New Solutions to New Problems-Tribology in Natual Sand Dust Environment

Dongfeng Diao
Key Laboratory of Education Ministry for Modern Design and
Rotor-Bearing System, School of Mechanical Engineering,
Xi'an Jiaotong University, Xi'an 710049, China
Corresponding Author:dfdiao@mail.xjtu.edu.cn

The natural sand dust environment due to the sand storm has attracted worldwide concern in recent years. Taklamakan desert has been clarified as the main source of Asia sand storm. Large amount of sand dust including multi-scale particles transport from Taklamakan desert in Northwest China to Korea and Japan by the sand storm. The dust environment with high falling dust deposition flux has been found as a big tribo-harm to various machines. Therefore, it would be necessary to consider the natural sand dust environment in the tribo-design criterion in industrial tribology.

In this paper, the industrial tribology problems in natural sand dust environment were proposed at first. In order to study the problem, an equipment for simulating the natural sand dust environment based on Multi-Venturi structure was developed using the gas-solid two-phase flow analysis with Navier-Stokes equation of the mixture. The density distribution of the dust particles in the equipment chamber were calculated using FLUENT software. The equipment showed the possibility of studying the industrial tribology problems in natural sand dust environment.

In the second part, we introduced the tribilogical performances of three types of tribosystems(roller-scraper system, head-card system, rotor-bearing system) in the natural sand dust environment formed by the equipment with Multi-Venturi structure. In roller-scraper tribosystem, the wear mechanisms of polymer tapes in sand dust environment were examined and it was clarified that the mean wear rate of polymer materials in the sand dust environment was above 500 times of that in the clean air environment. In magnetic head-card tribosystem study, the concept of blowing sand into the contact interfaces was proposed. The influence of blowing sand velocity, sand density as well as sand particle size and shape on the friction and wear mechanisms was discussed with micro-structural analysis. By using the rotor-bearing system, we studied the searing characters of bearings in the sand dust environment. The effect of searing structure on the intrusion of sand particles and the damage caused the sand dust at the surfaces of bearing were analyzed firstly.

Finally, in order to get better understand of the wear mechanism of tribosystems in natural sand dust environment, we studied the mechanism of a particle into the contact interface and discussed the abrasive wear mechanisms with particle intrusion mechanism. In the last, the wear mechanisms in natural sand dust environment were mapped corresponding with the critical intrusion condition of the particle.

TRIBOLOGY IN NATURAL SAND DUST ENVIRONMENT

D.F. Diao

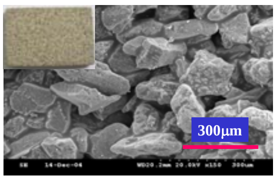
Key Laboratory of Education Ministry for Modern Design and Rotor-Bearing System, School of Mechanical Engineering,
Xi'an Jiaotong University, Xi'an 710049, China
E-mail:dfdiao@mail.xjtu.edu.cn

