Chromium	17.50-19.50
7	Nickel	8.00-10.50
8	Fe	Balance
9	Nitrogen	0.0-0.11

Table 2 chemical composition of SS304

## LIQUID NITRIDING OF STAINLESS STEEL 304

Liquid nitriding is a common term for a diffusion process that is actually liquid nitrocarburizing. A thermo – chemical reaction whereby nitrogen, primarily, and some carbon are diffused into the surface of iron – based materials. The nitrogen combines with the iron to form an iron – nitride compound layer that provides improved surface properties. e.g resistance to wear, friction, corrosion, and Fatigue. Liquid nitriding is not a coating or plating. It is a diffusion process that modifies/transform the surface layer is well integrated with the bulk material – hence it is not susceptible to flaking or peeling.

Stainless steels are preferred in industrial applications for their corrosion resistance but their poor tribological behaviour has been a barrier for their wider usage. Corrosion environments are frequently found in food processing and marine equipments as well as chemical and nuclear components. The poor corrosion wear resistance of the stainless steels was investigated by Jean-Paul lebrun during 1971(Bell 2002). Despite the wide significance of corrosion wear comparatively lesser research has been undertaken in this area as compared with the widespread studies on pure forms of mechanical wear and corrosion. Hence it has been identified that there is a dearth of research on which corrosion wear conditions can be mitigated through appropriate surface engineering. Thus it has become necessary to develop new technologies that can effectively improve the corrosion wear resistance of stainless steel. In this chapter, the claddings produced at different heat inputs and at optimum heat input conditions are liquid nitrided (LN) with optimum LN process parameters. The direct and interaction effects of the LN process parameters on the compound layer are discussed.

## SUMMARY

The liquid nitriding process parameters were found to have a significant influence on deciding the nitrided layer thickness of the stainless steel cladding. Liquid nitriding of stainless steels produced a compound or epsilon layer and a diffusion layer which has resulted in hardness improvement on the surface of stainless steels. This has ultimately created new avenues in liquid nitriding of stainless steel with lower temperatures and processing duration.

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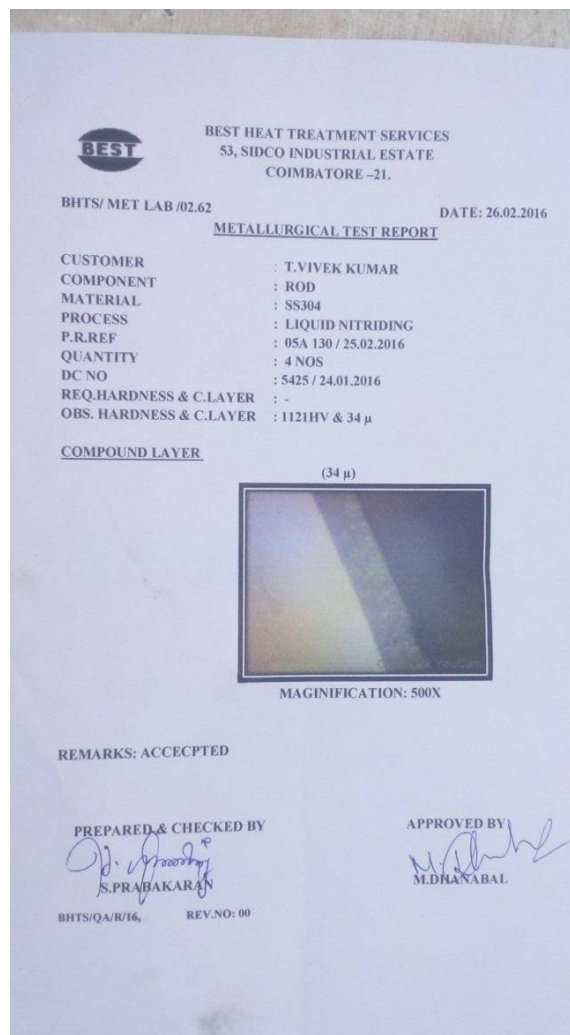
## III. TESTING AND RESULT ANALYSIS

### METALLURGICAL TEST REPORT

In this test the component steel rod it having a length 250 mm and diameter is 10 mm.the material is stainless steel grade 304.it involve to the liquid nitriding process. The quantity of the material four numbers.

RESULT;

OBS. Hardness and C. layer : 1121 HV & 34  $\mu$




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BHTS/MET LAB /02.62 DATE: 26.02.2016

METALLURGICAL TEST REPORT

CUSTOMER : T.VIVEK KUMAR  
COMPONENT : ROD  
MATERIAL : SS304  
PROCESS : LIQUID NITRIDING  
P.R.REF : 05A 130 / 25.02.2016  
QUANTITY : 4 NOS  
DC NO : 5425 / 24.01.2016  
REQ.HARDNESS & C.LAYER : -  
OBS. HARDNESS & C.LAYER : 1121HV & 34  $\mu$

COMPOUND LAYER  
(34  $\mu$ )



MAGNIFICATION: 500X

REMARKS: ACCEPCTED

PREPARED & CHECKED BY: S.PRABAKARAN  
APPROVED BY: M.DHANABAL

BHTS/QA/R/16, REV.NO: 00

Figure 2 Metallurgical Test Repor

### HARDNESS TESTING

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.

