PENN STATE BEHREND 2017/18 UNDERGRADUATE STUDENT ACADEMIC YEAR RESEARCH GRANT

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TO THE SENIOR ASSOCIATE DEAN:

I (we) hereby request approval for a Penn State Behrend Undergraduate Student Fall Semester Research Grant. I (we) intend to complete my (our) degree(s) at Penn State Behrend.

Grant Title

Acoustic Noise Emission Analysis for Manufacturing Processes

Student(s)	**Information**
Name:	Michael DeLeo
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Phone Number:	724-766-4563
2- or 4-year Behrend Major: **(e.g., CHMBD, PSHBS)**	CMPEN
PSU ID (9-####-####):	901071005

Cooperating Faculty Member(s) – if more than one, indicate primary	**Title**	**e-mail Address**
David Loker	Associate Professor of Engineering, Electrical and Computer Engineering Technology	Drl3@psu.edu

THE PROPOSAL SHOULD NOT EXCEED NINE DOUBLE-SPACED PAGES. Please use copy/paste as needed. ***Be sure to attach a résumé for each student.***

Abstract

The proposed research will continue to study non-destructive acoustic emission monitoring techniques for manufacturing processes. Prior to this proposal, two experiments were conducted; one, to determine if the soak time (the amount of time a sample of W1 tool steel was held at the elevated temperature 1450 ºF) would have any impact on the content of the acoustic emission when the sample was rapidly cooled during the quenching process. The second experiment was to relate tool wear to the audible acoustic emission captured during different milling conditions. These experiments showed a correlation between the soak time, tool wear, and RMS or effective sound pressure of the signals. Most of this analysis was done using the Noise Image software. The proposed research is a continuation of this progress with an aim toward an in-house development of a software using LabVIEW or MATLAB capable of analyzing acoustic properties of the quenching and milling processes. To validate the developed software, data will be collected from a spherical microphone array. The outcome of the analyzed data and devised algorithms could lead to new advancements for the monitoring techniques for multiple industrial operations.

Introduction

Two recent papers have been published by Penn State Erie students, and faculty investigating the acoustic signals during the metallurgical process known as quenching [1-2]. Quenching is part of the heat treatment process for medium and high carbon steel [1]. The purpose of quenching is to strengthen the steel by rapidly cooling it using some form of quenching medium such as water, brine or oil [2]. This process strengthens the steel by forming microstructures throughout the grains in the steel called tempered martensite [1]. This is essentially accomplished by heating the steel to a temperature known as the austenetizing temperature, and then cooling it at a very fast rate (5 ºC or more per second) [1-3]. During this process, occurrences of residual stress, surface cracking and distortion are highly monitored. Due to the aforementioned conditions, the cited papers explicitly focus on studying the amplitude and spectral data over time during multiple quenches which in the past, was typically ignored. The information gathered concerning amplitude in the time domain proved useful; however, the spectral data seemed to have been less reliable, possibly due to the inconsistency from one quench to another [1-2]. This is because the system required an operator to manually remove then dunk the samples being quenched. This time frame from furnace to quench medium could therefore only be made relatively consistent. This process has since been automated to improve the consistency of the results [4]. The next step is to try to draw some correlation between the spectral data and less favorable attributes in the hardened steel.

There is also a great deal of interest in using the software to investigate other processes such as additive manufacturing, tool ware, casting, and laser welding [5]. To continue to investigate the acoustic emissions emitted during milling, more experiments need be conducted to validate the results previously collected from a spherical 32-microphone array and NoiseImage [6] using the same analysis techniques with the newly constructed data collection system using MatLab and LabVIEW.

After the results from the milling process have been verified to be repeatable, turning will be investigated with the new data collection system to further the research of non-destructive acoustic emission monitoring in multiple manufacturing processes. From the various analyses conducted and continuation in the investigation of other manufacturing processes, this study has the potential to result in acoustic emission monitoring techniques tailored for specific manufacturing processes across all industries.

Comment [DL1]: ??

References

Comment [IR2]: The quench automation paper is missing T.J. Roney, S.N. Muhhuku, C.P. Nikhare, I. Ragai and D.R. Loker, Evaluation of quenching methods for the purpose of acoustic data collection, Procedia Manufacturing (in press)

[1] Nikhare, C., Loker, D., Conklin, C., Ragai, I., & Sweeney, S. (n.d.). Investigation of Acoustic Signals During W1 Tool Steel Quenching. (2015). Proceedings of ASME 2015 International Manufacturing Science and Engineering Conference, MSEC2015-9412.

