This is provided as an example proposal.
It is important that you follow the current guidelines.
The mentor letter is included.

PURF COVER PAGE

TITLE OF PROJECT: Dispersion of Solid in Fracturing Flows

NAME OF APPLICANT: Dallas Roberts
CAMPUS/LOCAL ADDRESS: 45 N. Shafer St. Apt C3
E-MAIL ADDRESS: dr670618@ohio.edu
DEPARTMENT: Mechanical Engineering

BUDGET: Total Request ______________
(May not exceed $1,500)

CLASS RANK: ◯ Freshman ◯ Sophomore ⊗ Junior ◯ Senior

GPA: 3.575

EXPECTED DATE OF GRADUATION: Spring 2021 *

* Note: Students must be enrolled and maintain undergraduate student status during the proposed project period.

FACULTY MENTOR INFORMATION:

NAME: Sarah Hormozi
E-MAIL ADDRESS: hormozi@ohio.edu
CAMPUS ADDRESS: 256 Stocker Center
DEPARTMENT: Mechanical Engineering
DEPARTMENT ADMIN/E-MAIL: mccoyb@ohio.edu

We the undersigned have read the PURF Guidelines and understand the responsibilities we undertake should funding be granted.
We certify that the application has been conceived, written and completed by the student.

Student signature: Dallas Roberts Date: 9-30-2019
Faculty signature: Sarah Hormozi Date: 10-3-2019
Faculty Advisor's Dept. Chair signature: Gregory G. Kremer Date: 10/3/19

IRB AND IACUC APPROVAL:
To ensure that the University is in compliance with all federal regulations, complete the checklist below. *Note: your proposal can be approved prior to IRB or IACUC approval (put "pending" or "to be submitted" instead of approval number), but funding will be withheld until notification of approval or exemption.*

Yes	*No*	*Office of Research Compliance*	*Policy #*
☐	☒	Human Subjects in Research (including surveys, interviews, educational interventions): Institutional Review Board (IRB) Approval #: Expiration Date:	19.052
☐	☒	Animal Species: Institutional Animal Care & Use Committee (IACUC) Approval #: Expiration Date:	19.049

☒ **Optional:**
If selected for funding, I give permission to the Research Division to use my proposal as an example during training and workshop exercises. (Sign below)
Signature: Dallas Roberts Date: 9-30-2019

Abstract

This experiment models a novel technique in which pulses of particle suspensions are pumped into hydraulic fractures for oil extraction. This technique shows promise in improving the efficiency of oil extraction. I will investigate the migration of particle pulses in narrow channel flows using Newtonian fluid particle suspensions. Data collection will be performed using Particle Imaging Velocimetry techniques. The results of this investigation are expected provide insight into considerations for these suspensions such as pulse frequency and effectiveness and an understanding of particle distribution in a variety of fields concerned with fluid flow through narrow channels.

Project Narrative

Goals and Scope:

During hydraulic fracturing used for oil extraction from the ground, homogenous (uniform) particle suspensions are pumped into the fractures. The porous medium created by the particles allows oil flow and supports the fracture to prevent it from closing. An alternate method called the channel fracturing technique is also used. In this method, pulses of fluid containing particles are pumped into the fracture. This alternate method aims to use the pulses like pillars to support the fracture. The goal of using pillars as opposed to a homogenous support is to create open spaces, without particles, where the oil can flow more easily thereby increasing the efficiency of the extraction (see figure 1) [1] [2].

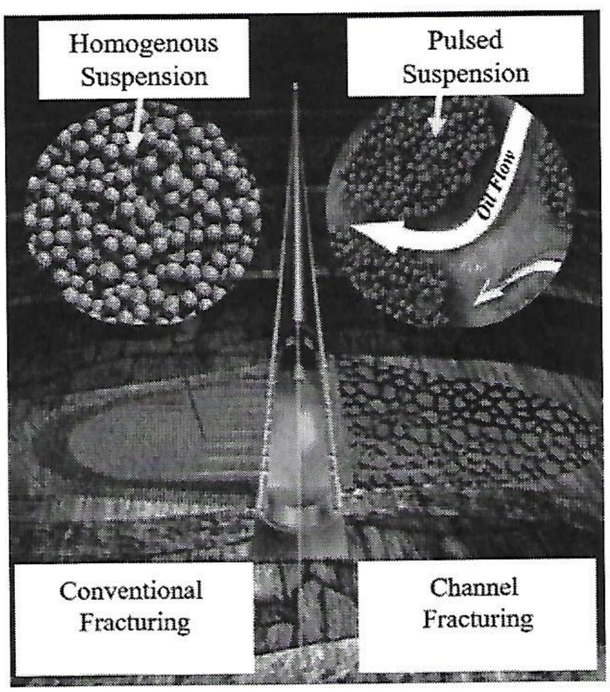

Figure 1: Shows the ideal difference between traditional suspensions and pluses of suspensions used to support hydraulic fractures

The goal of this study is to determine if and at what point the pulses of suspended particles migrate enough that they form a homogenous suspension inside the fracture [3]. When the suspension becomes homogenous, the benefit of using pulses to allow areas of unrestricted oil flow is lost.

