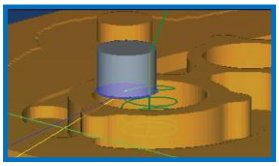


NSERC Canadian Network for Research and Innovation in Machining Technology (CANRIMT2)
NSERC Project Number: NETGP 479639 - 15

Project Interim Progress Report
(Rapport d'avancement de project intérimaire)
May 1 – October 31, 2019

Please submit by October 25, 2019
(Attn: management@nserc-canrimt.org)

Instructions
This progress report, updated milestones and the Form 300 are required as a condition of research funding support from the sponsors of the NSERC CANRIMT. ***Please report for activity in the current reporting period only.***

SUMMARY

THEME IV: ***Adaptive Tooling/Processes & Novel Manufacturing Processes/Applications***	**Leader/ Chef:** *(Veldhuis, McMaster)*
PROJECT IV.B.8: Development of Lubricating Multilayer PVD Coatings for Machining of Al-Si Alloys	**Leader/ Chef:** *(Veldhuis, McMaster)*
PROJECT DURATION/DURÉE DU PROJET : 4 years (Starting Sept 2018)	
STATUS/STATUT: *(**Milestones** to be updated by each Project Leader)*	

Ahead of Schedule		On Schedule	X	Delayed		Cancelled	

PROJECT DESCRIPTION/ DESCRIPTION DU PROJECT

(*Brief description in point form, including role of project in Theme.)*

- This research project will investigate the wear behaviour of various multilayer (hard/lubricating) coatings during the machining of Al-Si alloys where the Si content is 8-16 %, leading to high levels of abrasion.
- Investigations on the surface integrity of the machined part will also be done.

PROJECT OBJECTIVES & METHODOLOGY/ OBJECTIFS DU PROJET & MÉTHODOLOGIE

(Include alignment with Network objectives.)

- In this project the coating architecture will be developed to address two major wear mechanisms: built-up edge formation and intensive abrasion.
- Special lubricating materials will be developed for deposition on the surface of tooling to reduce sticking of workpiece materials on tools.

NSERC CANRIMT - NETGP 479639 - 15 (2016-2021)
Interim Progress Report – May 1 – October 31, 2019
PROJECT # & TITLE: IV.B.8 Development of Lubricating Multilayer PVD Coatings for Machining of Al-Si Alloys

1. RESEARCH TEAM/ ÉQUIPE DE RECHERCHE
(Summary for the current reporting period)

1a: Research Personnel (Supervisors, Co-Supervisors, Collaborators)/ Personnel de recherche

Name, given name/ Nom., prénom	*Organization/ Organisation*	*Sup./Co-Sup./ Collaborator*	*E-mail/Courriel*	*Phone No./ Téléphone*
Stephen C. Veldhuis	McMaster	Sup.	veldhu@mcmaster.ca	905 525 9140 Ext. 27044
J. Endrino	Cranfield University	Collaborator	j.l.endrino@cranfield.ac.uk	+44 (0) 1234 752931

1b: Students, Postdoctoral Fellows, Research Assist./ Assoc./Eng., Technical/Professional, Guests *(from outside Ontario; from outside Canada)*/ Étudiants, Boursier de recherches postdoctorales, assistants, techniciens et invites *(invite hors Ontario; hors Canada)*

Name, given nam Nom., prénom	*Position*	*Organization/ Organisation*	*Name/Nom. (S) or /ou (C)**	*Start/ Début*	*End/ Fin*	*CANRIMT Salary/Mo incl ben.*	*Extern. funding amount*	*Extern funding source*
Qianxi (Emily) He	Ph.D. student	McMaster	Stephen C. Veldhuis (S)	Sep 2018	Aug 2022	1282	317	SONAMI
Jose Mario Pavia	Postdoc	McMaster	Stephen C. Veldhuis (S)	Feb 2017			4200	SONAMI
German Fox-Rabinovich	Research Associate	McMaster University	Stephen C. Veldhuis (S)	Mar 2003		5333	5310	SONAMI

(S) – Supervisor
(C) – Co-Supervisor

TOTAL #	**BASc**	**MASc/ M.Eng.**	**Ph.D.**	**PDF**	**Res. Asst.**	**Res. Assoc.**	**Res. Eng.**	**Tech./ Prof.**	**Guests/ outside Ontario**	**Guests/ outside Canada**
2			1	1		1				

