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Experimental Investigation Of Adding TICN And ALCRN PVD Coating On D3 Tool Steel With Pre Treatments (Nitriding And Micro blasting)

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Abstract:

In this research, the focus is on the application of forming tools and the selection of D3 tool steel, a commonly used material for manufacturing forming dies. The aim is to investigate the impact of two processes, namely micro-blasting with TiCN coating and plasma nitriding with TiCN coating, on the mechanical and tribological properties of D3 tool steel. The wear resistance and effectiveness of forming tools are often limited due to various factors such as thermal and mechanical fatigue, cracking, erosion, corrosion, abrasive and adhesive wear, and galling. Moreover, the quality of the formed parts' surface influences the replacement and reconditioning of tools. One of the challenges in achieving smooth surfaces is the increased surface roughness and tool wear, particularly adhesive wear and galling. Furthermore, tool wear and galling contribute to elevated contact pressures and unstable friction during the forming process. The wear experienced by a tribological pair can vary depending on factors such as the materials in contact, speed, temperature, applied loads, and surface conditions (e.g., roughness, contact area).

1. INTRODUCTION

Forming industry is very important part of mechanical industries where surface treated forming tools is not developed yet. The aim of this dissertation is to investigate the performance of forming tool by using micro-blasting with TiCN coating and to investigate the influence of plasma nitriding with TiCN coatings on D3 Tool steel.

The D3 tool is an air hardening, high carbon , high chromium tool steel. It displays excellent wear resistance and has good dimensional stability and high compressive strength. The D3 Steel has various applications as follows

- Blanking, stamping, and cold forming dies and punches for long runs; lamination dies.
- Bending, forming, and seaming rolls
- Cold trimmer dies or rolls
- Burnishing dies or rolls
- Drawing dies for bars or wire
- Lathe centers subject to severe wear

2. PROBLEM STATEMENT

To investigate the effect of micro-blasting process and plasma nitriding process on TiCN coated D3 cold work tool steel and study the effect on Mechanical properties of D3 tool steel using Tension, Compression Test and tribological properties using Pin-on disc friction and wear monitor and analyze the results.

2.1 OBJECTIVES

1) To conduct Tension test on treated D3 tool steel specimens. And find out the effect of surface treatments on Yield strength and Tensile strength of D3 steel

2) To conduct Compression test on treated D3 tool steel specimens. And find out the effect of surface treatments on Compressive strength of D3 steel.

3) To conduct wear test on friction and monitor and study the wear behavior of D3 steel and the effect of Load and sliding distance on wear

3. SURFACE TREATMENTS AND COATING

3.1 Plasma Nitriding

Plasma nitriding is a case hardening thermo-chemical surface heat treatment of steel components to produce nitride layers by diffusing nitrogen to substrate surface, which increase wear, corrosion and fatigue resistance

Nitriding imparts the following properties to steel:

Increased surface hardness: Nitriding significantly increases the surface hardness of steel. It forms a hard layer of nitrides, typically iron nitrides, which can significantly enhance the wear resistance of the material.

Improved wear resistance: The nitride layer formed during nitriding offers excellent resistance against abrasion, erosion, and fretting wear. This makes nitrided steel suitable for applications involving sliding or rubbing contact with other surfaces.

Enhanced fatigue strength: Nitriding can improve the fatigue strength of steel, which is its ability to resist repeated cyclic loading without failure. The formation of a hard surface layer helps to distribute stresses and prevent crack initiation, thereby enhancing the material's fatigue life.

Increased corrosion resistance: Nitriding can provide a certain level of corrosion resistance to steel. The nitride layer acts as a barrier against corrosive agents, protecting the underlying material from chemical attack.

Retained core toughness: One advantage of nitriding compared to other surface hardening techniques is that it primarily affects the surface layer, leaving the core of the steel relatively unaffected. This allows the material to retain its toughness and ductility while benefiting from the improved surface properties.

Dimensional stability: Nitriding typically involves a low-temperature process, which minimizes distortion or changes in the dimensions of the treated steel. This is particularly advantageous for components with strict dimensional requirements.

3.2 Micro Blasting

Mechanical surface pre-treatment like micro-blasting, along with plasma nitriding can improve the tribological properties and adhesion of coating systems.

- The improved wear resistance of coated metal cutting tools is usually utilized to increase tool life.
- Reduced friction often means reduced energy consumption. In some cases, a lowered friction may permit the exclusion of lubrication or of cooling stages.
- Increased or controlled friction may be a beneficial effect in other applications such as brakes, bolted joints and safety connectors.
- Reduced tendency to sticking and cloth pick out up from the counter floor is imperative to the overall performance of forming equipment and many sliding applications. Anti sticking dealers may also be neglected in forming device applications.
- Components of decreased weight can be designed through software of coatings. Reduced weight potential e.g. an elevated ratio of strength to weight of automobile engines, which in flip may also provide decrease gas consumption.