Contents

Problems and Challenges

Images are from NASA, http://www.nasaimages.org

Laboratory-Sand Dust Environment

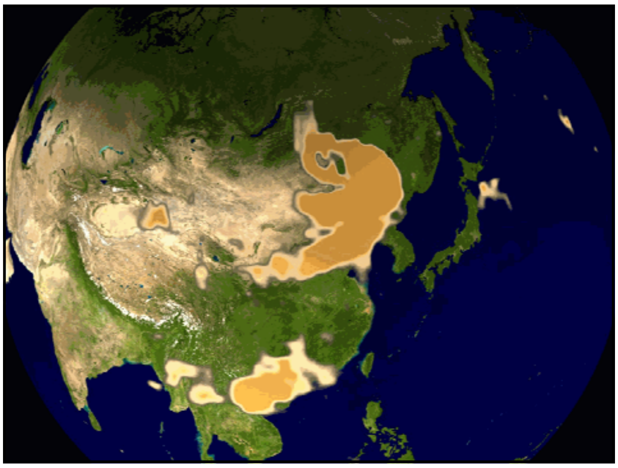


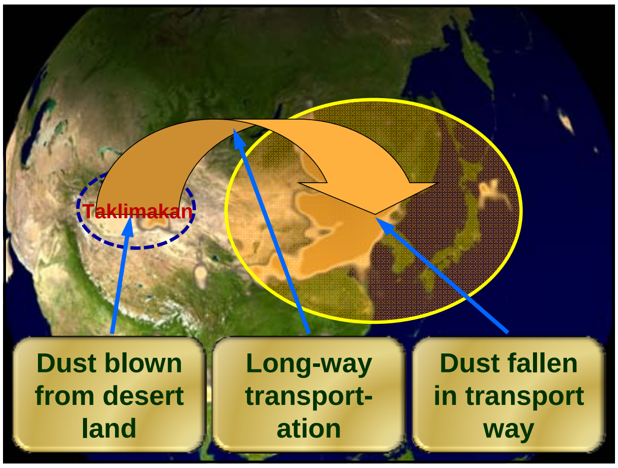
Chemical component of sand

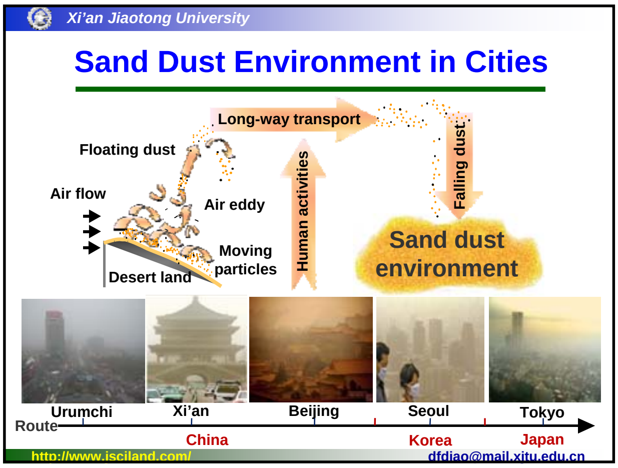
Main oxide	SiO_2	Al_2O_3	CaO	Fe_2O_3	MgO	others
Composition (%)	65.32	9.6	8.75	3.05	1.93	11.35

