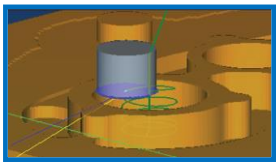

NSERC Canadian Network for Research and Innovation in Machining Technology (CANRIMT2)
NSERC Project Number: NETGP 479639 - 15

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

Please submit by Oct 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 : **Adaptive tooling/processes and novel manufacturing processes/applications**	**Leader/ Chef:** *Veldhuis, McMaster*
PROJECT IV.D.2: Improved Coolant Jet Coherency for Enhanced Heat Transfer in Grinding	**Leader/ Chef:** *Koshy, McMaster*
PROJECT DURATION/DURÉE DU PROJET : July 2018 to July 2020	
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.)*

- Grinding operations are typically accomplished at speeds between 30 m/s and 160 m/s. Such high speeds present unique problems in terms of transporting the grinding fluid into the grinding zone. This has to do with a moving layer of air in the immediate vicinity of the peripheral grinding wheel surface, which acts as a physical barrier to the ingress of the grinding fluid into the wheel-work interface
- In this context, the objective of the proposed work is to prove the concept of novel strategies for enhancing coolant flow into the grinding zone.

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

The first approach will investigate appropriate conditioning of the fluid (to minimize turbulence) before the fluid finds its way into the confines of the nozzle itself. The second approach refers to mixing of the grinding fluid with commercially-available polymer additives to enhance jet coherence.

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

NSERC CANRIMT - NETGP 479639 - 15 (2016-2021)
Interim Progress Report – Apr 1, 2019 – Oct 31, 2019
PROJECT # & TITLE: IV.D.2. Enhanced heat transfer in grinding

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*
Koshy, Philip Tullis, Stephen	McMaster McMaster		koshy@mcmaster.ca	905 525 9140 x27833

1b: Students, Postdoctoral Fellows, Research Assist./ Assoc./Eng., Technical/Professional, Guests *(from outside Québec; from outside Canada)*/ Étudiants, Boursier de recherches postdoctorales, assistants, techniciens et invites *(invite hors Québec; 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*
Lightstone, Maxwell	MASc student	McMaster	Koshy (S) Tullis (C)	Sep 2018	Aug 2020	1,200		

***(S) – Supervisor**
(C) – Co-Supervisor

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

1c: Partners & Contributions/ Partenaires et Contributions

Organization / Organisation	*Acronym/ Acronyme*	*Contact*	*Cash/ Espèce*	*In-Kind/ Nature*	*Overhead/ Frais généraux*	*Total*
Pratt & Whitney Canada	PWC	Mr. McIntosh				

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.)*

Complete characterization of jet coherence referring to the manufactured device, for a comparison against commercial round/needle nozzles.

Develop and apply techniques for measuring useful flow rate in grinding. Complete preliminary experiments to quantify coolant ingress into the grinding zone using grinding-burn threshold experiments.

The student is completing 3 courses this Term.
Last report, the following activities were planned:
1) Continuing the literature review and investigation into the state of the art
- This activity has progressed, and will continue for the duration of the project
- A focus was made on flow conditioners and coherent jets, particularly to enable the design of a flow

conditioner for this application.

- Information was gathered from diverse fields such as wind tunnel design techniques and fuel injection in engines
- Equations and observations described in the literature were used to create a model to describe if a fluid jet of a certain velocity and dimensions would be able to pierce the air layer

2) Design and construction of a flow conditioning device with a nozzle to provide a conditioned flow
   - A flow conditioning device was constructed, based on numerical standards used for wind tunnel design
   - The Hydraulic Flip phenomenon was observed, and its relevance to the research at hand was noted
3) Sourcing commercially available and industrially used nozzles to use as benchmarks of comparison
   - Examples of the commercial state of the art were acquired, including Rouse style and Needle style nozzles
   - A common, low cost commercial nozzle used in milling and turning was also acquired
4) Use a high speed camera to characterize the coherence of various jets, and the progression of jet breakup
   - A high speed camera was sourced and trained on
   - An apparatus to accurately capture high speed images of water jets was constructed
   - Images of jets from various nozzles at various flow rates were captured

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 work is in alignment with the core mission of the network: research and innovation in machining technology.

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:	
Progress: Modifications: Determined a method to quantify jet coherence data collected using a high-speed camera. • The data was quantified using imaging process techniques including edge detection and shadow correction • Compiling the data through this method proved to be an effective technique providing a time averaged diameter of the jet at various distances from the nozzle and flow rates. Compared in-house developed system against various commercial nozzles on a flow coherence basis. • The nozzles have been compared on a flow coherence basis using the aforementioned image processing technique • An increase in surface waves with increased nozzle flow rate and observation distance were observed, in agreement with the literature Designed a method for determining effective flow delivery/useful flow rate. • A method based on the literature was constructed, providing promising results for all nozzles tested • The method was determined to be lacking in the ability to collect the full effective flow, and a redesign is currently being undertaken Reproduced results of earlier researches. • Preliminarily results have been reproduced but have led to further questions about the underlying physics in these systems. • More experimentation is to be undertaken. The student (Max Lightstone) started working on this project in September 2018. He has now completed his course work requirements. A Mark 1 version of a device that renders coherent coolant jets has been designed and fabricated, and has undergone preliminary testing.	
% Completed/ Rempli	**40%**

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*
		Conference Title, Location and Date (Status: Invited, Not invited)	
		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.)

The student is undergoing training on using the grinding machine tool.
The student learned to use the High-Speed Camera.
The student is learning data analysis.

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.)

Comprehend the mechanism of fluid flow ingress into the grinding zone when using a coherent jet
Characterize the ability of the coherent jet to declog the wheel
Reconfigure setup for measurement of useful flow rate, and characterize useful flow rate of the coherent jet vis-à-vis commercial systems
Complete preliminary grinding burn threshold experiments

Complete characterization of jet coherence referring to the manufactured device, for a comparison against commercial round/needle nozzles.
Develop and apply techniques for measuring useful flow rate in grinding. Complete preliminary experiments to quantify coolant ingress into the grinding zone using grinding-burn threshold experiments.

1) Continuing the literature review and investigation into the state of the art
2) Determining a method to quantify data collected by high speed camera images.
3) Compare the various nozzles on a flow coherence basis.
4) Design an accurate method of determining effective flow delivery/useful flow rate.
5) Reproduce results of earlier researches.

6) Determining physical mechanism for fluid adherence to the grinding wheel

7) Begin grinding-burn threshold experiments
8) Complete work on redesign of flow collection system
9) Determine accuracy of air layer penetrating jet prediction model through experimentation
10) Compare the effectiveness of geometric flow conditioning to polymer addition in generating coherent jets.

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 Conference, Montreal, 2017 VMPT Conference, Hamilton, 2018 VMPT Conference, Vancouver 2019	