4. MATERIAL SELECTION

The AISI D3 tool steel is an air hardening, high carbon; high chromium tool steel which is mostly used in dies and punches of compression molding operations of forming Sheet Molding Component (SMC) and Dough Molding Component (DMC). Various surface treatments and coatings are applied as shown in Table I. Various treatments and coatings were done as per the Table II

Table 1 Chemical composition of AISI D3 steel

Element	C	Mn	Si	Cr	Ni	W	V	P	S
Weight %	2.00-2.35	0.60	0.60	11.00-13.50	0.30	1.00	1.00	0.03	0.03

Table 2 Various surface treatments and coating

Treatments	Notations
Untreated D3 substrate	D3
Nitriding + AlCrN coating	N+ AlCrN
Micro Blasting + AlCrN coating	B+ AlCrN
Nitriding +Micro Blasting + AlCrN coating	N+ B+AlCrN
Nitriding +Micro Blasting + Multilayer AlCrN coating	N+ B+m(AlCrN)
Nitriding + TiCN coating	N+ TiCN
Micro Blasting + TiCN coating	B+ TiCN
Nitriding +Micro Blasting + TICN coating	N+ B+ TiCN
Nitriding +Micro Blasting + Multilayer TiCN coating	N+ B+ m(TiCN)

Table 4.1 Chemical composition of AISI D3 steel

5. MATERIALS AND METHODOLOGY

5.1 MATERIAL

The various researches have been developed for tool steel properties enhancement by coating and nitriding. In this dissertation forming tool application has been considered and D3 tool steel is selected which is widely used for making forming dies. The D3 tool is an air hardening, high carbon; high chromium tool steel.it displays excellent wear resistance and has good dimensional stability and high compressive strength. The chemical composition of D3 steel is presented in table below

The following desk indicates the chemical composition of D3 device steels.

Table 5. 1 Chemical composition of D3 steel

Element	C	Mn	Si	Cr	Ni	W	V	P	S
Specification (%)	2.00-2.35	0.60	0.60	11.00-13.50	0.30	1.00	1.00	0.03	0.03
Actual Values	2.09	0.39	0.35	11.22	0.018	0.49	0.60	0.019	0.016

Following surface treatments and materials are used in investigation

Table 5. 2 Surface treatments of D3 steel

Sr No	Material	Notation
1	Untreated D3 tool steel	D3
2	Blasting +TiCN coating D3 tool steel	B-TiCN
3	Nitriding +TiCN coating D3 tool steel	N-TiCN
4	Blasting +Nitriding +TiCN coating D3 tool steel	B-N-TiCN
5	Blasting +Nitriding +TiCN (multilayer) coating D3 tool steel	B-N-m TiCN

6. RESULTS AND DISCUSSIONS: EXPERIMENTAL

Results will comprise of the results obtained from the separate test carried out on prepared samples:

6.1COMPRESSIVE STRENGTH

Results obtained from compression test are as shown below:

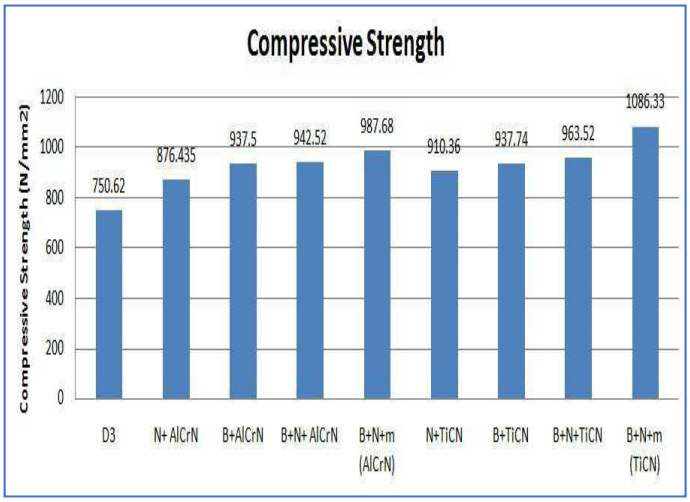


Fig.6.1: Results of compression test

The compressive strength of untreated D3 tool steel is low as compared to treated D3 Steel specimens Maximum compressive strength is observed with AlCrN multilayer coating. AlCrN gives good results in comparison with TiCN coating.