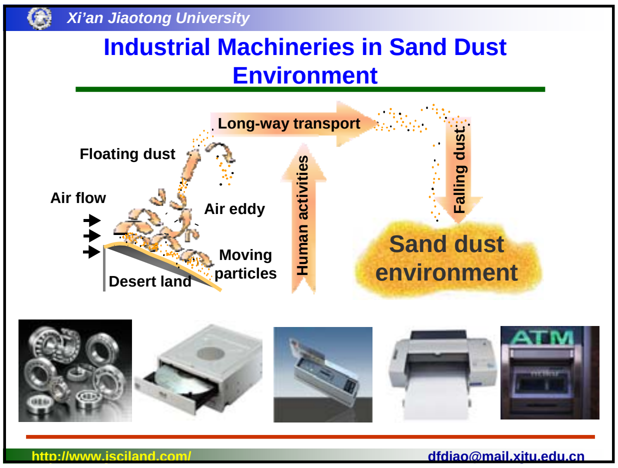
Size distribution of sand

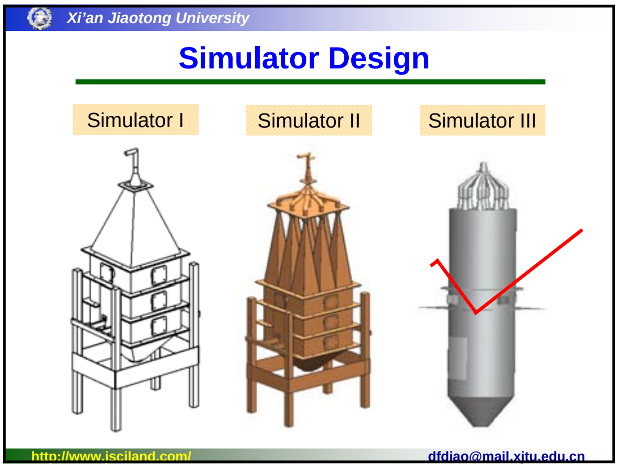
Grade interval (μm)	<54	54~61	61~77	77~97	97~130	130~172	172~216	>216
Percentage (%)	0.353	6.773	22.556	16.616	26.986	20.996	4.576	1.133











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Experiments In Three Tribosystems

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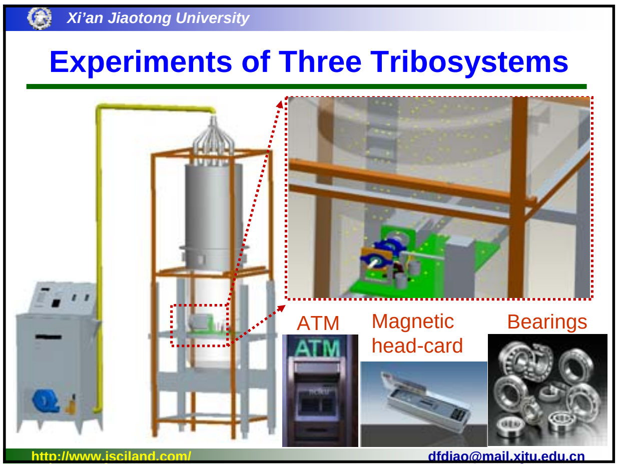
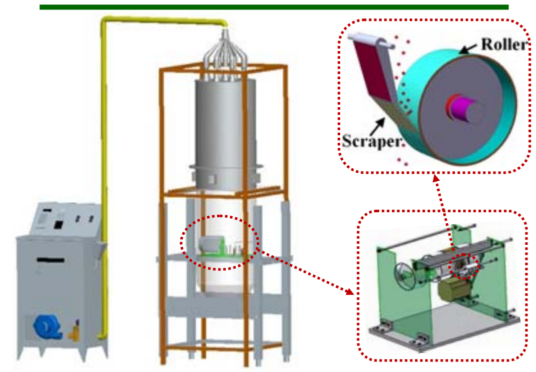
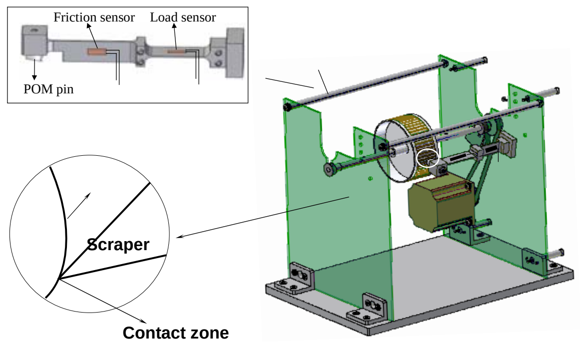