1c: Partners & Contributions/ Partenaires et Contributions

Organization / Organisation	*Acronym/ Acronyme*	*Contact*	*Cash/ Espèce*	*In-Kind/ Nature*	*Overhead/ Frais généraux*	*Total*
Honda McMaster-Veldhuis Projects		Mark Earle	120,000	152,500	30,000	150,000

2. RESEARCH PLAN FOR THE CURRENT PERIOD/PLAN DE RECHERCHE POUR LA PÉRIOD ACTUELLE *(Please list both the technical objectives, methodologies and milestones as stated in the previous report.)*

1) Literature review related to the Machining process, Tool Wear and Wear Mechanism, PVD coatings applied during machining of Al-Si Alloys - **undergoing**
2) Machining training - **completed**
3) Microscopy training - **completed**
4) Tool Wear training – **completed**

Start planning initial tests- **completed**

5) Define coating systems (chemical composition, architecture) and then employ the PVD and CVD processes to deposit the coatings over the cutting inserts - **completed**

6) Coating mechanical properties and micro-structure characterization training - **in progress**

3. ALIGNMENT OF RESEARCH PROJECT WITH NETWORK OBJECTIVES/ ALIGNEMENT DU PROJET DE RECHERCHE AVEC LES OBJECTIFS DU RÉSEAU

(Please comment on the alignment of the research project with the overall Network objectives.)

- Research will draw heavily off of work done in IV.B.5. Studies will include comparative wear performance tests involving various coated tooling during the face milling operation of high Si content alloy.
- Opportunities for incorporating lubricious layers on tooling will be explored in other projects as well.
- The role of surface lubricity will be incorporated in the virtual environment as well to allow manufacturing engineers to identify opportunities to improve performance.

4. PROBLEMS and RESOLUTIONS/ PROBLEMES ET SOLUTIONS PROPOSÉES

(Please summarize any problems arising during the current reporting period and their resolution or plans for resolution.)

Problem/ Problème:

Resolution / Résolution:

5. RESEARCH PROGRESS and RESULTS/ PROGRÈS DE LA RECHERCHE et RESULTATS:

(Summarize progress and results below.)

5a: MILESTONES/ÉTAPES

Summarize progress on milestones – including % completed – as outlined in the Research Plan for the current reporting period and any modifications since the last reporting period. (Milestones document also to be updated for each project.)

MILESTONE/ ÉTAPE: Literature review assessment of current coatings used for machining Al alloys and abrasive materials

Progress: I have started the literature review - undergoing **Modifications:**	
% Completed/ Rempli	**60%**

MILESTONE/ ÉTAPE: Production and characterization of coatings using bench top testing for lubricity, hardness and fatigue resistance.	
Progress: new coatings to improve lubricity, hardness and fatigue have been suggested to be deposited over the cutting tools through PVD and CVD techniques. **Modifications:**	
% Completed/ Rempli	**45%**

MILESTONE/ ÉTAPE: Production and lab-scale machining testing and validation of coating performance	
Progress: cutting tests and cutting conditions have been already selected according to the literature and will be applied during the lab-scale machining test for evaluation and validation of coating performance. **Modifications:**	
% Completed/ Rempli	**10%**

MILESTONE/ ÉTAPE: Implementation at industry partner site and publication of results	
Progress: **Modifications:**	
% Completed/ Rempli	**0%**

5b: PUBLICATIONS and PRESENTATIONS / PUBLICATIONS ET PRESENTATIONS

Please list all publications directly arising from Network-funded research during the current period. Do not include abstracts.

A: REFEREED CONTRIBUTIONS - ARTICLES

Include articles in refereed publications – please specify whether the article has been submitted (S), accepted (A) or published (P).

Last Name, Initial	*Year*	*Title, Journal, Volume*	*Status*

B: REFEREED CONTRIBUTIONS - OTHER

Include papers in refereed conference proceedings, letters, notes, communications, review articles, monographs, books, book chapters and government publications.

Last Name, Initial	*Year*	*Description*	*Status*
		Journal/Book/Publication Title (Status: S-submitted; A-accepted; P published)	

C: NON-REFEREED CONTRIBUTIONS

Include papers in non-refereed conference proceedings, papers, letters and review articles.

