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Research Paper

FRICTION BEHAVIOUR OF TiN, CrN COATING ON AISI 4320 STEEL SUBSTRATE

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Wear behaviour of materials depends upon chemical, physical and mechanical properties. Understanding of these properties is very useful in selection of materials for tribological application to reduce friction and wear. Thickness of coating plays an important parameter, if coating thickness is in stipulated limit less wear and friction occurs. Beyond the limits more wear, hence material life reduces. Friction behaviour of CrN, and TiN nanomaterials coated on steel substrate studied in this article.

Keywords: Friction, Coating, Nanomaterials, Tribology

INTRODUCTION

Surface engineering can involve a surface modification process. Material sizes in the order of 1 nm-100 nm or less generally known as Nanomaterials. Material dimensions between 1-100 nm are known as the nanoscale zone of materials, where physical, chemical and mechanical properties emerge at nano scale. Coating is a protective layer on material either applied by Physical Vapour Deposition (PVD) or Chemical Vapour Deposition (CVD). A surface modification process changes the properties of the materials surface. Numerous researchers have been investigated coated steel substrate. Grzesik *et al.* (2006) investigated TiAlN coating on AISI 316 stainless steel, and found that higher values of the co-efficient of friction at the lower loads and sliding speeds applied (Grzesik *et al.*, 2006). Lubricated CrAlN and WC/Ccoatings provided to steel surfaces, it gives low friction losses and highly wear resistance for automobile application (Bobzin *et al.*, 2009). C/CrN Coating wear deposited on M2 steel substrate by unbalanced Magnetron sputtering and found that coatings thickness of 4nm provides highest hardness and better wear resistance (Zhang *et al.*, 2007).

The aim of the present work is to study friction, and wear mechanism of TiN, CrN coatings, when steel substrate exposed to dry sliding contact. The test carried by Pin on Disk

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Tester with a sliding velocity of 0.3 m/s. Steel substrate material 4320 were used to study the friction properties.

MATERIALS

Steel substrate 4320 used for study, Properties of specimen presented in Table 1. Steel 4320 is a alloy steel that has capable of welding, machining, and casting. It contains low carbon content, due to this it allows to be weld, forged and machined.

Table 1: Properties of Substrate Material

Substrate Material	Chemical Composition	
Disk (Steel 4320)	C 0.17-0.22%, Mn 0.45-0.65%, K 0.035%, S 0.04%, SI 0.15-0.30%, Cr 0.40-0.60%, Ni 1.65-2%	
Pin (EN 8)	0.40% C, 0.25% Si, 0.80% Mn, 0.015% S, 0.015% P	
Substrate Material	**Coating**	**Hardness**
4320 Steel	TiN	1750
	CrN	900

EXPERIMENTAL PROCEDURE

Tribological tests were carried out using a pin-on disc machine, Figure 1 (DUCOM Bangalore). The equipment is designed to apply loads up to 100 N and speeds starting from 100 to 1000 RPM, provision is made to conduct tests under dry and lubricated conditions. This apparatus facilitates study of friction and wear characteristics in sliding contact under different test conditions, i.e., sliding occurs between the stationary pin and a rotating disc. The normal load, rotational speed and wear track diameter can be varied to suit test conditions. The flat face of a high-speed steel pin (diameter 4 mm) was loaded normally and pressed against the flat surface of a rotating Stainless Steel disc. The disc was sliding against the pin at 0.3 m/s surface speed. The friction force was measured by a load cell attached to the pin holder (resolution 0.1 N) and the displacement of the pin was measured using displacement sensor (LVDT, resolution 1 μm, range = ± 500 μm). The specification of the POD tribometer is listed in Table 2 (Pin on Disk Tribometer).

Figure 1: Schematic Diagram of Pin on Disk Tester

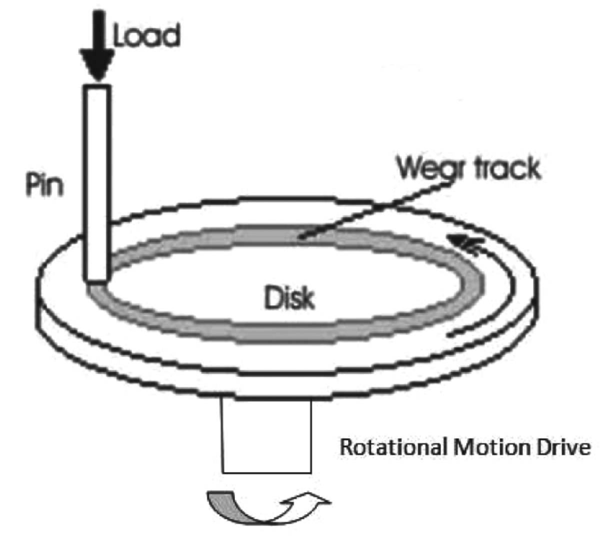

Table 2: Specification for Pin on Disk Tester

	Parameter	Specification
Pin on Disk Tester	Wear Disc Diameter	Dia 100 mm, 8 mm thick
	Pin Diameter, Length	4 mm, 30 mm long
	Wear Track Dia	80 mm
	Disc Speed	100 rpm
	Normal Load	29.43 N
	Frictional Force	Max 100 N

RESULTS AND DISCUSSION

The steel substrate had a young modulus of 200 GPa and Poisson ratio 0.3. Nanomaterials, i.e., CrN, and TiN coating of thickness 3 μm and 4 μm were provided by

Physical Vapour Deposition Technique (PVD). Tests were performing at 20-25 °C, and 50% relative humidity. Steel substrate under test condition having hertzian pressure of 1.60 GPa at 3 N load. Co-efficient of friction of coated nanomaterials reported in Table 3. Test were perform at different load condition and several time for repeated results. Average friction coefficient values illustrated in Table 3.

Table 3: Coated Nanometerials Co-Efficiant Friction

Substrate Material	Coating	Load (N)	Friction Coefficient
AISI 4320 (3 μm)	TiN	3	0.22
		2	0.18
	CrN	3	0.20
		2	0.24
AISI 4320 (4 μm)	TiN	3	0.35
		2	0.32
	CrN	3	0.30
			0.39

It is clear from test that TiN provides better results than CrN coating. Friction values at 3 N load is higher than 2 N. As the load increases due to contact pressure surface asperities rub against each other with higher friction values. Coating with CrN particles gives higher values when load is decreased may be due to removal of particles from coating. When coating thickness increased from 3 μm to 4 μm its friction values increased rapidly from 0.22 to 0.35, and 0.18 to 0.32 in the case of TiN coating at 3 N. At 2 N friction values increased from 0.20 to 0.30 and 0.24 to 0.39 in the case of CrN coatings.

CONCLUSION

Due to enhancement in materials properties it is necessary to use more noble particles for surface modification. These nanomaterials can possess good interfacial characteristics, they penetrate deeper inside the material gap and make it smooth. Coating of 3 μm thickness provides better friction values than thickness of 4 μm. As the reduction in friction values substantial, loss of material reduces and it protects metal from direct contact.

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