



**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 projet 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.C.4: Oxidation/Corrosion Performance of Surfaces	Leader/ Chef: (Veldhuis, McMaster)
PROJECT DURATION/DURÉE DU PROJET : 4 years (Starting Sept 2018)	
STATUS/STATUT: <i>(Milestones to be updated by each Project Leader)</i>	
Ahead of Schedule	On Schedule <input checked="" type="checkbox"/>
Delayed	Cancelled

PROJECT DESCRIPTION/ DESCRIPTION DU PROJET

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

- High temperature oxidation resistance is one of the most important characteristic of a surface system for longevity.
- This is particularly true for cutting tools operating under high performance machining conditions, such as dry high performance machining of hardened tool steels.
- Analysis of the corrosion protection properties of the coatings will also be performed using electrochemical methods, such as potentiodynamic measurements, open circuit potential measurements and impedance spectroscopy. Tafel plots will be used to analyse corrosion potentials, currents and rates.
- This is highly sensitive to the detection of small pores in the coatings thus allowing for the detection of defects at early stages of corrosion damage. This aids in the prediction of coating lifetime and durability, and significant reduction of testing time required for optimizing coating microstructure, thickness and overall design.

PROJECT OBJECTIVES & METHODOLOGY/ OBJECTIFS DU PROJET & MÉTHODOLOGIE

(Include alignment with Network objectives.)

Develop an electrochemical express testing method based on the analysis of the frequency dependencies of the electrochemical impedance components using a detailed software modeling approach. Apply this technique to assess the oxidation and corrosion protection ability of a wide range of coatings and relate this property to tool performance in machining operations.

1. RESEARCH TEAM/ ÉQUIPE DE RECHERCHE

CONFIDENTIAL AS PER NSERC CANRIMT2 AGREEMENT

NSERC Canadian Network for Research & Innovation in Machining Technology
The University of British Columbia, Vancouver, BC V6T 1Z4

(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
Igor Zhitomirsky	McMaster	Co-Sup.	zhitom@mcmaster.ca	905 525 9140 Ext. 23914
Ahmet Alpas	Univ. of Windsor	Collaborator	aalpas@uwindsor.ca	519 253 3000 Ext. 2602

**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 name/ 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
Alireza Hemmati	PhD	McMaster	Stephen C. Veldhuis (S)	Sept 2018	Aug 2022	1340	100	SONAMI (FedDev)
Bipasha Bose	Post Doc.	McMaster	Stephen C. Veldhuis (S)	July 2016			4500	SONAMI (FedDev)
German Fox-Rabinovich	Research Associate	McMaster University	Stephen C. Veldhuis (S)	Mar 2003		5333	5310	SONAMI (FedDev)

*(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
3			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 PÉRIODE ACTUELLE (Please list both the technical objectives, methodologies and milestones as stated in the previous report.)

Machining with different parameter to create and investigate oxidation and diffusion using the results of tool life obtained in the first machining step. Developing new coating composition and structure with optimum tribological and electrochemical performance.

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.)

- The coatings developed in IV.B.4-8 and IV.B.11-14 will be studied by using Thermogravimetric–Differential Thermal Analysis (TG-DTA) within a temperature range of 25–1200 °C in dry air.
- DTA will determine the thermal behaviour of the coating and indicate the formation of oxide films, where relevant, these will be related to performance in service.
- Films which provide a pronounced improvement in the thermal performance of the friction surface will be studied for application on cutting tools.
- Improved thermal behaviour promotes beneficial heat dissipation via chip removal and prevents overheating of the coated tool surface.
- This data will be related to the results of the tribofilm characterization performed in IV.A.2. by X-ray photoelectron spectroscopy and auger electron spectroscopy.