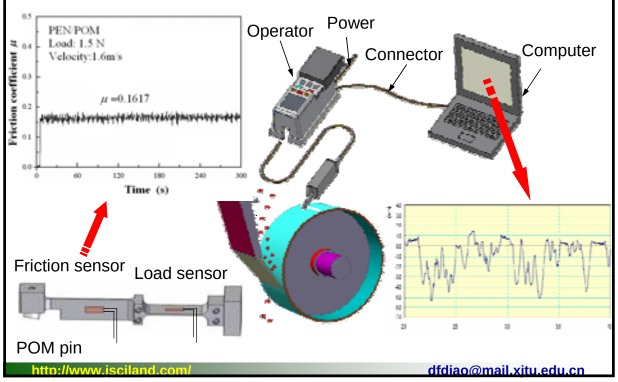
Roller-Scripter System in ATM



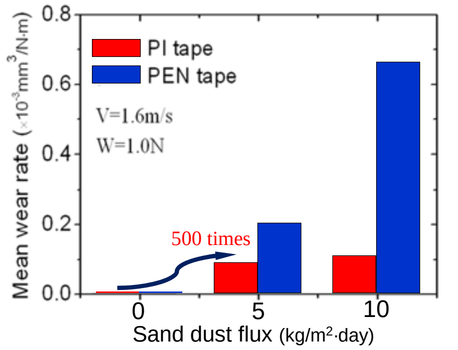
Friction Measurement System



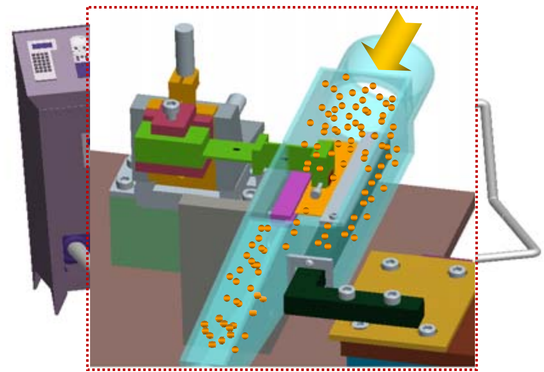
Friction Measurement System

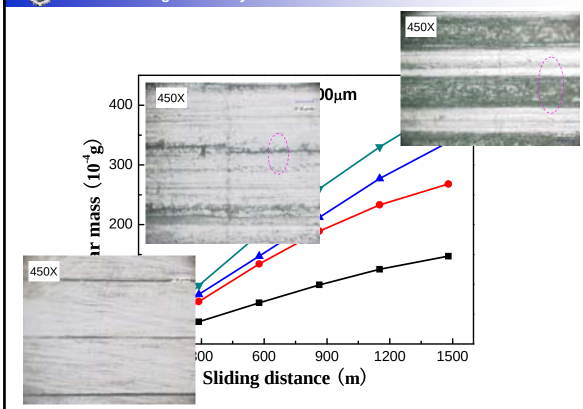


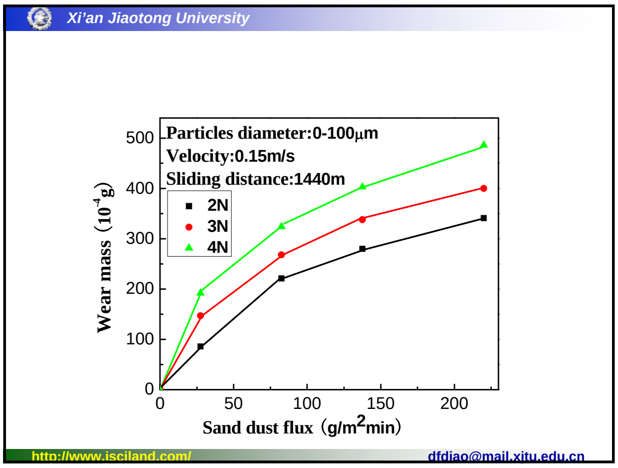
Result Analysis



Magnetic Head-Card System



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Particles diameter:0-100μm
Velocity:0.15m/s
Sliding distance:1440m
2N
3N
4N
Wear mass (10⁻⁴g)
0
100
200
300
400
500
0
50
100
150
200
Sand dust flux (g/m²min)