Last Name, Initial	*Year*	*Description*
		Conference Title, Location and Date

		Journal/Book/Publication Title
D: SPECIALIZED PUBLICATIONS - PRESENTATIONS *Include theses, presentations, industrial/technical reports, internal reports, discussions of abstracts and symposium records.*		
Last Name, Initial	*Year*	*Description*
		Thesis or Conference Title, Location and Date
		Journal/Book/Publication Title
E: PUBLICATIONS – ***Not originally funded by NSERC CANRIMT but continuing or completed with Network funding***		
Last Name, Initial	*Year*	*Description/Title* ***(include start date of NSERC CANRIMT funding)***
F: PUBLICATIONS – ***Not funded by NSERC CANRIMT but related to the Network research focus***		
Last Name, Initial	*Year*	*Description/Title*

5c: PATENTS and LICENSES/ BREVETS ET LICENSES

Non-disclosure agreements signed, patent applications filed, patents issued, copyrights, licenses under negotiation, licenses granted, etc.

Category	*Owner*	*Description*

5d: OTHER COMMUNICATIONS, AWARDS/ AUTRES COMMUNICATIONS, PRIX

Provide information on additional communications related to your work, such as awards and distinctions, news stories, interviews, public forums, press releases, etc. for the current reporting period (please provide copies or links.)

Name, given name/ Nom, prénom	*Details*	*Date*	*Link or copy attached*

6. TRAINING/ FORMATION

(Describe the extent of cross-network and partner involvement in training for the current reporting period.)

I have completed microscopy training
I have completed machining training
Coating mechanical properties and micro-structure characterization training-in progress

7. RESEARCH PLAN FOR NEXT 6 MONTHS/ PLAN DE RECHERCHE POUR LES 6 PROCHAINS

MOIS *(Describe Planned Research Activities for the next 6 month period and include any modifications made during the current reporting period.); also please list both the technical objectives and milestones.)*
1. Select different Al-Si grades to be used as workpiece material for the cutting tests. 2. Select different commercially available PVD coatings to be deposited on cutting tools (turning). 3. Machining tests using the selected commercially available PVD coatings in order to understand the tool wear mechanism during the machining of Al-Si Alloys. 4. Cutting tests with different coating systems (chemical composition, architecture) obtained by PVD and CVD process. 5. Evaluate the mechanical properties of the coatings and correlate the results with cutting test results.

8. OPTIONAL – Comments, Questions and/or Feedback/ OPTION – Commentaires, questions et/ou des commentaires

ıde any supplemental comments or questions pertaining to the Network here.

9. NETWORK EVENTS ATTENDED or SUGGESTIONS / ÉVÉNEMENTS RÉSEAU ONT ASSISTÉ ou SUGGESTIONS

Please list any Network-related events attended and include comments and suggestions for events which may be helpful and informative for Network members to attend in future.	
Event	*Comments/Suggestions*
Canadian Manufacturing Technology Show	

May 1, 2018 – October 31, 2018

I have started my grad studies at McMaster University on September. Since there, I have done Safety training and taking courses. For the next period. I have planned different activities according to plan provide in section 7.

Nov. 1, 2018 – April 30, 2019

The literature review shows that the machine of Al Si Alloys has high work hardening even at low deformations rates and low thermal conductivity. These two characteristics make those materials more difficult to machine than carbon steels. Due to the high plasticity and tendency to work-harden of these materials, machining surface quality of the workpiece and tool life can be difficult to maintain. Hard coating application is an effective way to realize cutting tool life improvement during machining of stainless steels.