[2] Erich N., Loker, D., Conklin, C, & Nikhare, C. (n.d.).Study of Acoustic Signals and Mechanical Properties Dependence During Cold Drawn A36 Steel Quenching. (2015). Penn State Erie.

[3] W. D. Callister, and D. G. Rethwisch, 9th Ed. John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ (2014).

[4] T.J. Roney, S.N. Muhhuku, C.P. Nikhare, I. Ragai and D.R. Loker, Evaluation of quenching methods for the purpose of acoustic data collection, Procedia Manufacturing (in press).

[5] Penn State Erie, the Behrend College, P. (2014). 3- Year Research plan for Beamforming project.

[6] Roney, T., Bauccio, A., Ragai, I., Loker, D., & Nikhare, C. (n.d.). Audible Acoustic Emission Analysis for Prediction of Flank Wear during Conventional Milling. (2017). Penn State Erie.

Problem Statement and Research Plan

There is a limited amount of techniques that a manufacturing process can be monitored. The non-contact technique used to automate the process with respect to milling is achieved by using a laser to measure the geometry of the tool after a certain amount of run-time. Tool chatter and tool wear are also monitored in a similar fashion by collecting vibration data during milling operations. Other techniques used to monitor quenching usually involve destructive processes. These processes used for milling and quenching increase the time, money, and capital needed to manufacture a batch of parts for the customer. This research could potentially prove the feasibility of a tool monitoring method less obtrusive to manufacturing processes, thus shortening run times, increasing production volumes, and increasing efficiency.

Comment [IR3]:

Research Plan

Goals of this research project include:

To Be Completed By:	***Objectives***
Late May 2018	Become familiarized with techniques used to test equipment and LabVIEW software
Mid to late June 2018	Develop software algorithm to collect data from at least one microphone from the microphone array
End of June 2018	Perform necessary testing to collect data with LabVIEW software to compare with data collected from NoiseImage
Beginning of July 2018	Debug/modify program, if necessary, to ensure results are accurate and equivalent to NoiseImage results
Mid July 2018	Use new software to begin testing quenching experiments
End of July 2018	Become familiarized with MatLab software and data processing
Beginning August 2018	Develop MatLab program to process data collected from LabVIEW
Beginning August 2018	Test MatLab program to verify proper functionality
Mid August 2018	Debug/modify Matlab program to ensure results are accurate
End of August 2018	Organize data collected to be presented to showcase results of the research

The use of the current software, NoisImage, will discontinue by the end of 2017. Therefore, the first priority of this research will be to construct a new method of data collection and analysis using engineering software like MatLab or LabView to facilitate the process of gathering and analyzing relevant data in the future. Using the analyzed data from previous experiments, newly analyzed data collected from the new data collection system will be compared for verification and any errors or failures will be resolved. With the help of advanced engineering software, the information gathered will then be used to create an algorithm capable of data logging relevant, real-time information during the manufacturing processes tested. Then, the techniques employed to analyze previous data will be used to analyze other manufacturing processes in the future. These results will help create an algorithm to relate the data to previously determined experimental conditions. Upon successful completion of this algorithm, the information gathered from these manufacturing processes will then be used to help predict tool failure.

Anticipated Outcome

The anticipated outcome of this research is to relate the spectral content of the acoustic emission data gathered from an acoustic beam former to the level of residual stress, surface cracking, and distortion during quenching operations and to the level of tool wear during milling operations. It is also sought to correlate the acoustic sound signature data gathered during the milling process with tool failure. Assuming a correlation is made, signal processing algorithms will be developed for real-time monitoring of material quality, tool wear and predictions of tool failure. The algorithms and results from this research will be used to aid future research at Behrend.

Justification for multiple students (if applicable)

UNDERGRADUATE RESEARCH BUDGET
ACADEMIC YEAR 2018

Student Name	PSU ID (9-####-####)
Michael DeLeo	**901071005**

Faculty Mentor(s) ***list primary first***	**David Loker**

*CATEGORY	DETAILS	AMOUNT
Wages (rate and # of hours)	($10/hr for 111 hrs)	$1,110
Fringe Benefits • **no fringe benefits required for students taking at least 6 credits in FA16** • **7.8% for students taking less than 6 credits in FA16** ○ **Total amount available for wages divided by 1.078 - *Wages** ○ **Total amount available for wages minus *Wages = Fringe Benefits**		
Supplies (list major items)	Tool Inserts	$90
Travel related directly to research (but not conference travel)		
Copying/Printing/ Poster Supplies		
Payment of Human Subjects		
Other Costs		
TOTAL		**$1,200**

***Rental for housing is not permitted by Penn State policy.**

12/16/16

Résumé
Include a résumé for each student researcher.