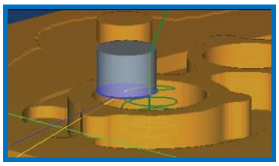

NSERC Canadian Network for Research and Innovation in Machining Technology (CANRIMT2)
NSERC Project Number: NETGP 479639 - 15

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.C.14: Assessment of Performance in High-Speed Dry Machining of Low Carbon Steel	**Leader/ Chef:** *(Veldhuis, McMaster)*
PROJECT DURATION/DURÉE DU PROJET : 2 years (Starting July 2017)	
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 project involves tool performance assessment, cycle time reduction and chip management in plain, low carbon steel, with dry cutting at a high speed up to 30,000 RPM.
- Adhesive wear and chip management are major issues associated with machining this material due to its "gummy" nature.

PROJECT OBJECTIVES & METHODOLOGY/ OBJECTIFS DU PROJET & MÉTHODOLOGIE
(Include alignment with Network objectives.)

- Develop tooling and machining strategies to deal with "gummy" and "sticky" workpiece materials.
- This project will investigate the effect of tool geometries in high-speed, dry drilling of low-carbon steel on hole quality, chip formation and tool life.
- The project was focused on turning instead of drilling, and the surface roughness was evaluated.

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

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*
Kan Zhang	MASc Student	McMaster University	Stephen C. Veldhuis (S)	Sep 2017	Aug 2019	1340	100	SONAMI (FedDev)
Jose Mario Pavia	PDF	McMaster University	Stephen C. Veldhuis (S)	Feb 2017			4200	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 PÉRIOD ACTUELLE *(Please list both the technical objectives, methodologies and milestones as stated in the previous report.)*

1. Conduct Literature review of high-speed machining of low carbon steel. – In Progress
2. Complete Training on CNC milling machine. – Completed
3. Study different tool geometries for high speed milling machining. – Shifted "See 4"
4. Study different tool geometries for high speed turning machining. – In progress
5. Study the mechanical properties of low carbon steel. – In Progress
6. Training on Material Preparation – Completed
7. Training on High-speed Camera – Completed
8. Conduct preliminary machine test on low-carbon steel at high speed conditions. – Completed
9. Study different tool geometries for high speed turning machining. – Completed
10. Perform wear mechanism study for the preliminary result. – Completed
11. Using preliminary test result and wear mechanism study to establish the research work plan. – Completed
12. Conduct machine test on low-carbon steel at high speed conditions with target tools. – Completed
13. Study different tool coating and substrate for high speed turning machining. – Completed
14. Study tool wear mechanism during machine of low-carbon steel at HS conditions. – Completed
15. SEM to evaluate the worn cutting tools. – Completed
16. Cross section studies the worn cutting tools. – Completed
17. Low scale production test. – Completed
18. Study of developing a new coating based on the test result. – Completed
19. Thesis writing and completion. – Completed

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.)

- Aspects under consideration include coatings and surface treatments which extend life and increase the productivity and life of tooling.
- Emphasis will be placed on factors which reduce the cycle-time through intelligent analysis of the process and through the application of virtual machining simulations developed previously in Phase 1.

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 techniques established in IV.A.1-2 and IV.B.2	
Progress: Literature review of high speed machining, low-carbon steel, dry machining. Training scheduled to finish. **Modifications: N/A**	
% Completed/ Rempli	**100%**

MILESTONE/ ÉTAPE: Application of surface engineering techniques developed in IV.B to cutting insert.	
Progress: Start to evaluate the commercially available coatings and prepare a new coating design based on the result. **Modifications: Decided to work with cutting insert for turning purpose instead of drilling.**	
% Completed/ Rempli	**100%**

MILESTONE/ ÉTAPE: Lab testing and characterization	
Progress: Preliminary testing on high and low end surface speed for finishing process. **Modifications:**	
% Completed/ Rempli	**100%**

MILESTONE/ ÉTAPE: Production scale testing	
Progress: Low scale of production testing. **Modifications:**	
% Completed/ Rempli	**100%**

MILESTONE/ ÉTAPE: Conclusion, technology transfer and publication	
Progress: **Modifications:**	
% Completed/ Rempli	**100%**

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*
Zhang, K. Paiva, J.M. Oomen-Hurst, S. Veldhuis, S.C.	2018	Assessment of CBN tools during high-speed dry Machining on low carbon steel. VMPT, McMaster University, May 7-9	P
Zhang, K. Paiva, J.M. Oomen-Hurst, S. Veldhuis, S.C.	2019	High speed machining of low carbon steel using coated CBN and carbide tools. VMPT, Vancouver, April 23-25, 2019	P

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*
Zhang, K	2019	VMPT, Vancouver, April 23-25, 2019
		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.)