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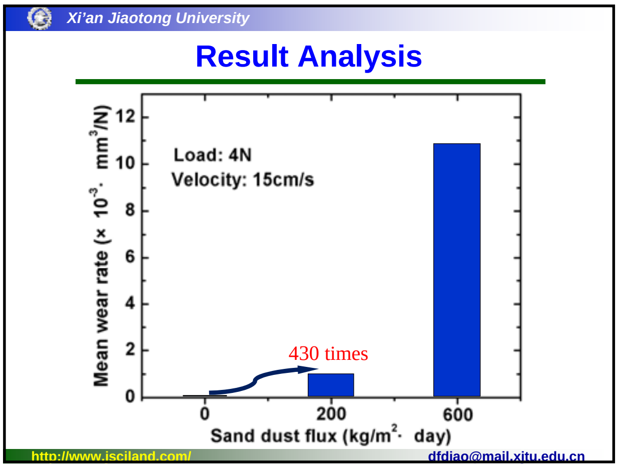
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Result Analysis
Load: 4N
Velocity: 15cm/s
430 times
Mean wear rate (× 10⁻³· mm³/N)
0
2
4
6
8
10
12
0
200
600
Sand dust flux (kg/m²· day)
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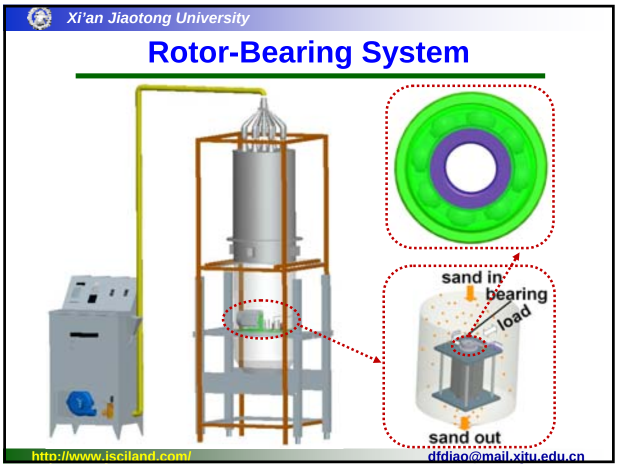
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Rotor-Bearing System
sand in
bearing
load
sand out
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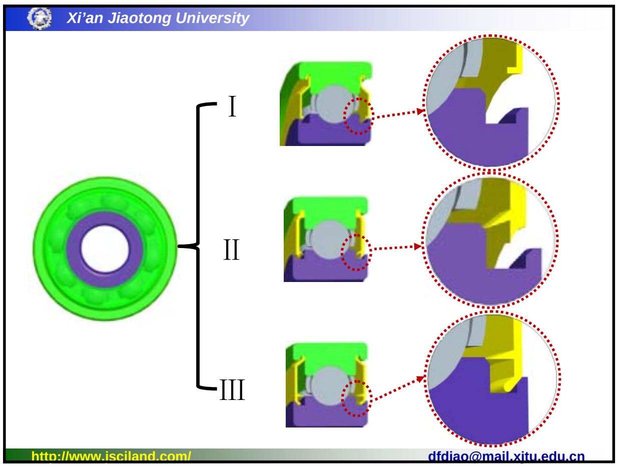
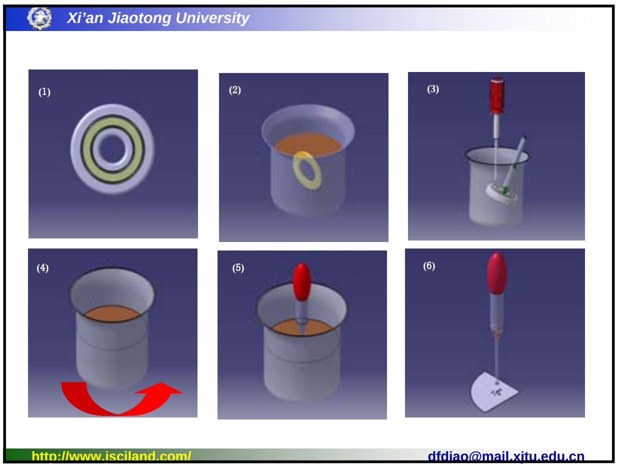