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### VICKERS HARDNESS TEST

The Vickers hardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a square base and an angle of 136 degrees between opposite faces subjected to a load of 1 to 100 kgf. The full load is normally applied for 10 to 15 seconds. The two diagonals of the indentation left in the surface of the material after removal of the load are measured using a microscope and their average calculated. The area of the sloping surface of the indentation is calculated. The Vickers hardness is the quotient obtained by dividing the kgf load by the square mm area of indentation. When the mean diagonal of the indentation has been determined the Vickers hardness may be calculated from the formula, but is more convenient to use conversion tables.

To convert HV to MPa multiply by 9.807

To convert HV to GPa multiply by 0.009807

### TENSILE TESTING

TENSILE TESTS are performed for several reasons.

The results of tensile tests are used in selecting materials for engineering applications. Tensile properties frequently are

included in material specifications to ensure quality. Tensile properties often are measured during development of new materials and processes, so that different materials and processes can be compared. Finally, tensile properties often are used to predict the behavior of a material under forms

of loading other than uniaxial tension. The strength of a material often is the primary concern. The strength of interest may be measured in terms of either the stress necessary to cause appreciable plastic deformation or the maximum stress that the material can withstand. Tensile testing machine as shown in figure 1. Test carried out the universal testing machine under the normal load 177KN. The parameters are given by 250 mm length and 10mm diameter rod. The material is liquid nitrated stainless steel 304. The testing values are the given below



Figure 1 Tensile Testing Machine

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### RESULTS :

Stress = load / Area unit is (N/mm<sup>2</sup>)

Area =  $(3.14 * 10^2) / 4$   
= 78.5 mm<sup>2</sup>

Load = 177.5 KN

Ultimate stress =  $177.5 / 78.5 = 2.26 * 1000$   
= 2260 N/mm<sup>2</sup>

Yield stress =  $172.5 / 78.5 = 2.19 * 1000$   
= 2190 N/mm<sup>2</sup>

Breaking point (stress) =  $85.2 / 78.5 = 1.09 * 1000$   
= 1090 N/mm<sup>2</sup>

So the improve the tensile strength in after liquid nitrated stainless steel SS304.

### FATIGUE TESTING

A perusal of the broken parts in almost any scrap will show that a high number of fail-ures occur at stresses below the yield strength of the part's materials. This complex phenomenon is known as "Fatigue". Fatigue is responsible for

up to 90% of the in-service part failure which occur in industry. Fatigue test machine as show in figure 3. A fatigue testing machine may be classified from different viewpoints such as purpose of the test, type of stressing, means of producing the load, operation characteristics, type of load etc.



Figure 3 Fatigue Testing Mechine

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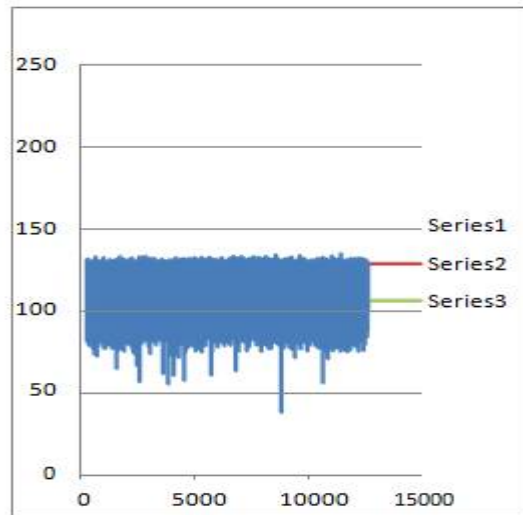
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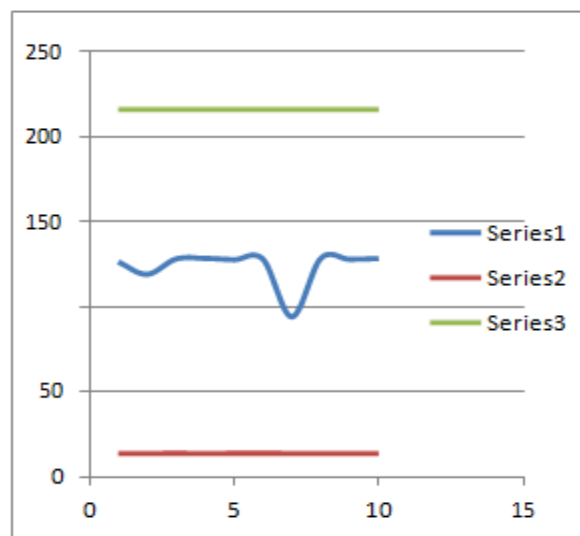
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## RESULT:

Fatigue testing carried out the multi axial fatigue testing machine. Normal stress 142 mpa.the 120 mm length and 6 mm diameter rod. The material is liquid nitrated stainless steel 304.