CNC milling machining - Completed
Tool wear measurement - Completed
CMM Measurement machine - Completed
High Speed Camera Training – Completed
Material Preparation Training – Completed
SEM EDS 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.)

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.

Event	*Comments/Suggestions*
VMPT 2018	**Poster presentation**

VMPT 2019	Oral presentation

Progress
May 1 – October 31 2017

Conducting training on a wide range of manufacturing process in the MMRI.

November 1, 2017 – April 30, 2018
Conducting training on a wide range of manufacturing process in the MMRI, MSL, and Material department. Training on Alicona microscope, tool wear measurement feature. CMM machine training.

Literature review on low carbon steel properties, high speed machining, dry machining.

Finished sustainable manufacturing course, and modeling method course.
Attend advanced finite element analysis and machine tool analysis courses.

May 1, 2018 – October 31, 2018
Conducted and finished most of the training included High-speed camera, turning machine training.

Literature review on CBN tool and the interaction between low carbon steel and the tool.

Perform preliminary test on workpiece material in high-speed cutting condition. The preliminary test was performed under the following cutting condition included the combination of dry and wet for 500 m/min surface speed. The figure below reviews the tool wear curve verses cutting length.

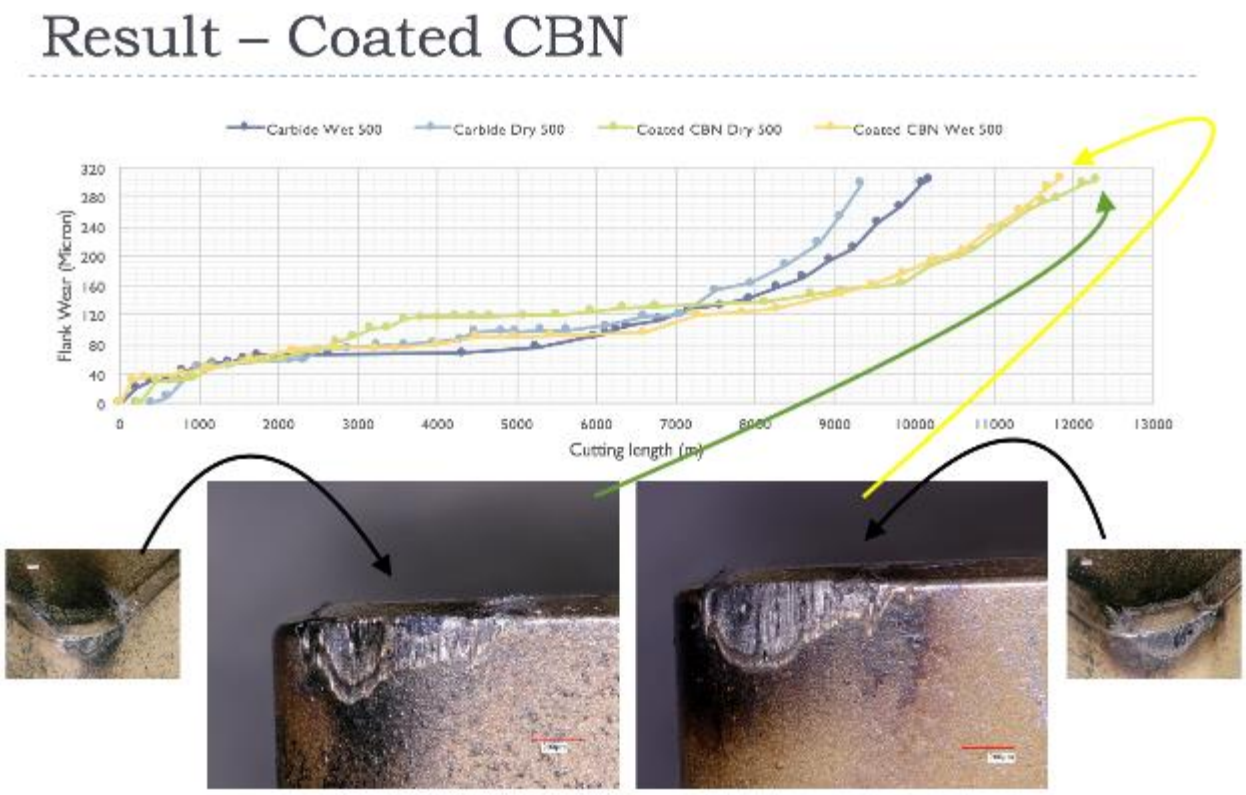

Figure 1. Preliminary testing result for commercial Coated CBN insert in 500 m/min.

Nov. 1, 2018 – April 30, 2019

- *Testing three pairs of coated and uncoated CBN insert with dry cutting condition at 500 m/min. Result shown that the binder material and grain size of CBN play a significant role in tool life. The figure below showed the tool life curve comparison.*

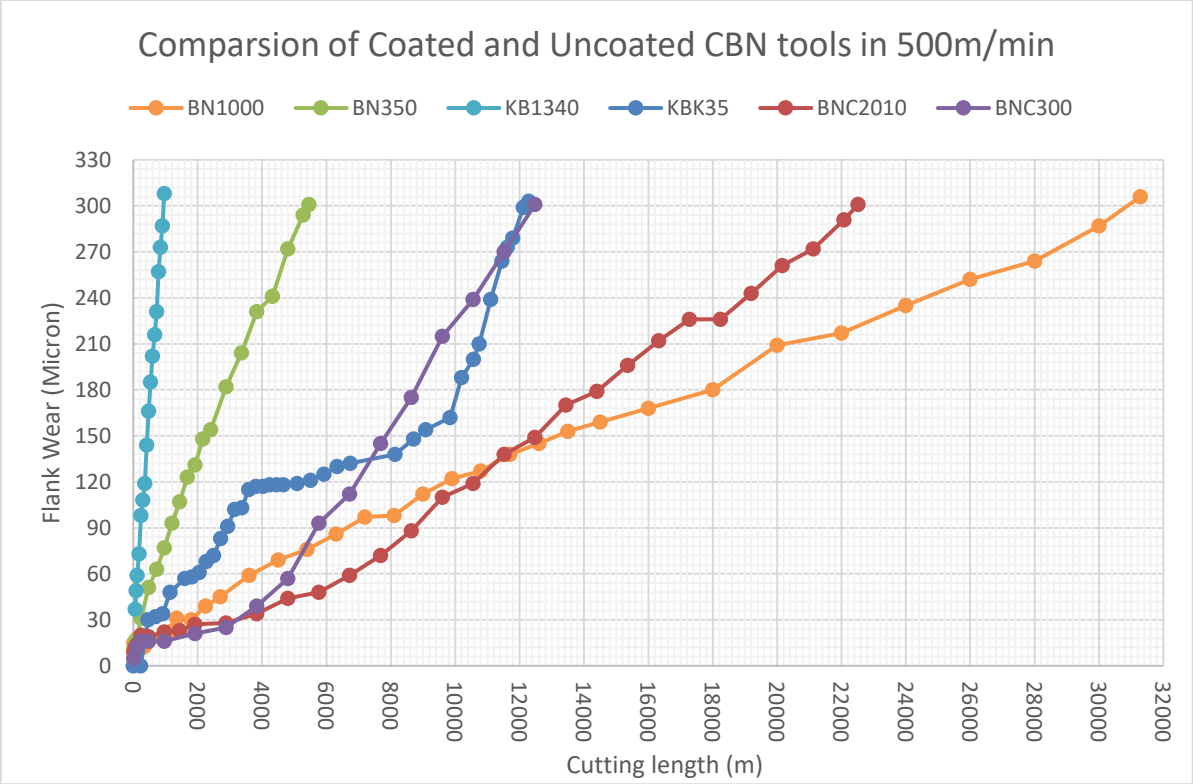

Figure 2. Comparison of Coated and Uncoated CBN tools in 500m/min for dry turning AISI 1018.