6.2 IMPACT STRENGTH

AlCrN coating has a more impact resistance than that of TiCN coating. Combination of nitriding and blasting plays the intermediate role.

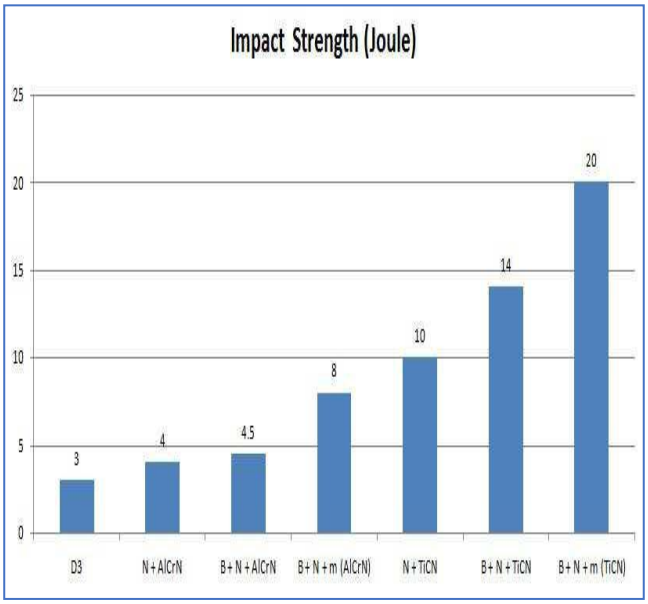
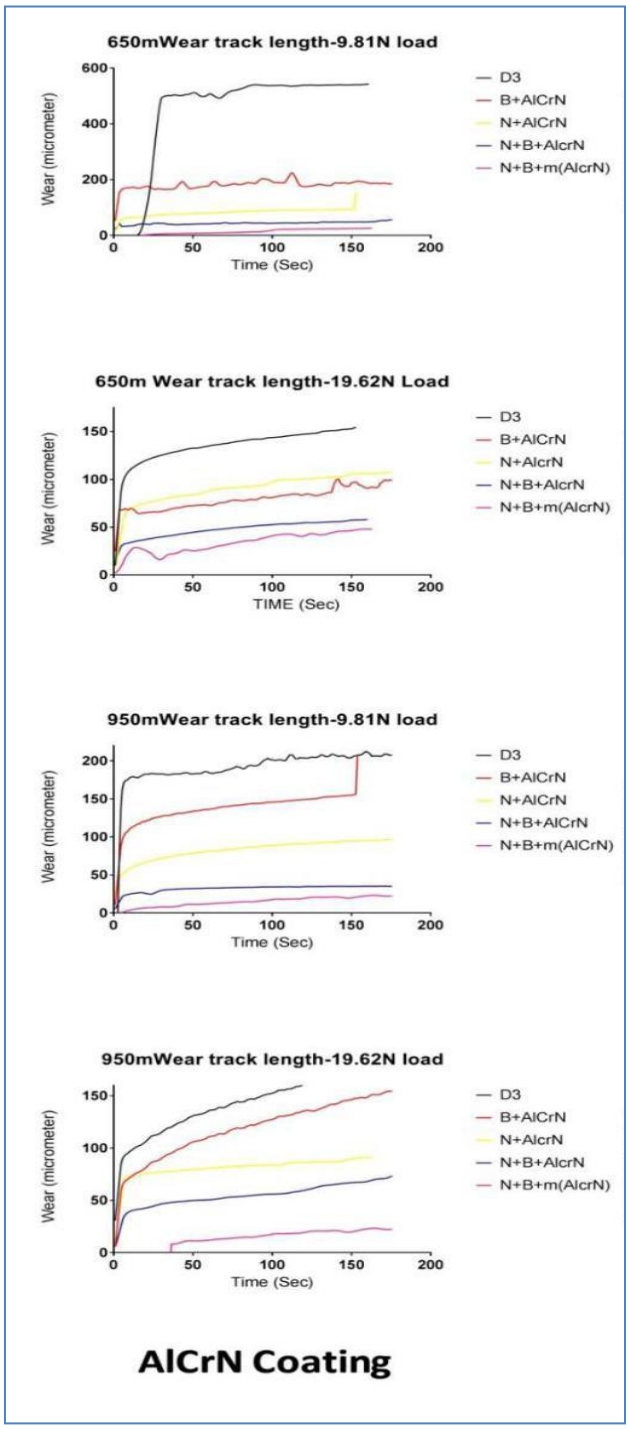