Xi'an Jiaotong University
I
II
III
http://www.isciland.com/
dfdiao@mail.xitu.edu.cn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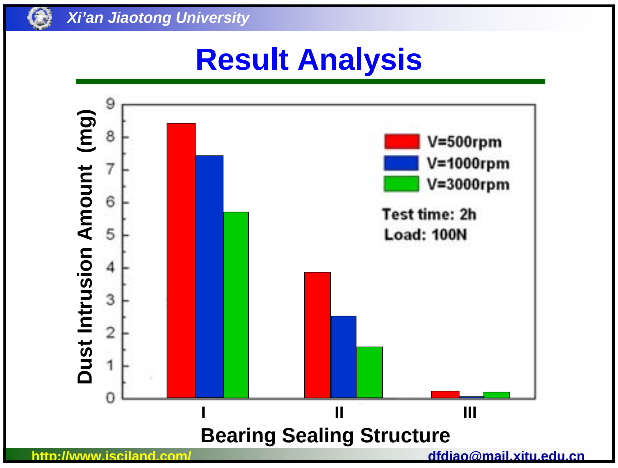
Xi'an Jiaotong University
Result Analysis
V=500rpm
V=1000rpm
V=3000rpm
Test time: 2h
Load: 100N
Dust Intrusion Amount (mg)
0
1
2
3
4
5
6
7
8
9
I
II
III
Bearing Sealing Structure
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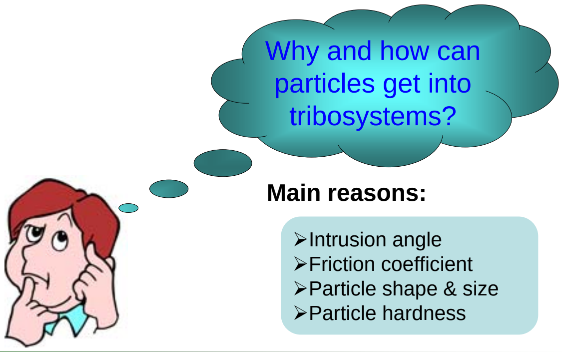
Mechanisms in These Tribosystems

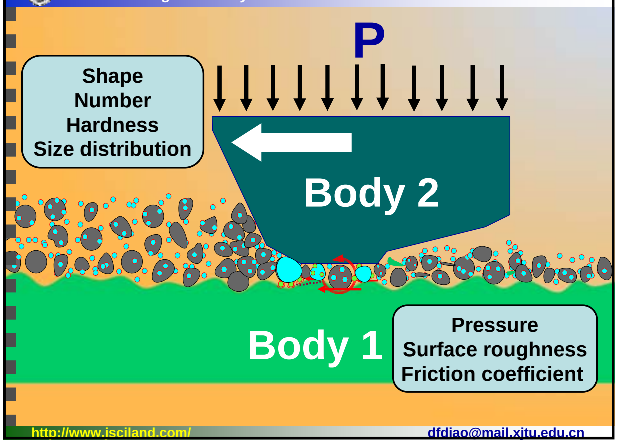
Particles Intrusion Analysis

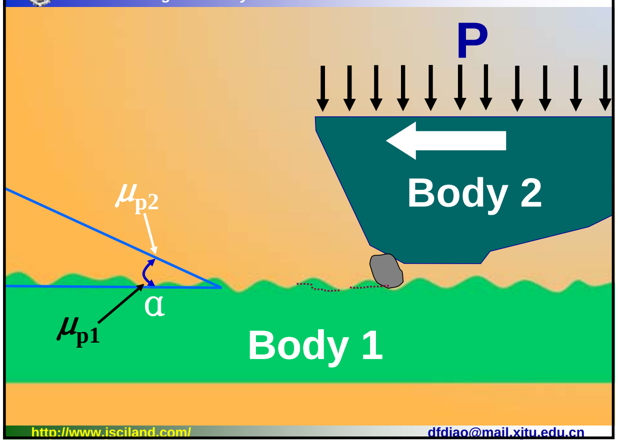
Why and how can particles get into tribosystems?