May 1 – October 31, 2019

The thesis was complete and have concluded as below:

The dominant wear mode in the uncoated CBN tool (with an AISI 1018 workpiece) was abrasion. Al2O3 and TiAlN coatings improved CBN tool life (TiN binder) and are therefore recommended for LCS machining. CVD Al2O3 thick coating performed slightly better than PVD TiAlN, and TiAlN coating applied in the MMRI showed a tool life improvement compared to a CVD Al2O3 and a TiCN multi-layer coating. Figure 3 shows that the CBN tool with a TiCN binder performed better when uncoated.

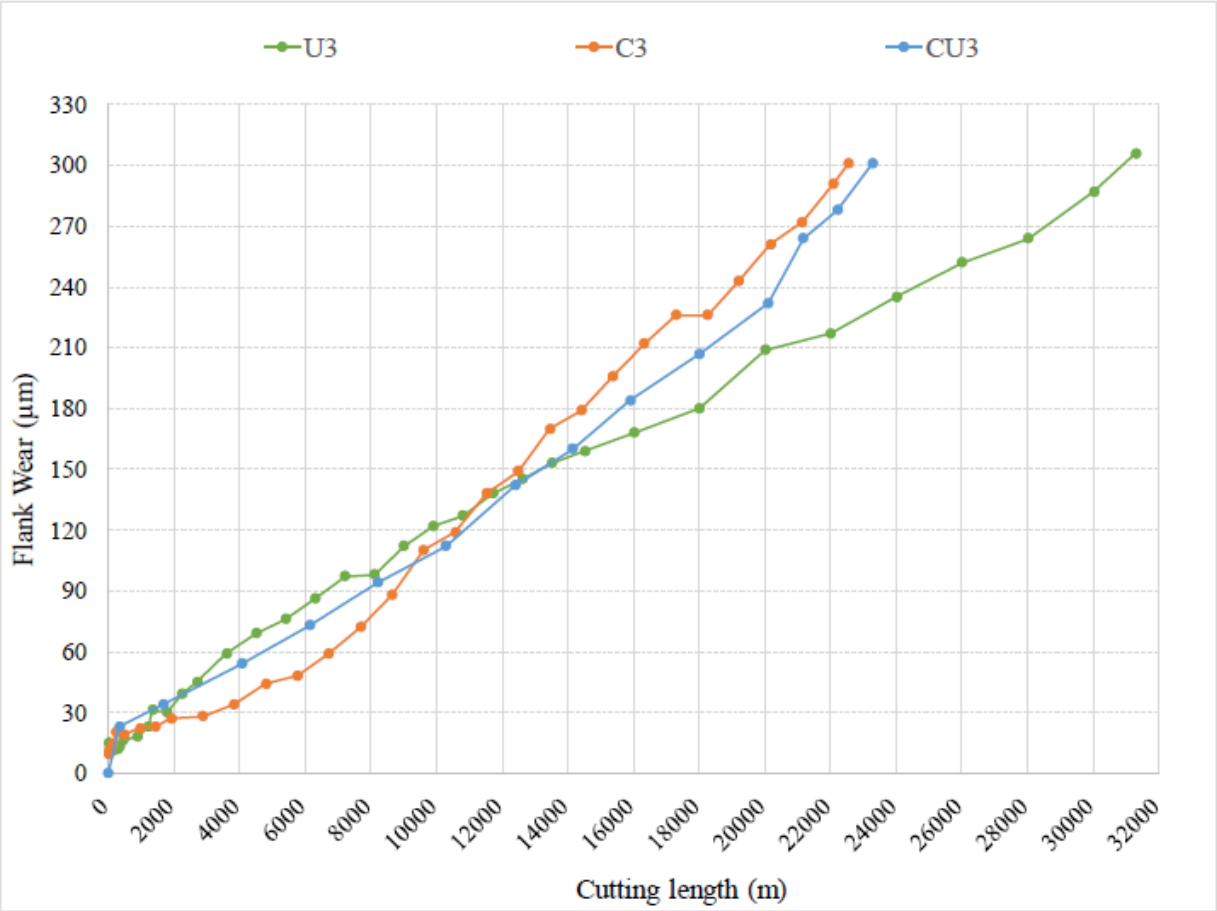

Figure 3. U3, C3, and CU3 Wear vs. Cutting length