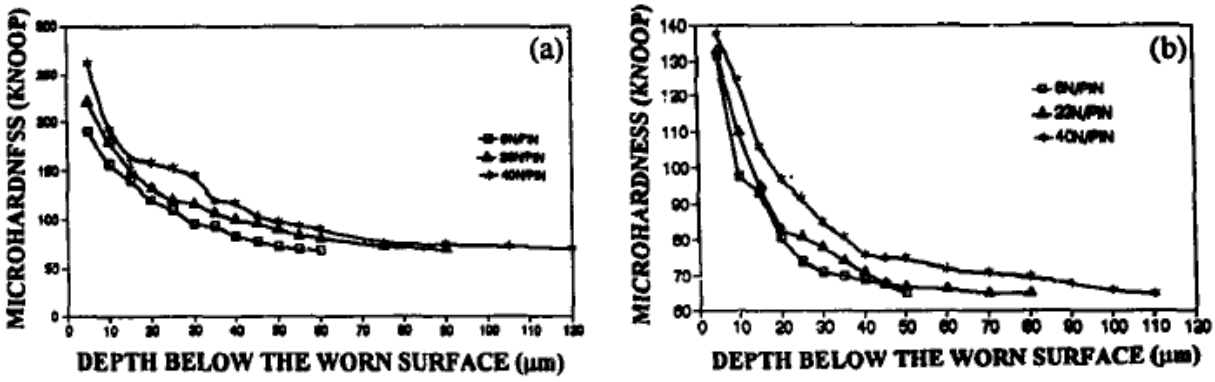
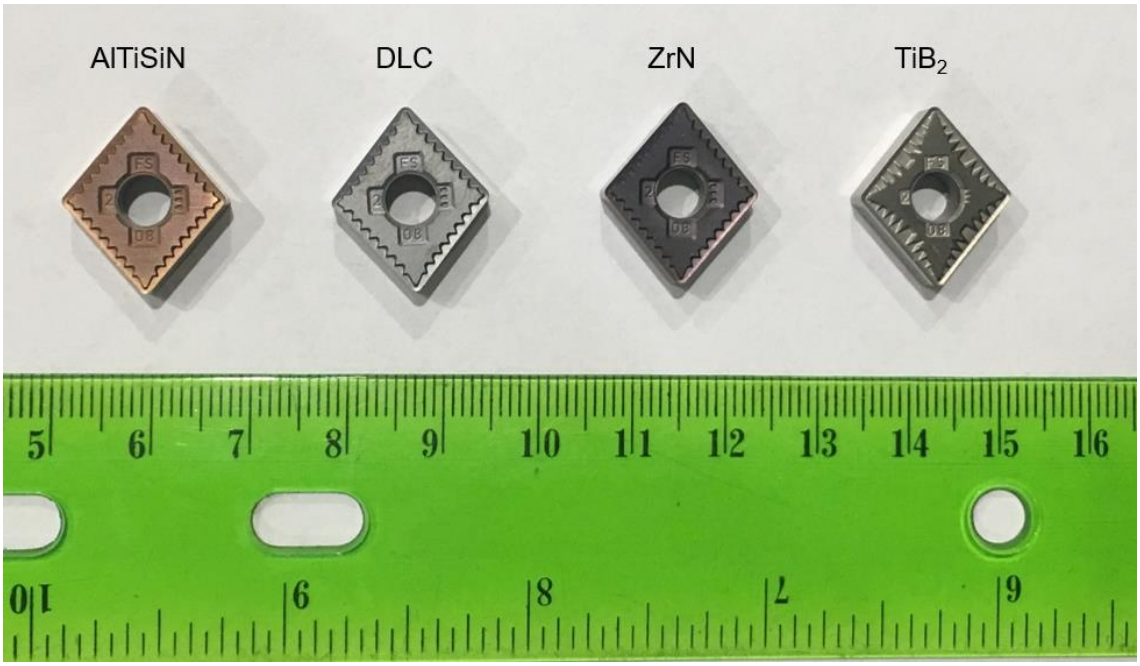


Fig. 9. Microhardness (Knoop) as a function of depth for the three loads tested, (a) the Al–Cu alloy and (b) the Al–Si alloy.

C.Perrin, W.M.Rainforth. Work hardening behaviour at the worn surface of Al-Cu and Al-Si alloys. Wear, 1997. Vol 203-204: 171-179.

May 1 – October 31, 2019

During this period, based on the literature revuew, the following coatings have shown good performance during machining of Al-Si Alloys: AlTiSiN, DLC, ZrN, and TiB_2.
Therefore, these coatings will be used as Benchmarks to start the cutting tests.
Based on the performance of the suggested coatings and on the wear mechanisms that we will observe during the cutting tests, we will develop a new coating system to be deposited on the cutting tools.
The figure below shows the coated cutting inserts selected for the initial cutting tests.


AlTiSiN
DLC
ZrN
TiB_2