Fig.6.2: Result of Impact Strength

6.3 WEAR RESISTANCE



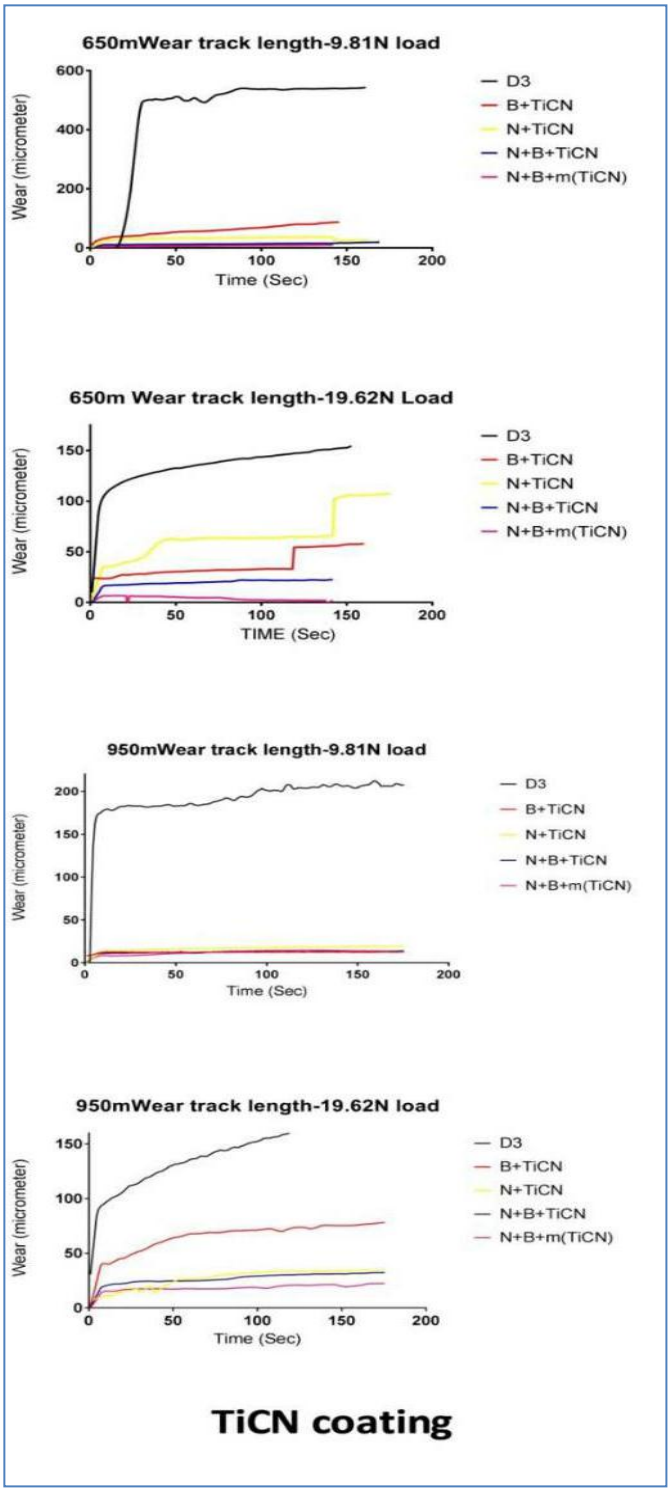


Fig.6.3: Wear volume of TiCN and AlCrN coating

It can be seen that untreated D3 tool steel wears fasters than that of the treated specimens. Fig. shows the wear behaviour of TiCN and AlCrN coated samples. Only blasting shows more wear than that of nitriding. Results obtained from impact and compression tests found to be supporting that TiCN as multilayer coating has shown reduced wear than that of other conditions.

7. CONCLUSION

The aim of this work was to study different surface treatments and coatings for enhancement of tool life.

Following conclusions can be drawn:

1. TiCN coating gives superior performance in impact strength, compression strength and wear behaviour than AlCrN.
2. Basically nitriding of tool steels prior to PVD coatings improves the impact and compressive strength of the tool steels but other factors such as surface roughness, type of coatings and type of treatment should be considered.
3. Multilayer coating always gives better performance in impact strength and compressive strength.
4. Compressive strengths of coated samples gives almost double increase in strength than that of Uncoated.
5. Impact strength of multilayer samples gives six times strength than that of untreated samples.
6. Impact Strength of multilayer samples gives six times strength than that of untreated samples

Carbide content increases for duplex treatment than single treatment. Increase in carbide content is found in increased mechanical properties.

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