Another aspect of the pulses will also be studied. Increasing the space between pulses may increase the distance before the homogenous suspension would form. However, too much space between pulses will not provide enough support, and the fracture could close. Due to this, the experiment will examine various frequencies of pulses. The migration of single pulses will also be examined to determine migration effects without interaction between pulses and to establish a baseline for the behavior of the pulse.

Context:

This study extends the work of Ahmadreza Rashedi and Mohammad (Sohrab) Sarabian [4] who are both graduate students at Ohio University. Sarabian's work has determined the volume fraction of suspended particles that produces the greatest migration effects. Rashedi has designed the experimental setup that will be used for this experiment including the fluid channel and the fluid that is used to create the suspensions. He has developed an excel document that provides the amount of each material required to mix the fluid for the suspension. He has also examined the migration of particles in a homogenous particle suspension of Newtonian fluid. That is, a fluid whose viscosity does not change with velocity or force. I assisted Rashedi with the data collection for this experiment over the summer of 2019. The results of the homogenous suspensions confirm the migration of particles as the fluid flows through the channel and show that the migration tends toward the center of the channel. The experiment I perform will provide the next step of this research. While I will also use a Newtonian suspension, this study moves forward the research by examining the effects of using pulses of suspensions. The previous work provides a baseline which allows me to separate the effects of using pulses of suspensions from the effects of the overall fluid flow. The experiment I perform will provide the baseline to continue the research into non-Newtonian fluid suspensions.

Methods:

This project will examine the migration of particles suspended in a narrow-channel, fluid flow. This project will specifically examine the migration of slugs or pulses of suspended particles into a flow without particles. The fluid used in this experiment will be Newtonian. The narrow channel flow studied in this experiment models the hydraulic fractures into which suspensions are pumped for the channel fracturing technique.

High power, Nemysis, syringe pumps will be used to pump the fluid and suspension through the channel. These pumps can accurately control the fluid flow rate through the fluid channel.

Particle Imaging Velocimetry (PIV) will be used for data acquisition during this study (see figure 2). In the PIV setup, A high power laser is focused into a narrow sheet using optical lenses. This narrow sheet is used to illuminate a specified area of the channel. A Basler camera uses the illumination from the sheet to record images of the channel at specified time intervals. Images of the suspension pulses will be recorded along the length of the channel using this method. After the images are recorded, they are processed via computer software for study. Matlab software will be used to plot the data from the images to gain understanding of the migration.

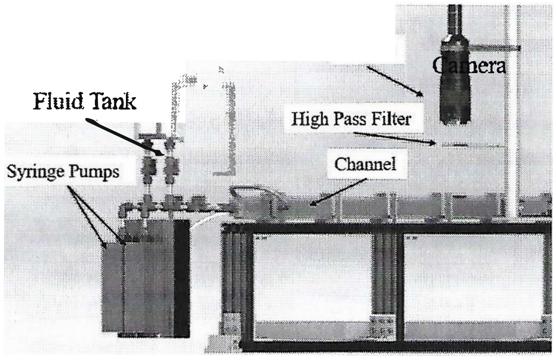

Figure 2: An overview of the PIV setup for data collection from the experiment

Timeline:

I will be devoting a minimum of 9 hours per week to this experiment. I expect that mixing the suspension and loading it in the channel will take one week of time per run. Data collection will take one week per run. And cleaning/preparing for the next suspension will take one week. Image processing will be performed as data is collected. This should allow time for data collection on up to four different fluid suspensions.

October 2019 – January 2020: Perform data collection and image processing

February 2020 – March 2020: Prepare reports and present at the student research and creativity expo

My Role:

My role in this experiment has three main aspects: 1.) performing the experiment, 2.) analyzing the data, and 3.) interpreting the results. I will complete all operations of this experiment under the supervision of professor Sarah Hormozi.

I will perform the data collection and analysis for this experiment. This includes matlab coding, camera setup including focus and position, pump setup, and image processing. I will also be mixing the materials to make the f luid f or the suspensions and utilizing the excel spreadsheet developed by Rashedi to determine the amounts of the materials required. In addition, I will perf orm general maintenance of the channel and equipment. I will clean the channel, pumps, connective tubing, and glassware. I will repair any leaks that may develop in the channel. I will also recover the particles from the fluid once it has been used. I will also be responsible for creating an academic report of the findings of the experiment.