(A)



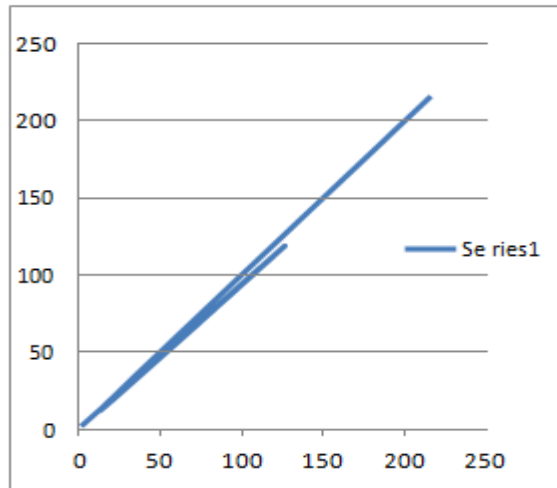
(B)

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(C)

Figure (A),(B) And (C) is Graph Between Stress Vs Number Of Cycles

### WEAR TESTING (pin on disk)

This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus. Materials are tested in pairs under nominally non-abrasive conditions. The principal areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction may also be determined. Wear testing machine as show in figure 4.



Figure 5 Wear Testing Machine



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## RESULT:

wear testing carried out the pin-disc apparatus. The parameters are given by 30 mm length, 10mm diameter rod. The normal load is 5kg and wear track diameter is 80 mm.sliding velocity is 0.5 m/s and then sliding distances is 500m.the material is liquid nitrated stainless steel 304,timing 12.23 sec and then rpm is 250.same parameters are followed to the two materials. The testing reports are given below

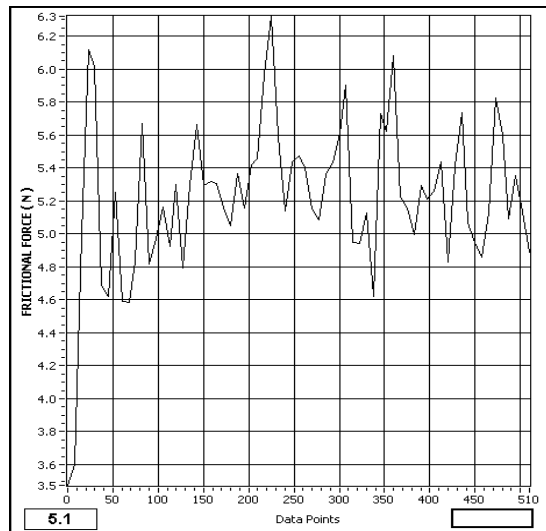
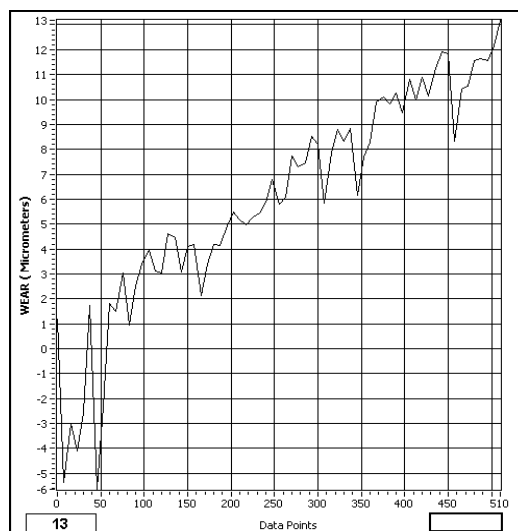


Figure (c) graph is friction vs timing



(E)

Figure (d) graph is wear rate vs timing

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## IV. ADVANTAGES

- Diverse Application – can be used for all types of medical devices – economies of scale – reducing raw material costs.
- Rust Proof – reduces the risk of infection from rust and other surface imperfections caused by oxidation.
- High Corrosion Resistance
- Recyclable
- Antibacterial properties
- It does not stain – so it can be cleaned and re-used many times in the medical field.

## V. APPLICATION

- Aircraft Landing Gear Components
- Intake and Exhaust Valves
- Stainless Steel Wool
- Magnetic Resonance Imaging
- Surgical Implants
- Generator                      End                      Ring Steam Turbine Blades

## VI. CONCLUSION AND FUTURE WORK

### CONCLUSION

Wear resistance of liquid nitrated stainless steel 304 was analyzed on a unidirectional mode. Unidirectional wear test was carried out in Pin on Disc apparatus. Wear rates were found to be increased with the corresponding increase in load and sliding distance.

liquid nitrated stainless steel 304 has better tensile strength compared to the normal stainless steel 304. it is still a ductile material and has good machinability properties. Fatigue testing values are within the endurance limit after 12601 cycles (tensile - compression) for the liquid nitrated stainless steel 304 even after increase in hardness values when compare to the normal stainless steel 304.

### FUTURE WORK

To determine the wear rate of carbursing process of stainless steel 304 in wet wear test has to be done, in ringer solution presents.

Simulation of dry wear test in ANSYS workbench using contact analysis.

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