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 and training on oxidation and corrosion testing equipment	
Progress: literature review and developing new coatings and machining for tool wear study Modifications:	
% Completed/ Rempli	25%

MILESTONE/ ÉTAPE: Develop assessment techniques and refine the software models used for assessment.	
Progress: Modifications:	
% Completed/ Rempli	0%

MILESTONE/ ÉTAPE: Apply assessment technique to a wide range of coated tools	
Progress: Modifications:	
% Completed/ Rempli	0%

MILESTONE/ ÉTAPE: Organize data for inclusion in the expert system and prepare publications	
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			
<i>Include articles in refereed publications – please specify whether the article has been submitted (S), accepted (A) or published (P).</i>			
Last Name, Initial	Year	Title, Journal, Volume	Status
B: REFEREED CONTRIBUTIONS - OTHER			
<i>Include papers in refereed conference proceedings, letters, notes, communications, review articles, monographs, books, book chapters and government publications.</i>			
Last Name, Initial	Year	Description	Status
		Conference Title, Location and Date (Status: Invited, Not invited)	
		Journal/Book/Publication Title (Status: S-submitted; A-accepted; P-published)	
C: NON-REFEREED CONTRIBUTIONS			
<i>Include papers in non-refereed conference proceedings, papers, letters and review articles.</i>			



Last Name, Initial	Year	Description
		Conference Title, Location and Date
		Journal/Book/Publication Title
D: SPECIALIZED PUBLICATIONS - PRESENTATIONS		
<i>Include theses, presentations, industrial/technical reports, internal reports, discussions of abstracts and symposium records.</i>		
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.)

Health and Safety Orientation (Completed)

Chemical Handling and Spills (Completed)
Ergonomics (Completed)
Fire Safety (Completed)
Slips, Trips and Falls (Completed)
Violence & Harassment Prevention (Completed)
WHMIS Core (Completed)
Accessibility for Ontarians with Disabilities Act (AODA) (Completed)
Academic Research Integrity and Ethics (Completed)
Scanning Electron microscopy training (Completed)
EDS analysis training (Completed)
Metallography training (Completed)
Automatic polishing training (Completed)
Turning process training (Completed)
TG/DTA testing training (completed)
X-ray Diffraction training (completed)
Tribometer training (completed)

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.)

- Study of traditional electrochemical method for assessing corrosion and oxidation of metals (In progress)
- Study of frequency-based electrochemical technique to be used in in-situ monitoring of corrosion during machining (in progress)
- Literature review: corrosion and wear resistance coating deposited by PVD and magnetron sputtering technique (in progress)
- Develop a draft for the research project
- Develop an experimental procedure for assessing oxidation behaviour of cutting tool with different coatings
- Assessing diffusion wear performance of different cutting tool coating by using TG-DTA method during turning
- Evaluating post machining corrosion issues of austenitic stainless steel by using electrochemical corrosion assessment technique
- Evaluating post machining corrosion issues of martensitic stainless steel by using electrochemical corrosion assessment technique
- Machining with new cutting condition for evaluating oxidation and diffusion wear to measure the intensity of crater wear
- Studying BUE formation during machining
- Designing new coating composition and architecture for machining austenitic stainless steel
- Developing and optimizing new coating for tribological and electrochemical application



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

Include 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.

CMTS 2019	Comments/Suggestions

May 1, 2018 – October 31, 2018

Currently I do not have any specific result from my research and I passed all the required training and just started my literature survey.

Nov. 1, 2018 – April 30, 2019

Based on the literatures and with respect to the gap identified in evaluating oxidation and diffusion wear behavior of different cutting tool coatings, experimental procedure for the selecting and depositing coating materials and wear assessment are in the final stage. To this end, TG-DTA as a powerful technique will be used to study the crater wear in cutting tool and then, based on the microstructural characterization technique, the goal of first phase of project will be obtained. Soon after, effect of different coatings on the surface integrity will be studied and post machining corrosion issues will be addressed.

May 1 – October 31, 2019

The results of machining for tool life assessment are shown in the figure below. The best result was obtained for the $Ti_{50}Al_{50}N$ coating with a single phase cubic structure and $Ti_{33}Al_{67}N$ coating with a combination of hcp and cubic structures. Based on the results of other tests (TG/DTA specifically) and literature, a detail investigation with a new cutting condition for oxidative wear study are currently going on these two coating compositions. Meanwhile, the oxidized surface of the coating have been analyzed using scanning electron microscopy and EDS techniques. The micrographs showed that the surface generally was covered by Ti oxide, mostly rutile particles with aluminum oxide nodules at some points.