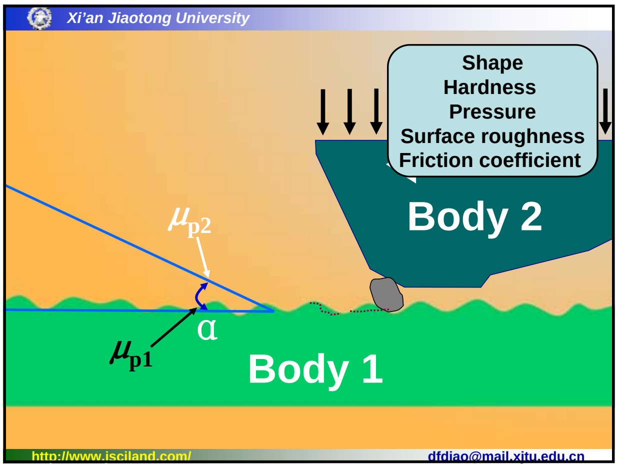


Main reasons:

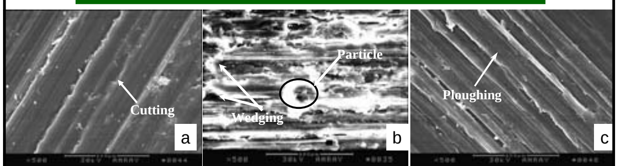
- Intrusion angle
- Friction coefficient
- Particle shape & size
- Particle hardness



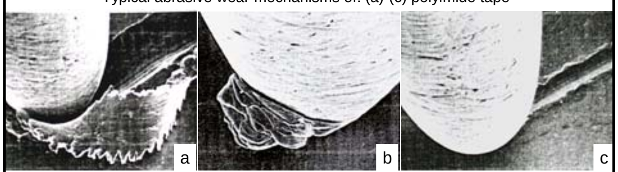




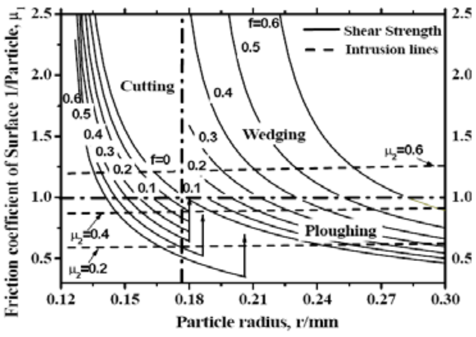
Mechanism of Abrasive Wear

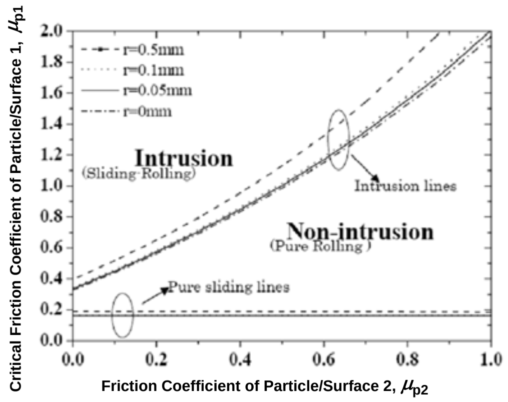


Typical abrasive wear mechanisms of: (a)-(c) polyimide tape



Wear mechanisms of abrasive wear follwing K.Hokkirigawa and K. Kato (1988) . a- cutting; b- wedging; c- ploughing





Summary

The industrial tribology problems of tribosystems in natural sand dust environment were studied.

Results:

Mean wear rate in the sand dust environment was about 500 times greater than that in the clean air environment.

Reasons:

Dust particles intruded into tribosystems

Key factors:

Single particle: friction coefficient, contact angle
Particle swarm: size distribution, flux

Acknowledgements

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