Effects of DLC/TiAlN-coated die on friction and wear in sheet-metal forming under dry and oil-lubricated conditions: Experimental and numerical studies

By: Sulaiman, MH (Sulaiman, M. H.)[1]; Farahana, RN (Farahana, R. N.)[1]; Bienk, K (Bienk, K.)[2]; Nielsen, CV (Nielsen, C. V.)[3]; Bay, N (Bay, N.)[3]

View Web of Science ResearcherID and ORCID

WEAR
Volume: 438
Article Number: 203040
DOI: 10.1016/j.wear.2019.203040
Published: NOV 15 2019
Document Type: Article
View Journal Impact

Abstract

Experimental and numerical analyses were conducted to explore the influence of DLC/TiAlN-coated die surfaces in sheet-metal forming under dry and oil-lubricated conditions. In this study, ironing and deep-drawing experiments were performed to determine the potential of the DLC/TiAlN coating in the sheet forming of stainless steels under different tribological conditions. The performance and physical properties of the DLC/TiAlN-coated die surface were obtained through load, surface roughness, and wear measurements as well as hardness and microstructure examination. The experimental results indicated that the DLC/TiAlN coating strongly resists galling under dry friction and thin film lubrication conditions that reduces the friction and forming load. The presence of a thin oil film reduces the sliding-originated surface tensile stresses of the DLC/TiAlN coating, improving the wear resistance of the die surface even at high temperatures and high contact pressures. Thermomechanical numerical analysis supported the experimental results, which confirmed that the lubricant discharged the heat generated in the die-workpiece contact region to reduce the friction and forming load. With the DLC/TiAlN coating, the plain mineral oil with no extreme pressure additives can function as effective as chlorinated paraffin oil for protecting the die surface, thus extending the die service life.

Keywords

Author Keywords: Sliding wear; Sliding friction; Galling; Steel; Carbon-based coatings; Other manufacturing processes

KeyWords Plus: PVD COATINGS; BEHAVIOR; PERFORMANCE; TIALN; AEROSPACE; ALLOYS

Author Information

Reprint Address:

University of Malaysia Perlis Univ Malaysia Perlis, Sch Mechatron Engn, Arau 02600, Perlis, Malaysia.

Corresponding Address: Sulaiman, MH (corresponding author)

+ Univ Malaysia Perlis, Sch Mechatron Engn, Arau 02600, Perlis, Malaysia.

Addresses:

+ [1] Univ Malaysia Perlis, Sch Mechatron Engn, Arau 02600, Perlis, Malaysia

[2] CemeCon Scandinavia AS, Navervej 28, DK-8382 Hinnerup, Denmark

+ [3] Tech Univ Denmark, Dept Mech Engn, DK-2800 Lyngby, Denmark

E-mail Addresses: hafissulaiman@unimap.edu.my

Funding

Funding Agency	Show details	Grant Number
Det Frie Forskningsrad (DFF)		DFF-4005-00130
Taiho Kogyo Tribology Research Foundation Japan		9008-00015
Short-term Grant UniMAP		9009-00059
Universiti Malaysia Perlis (UniMAP)		
Technical University of Denmark (DTU)		

View funding text

Publisher

ELSEVIER SCIENCE SA, PO BOX 564, 1001 LAUSANNE, SWITZERLAND

Journal Information

Impact Factor: Journal Citation Reports

Categories / Classification

Research Areas: Engineering; Materials Science

Web of Science Categories: Engineering, Mechanical; Materials Science, Multidisciplinary

See more data fields

JURNAL TRIBOLOGI (2020)

View All

Use in Web of Science

Web of Science Usage Count

3	11
Last 180 Days	Since 2013

Learn more

This record is from:
Web of Science Core Collection
- Science Citation Index Expanded

Suggest a correction

If you would like to improve the quality of the data in this record, please suggest a correction.

1 of 1

Cited References: 43

Showing 30 of 43 **View All in Cited References page** *(from Web of Science Core Collection)*

1. **Bending under tension test with direct friction measurement** — **Times Cited: 27**
By: Andreasen, JL; Olsson, DD; Chodnikiewicz, K; et al.
PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS PART B-JOURNAL OF ENGINEERING MANUFACTURE Volume: 220 Issue: 1 Pages: 73-80 Published: JAN 2006

2. **Dry machining of Ti-6Al-4V using PVD coated TiAlN tools** — **Times Cited: 1**
By: Andriya, N.; Rao, P.V.; Ghosh, S.
P WORLD C ENG Pages: 2-7 Published: 2012

3. **Assab steels Vanadis 4 cold work steel** — **Times Cited: 1**
By: [Anonymous].
Mater. Prop. Data Published: 2018
Accessed date: 20 January 2019
URL: http://www.matweb.com/search/datasheet.aspx?matguid= b08b84d722724503b1f80c438ec68cbd&ckck=1

4. **A new lubricant carrier for metal forming** — **Times Cited: 22**
By: Arentoft, M.; Bay, N.; Tang, P. T.; et al.
CIRP ANNALS-MANUFACTURING TECHNOLOGY Volume: 58 Issue: 1 Pages: 243-246 Published: 2009

5. **Environmentally benign tribo-systems for metal forming** — **Times Cited: 152**
By: Bay, N.; Azushima, A.; Groche, P.; et al.
CIRP ANNALS-MANUFACTURING TECHNOLOGY Volume: 59 Issue: 2 Pages: 760-780 Published: 2010

6. **Lubricant test methods for sheet metal forming** — **Times Cited: 62**
By: Bay, N.; Olsson, D. D.; Andreasen, J. L.
TRIBOLOGY INTERNATIONAL Volume: 41 Issue: 9-10 Pages: 844-853 Published: SEP-OCT 2008

7. **Wear behavior of adaptive nano-multilayered AlTiN/MexN PVD coatings during machining of aerospace alloys** — **Times Cited: 68**
By: Biksa, A.; Yamamoto, K.; Dosbaeva, G.; et al.
TRIBOLOGY INTERNATIONAL Volume: 43 Issue: 8 Pages: 1491-1499 Published: AUG 2010