The interpretation of the data requires deep understanding of the problem. The interpretation will provide physical insight into the mechanics of narrow channel flows. I will be working closely with professor Hormozi to ensure that this aspect of the experiment is properly executed.

Significance:

This experiment aims to isolate the effects of using pulses of particle suspensions rather than the previous, homogenous suspensions. This will prepare for future research to explore the migration of pulses of particle suspensions using non-Newtonian fluids. Many applications of this research in industry would be performed using non-Newtonian fluids. However, it is necessary to first isolate the effects caused by using pulses of suspensions in a channel flow before the effects of using non-Newtonian fluids can be determined. The results of this experiment will refine the method used for supporting hydraulic fractures by helping to determine when pulses of suspensions should be used and what the spacing between pulses should be. The results also have farther reaching implications for any fluid flow which has suspended particles. Examples include the food and cosmetic industries. Understanding the migration of particles will help understand the distribution or mixing of ingredients or materials for products that travel via a flow in these industries. Another major area that this research has implications in is the medical field for blood flow in order to separate cancer cells from healthy cells. Blood vessels are narrow channels and blood is a particle suspension in which red blood cells are deformable particles. Understanding the migration of particles in narrow channel flows will deepen the understanding of how blood flows throughout the body.

Bibliography

[1] Barasia, A. and Pankaj, P. *Tail-in Proppant and its Importance in Channel Fracturing Technique.* SPE One Day Seminar held in Grighallen, Norway, April, SPE, paper 169227-MS (2014).

[2] Hormozi, S., & Frigaard, I.A. (2017) Dispersion of solids in fracturing ows of yield stress uids. J. Fluid Mech. 830, 93-137.

[3] Nott PR, Brady JF, Pressure-driven flow of suspensions: simulation and theory. J Fluid Mech 275 (1994) 157- 190

[4] Sarabian, M., Firouznia, Metzger, B. & Hormozi, S., (2019) Fully developed and transient concentration proles of particulate suspensions sheared in a cylindrical Couette cell. J. Fluid Mech, 862, 659-671.

Biographical Information

I spent the summer of 2019 working with Ahmadreza Rashedi in the laboratory in which the experiment will be held. He trained me to use the software related to using the experiment equipment including the software that controls the pumps and camera. He also trained me in maintenance of the channel and equipment, and he provided training on how to mix the fluid for the suspensions. I have written a report on maintenance of the channel and data collection from it.

I have completed courses relevant to the experiment including Heat and Fluid Trnasport I, Thermodynamics, Principles of Engineering Materials, and Strengths of Materials from Ohio University. I have also completed General Chemistry II and Physics II from Columbus State Community College. In addition, I have gained experience using Matlab and Solidworks programs through a variety of classes at both Ohio University and Columbus State Community College.

Budget

Item	**Amount**	**Source**	**Justification**
Triton	4 x $191 = $764	PURF	This is the main component of the fluid used to make the fluid suspensions
Nitrile Gloves	10 x $10 = $100	PURF	Gloves are required to protect the experimenter
Disposable Spatulas	$45	PURF	Spatulas are used to aid in all aspects of the experiment from mixing to cleaning
Kimtech Wipes	10 x $9.60 = $96	PURF	Kimtech wipes are necessary because they do not leave debris that can contaminate the fluid
2 Liter Beaker	2 x $128.89 = $257.78	PURF	Beakers are necessary for mixing and storing the fluid
1 Liter Beaker	2 x $97.49 = $194.98	PURF	Beakers are necessary for mixing and storing the fluid
Acrylic Adhesive 4SC	$24.49	PURF	Acrylic Adhesive is necessary for repairing leaks in the channel
Acrylic Adhesive 16	$16.68	PURF	Acrylic Adhesive is necessary for repairing leaks in the channel
Total Requested	$1499.93		

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Subject: Endorsement letter for Dallas Roberts

Dear members of search committee,

I am delighted to strongly recommend Dallas's application to Provost Grant Proposal at OHIO. Dallas was initially my best undergraduate student in the Fluid Mechanics course, who earned 100 out of 100 in the course. Then he joined my lab as an undergraduate research assistant this summer and has been working with my PhD student since then. Dallas learnt about the physics of the problem and how to perform experiments meticulously in the summer. The impressive progress that Dallas made during the summer semester and the well-thought-out questions that he was raising during the course of the research led me to conclude that Dallas is a genius. And if I mentor him and familiarize him with the fundamental research, he will have a very bright future in the fundamental research. In short, Dallas loves science and he has a beautiful mind. I discussed this with the department head, professor Kremer, and he encouraged that he applies for Provost Grant to have Dallas involved in the research.

The proposed project is based on a new fracturing technique which was initially supported financially by receiving a prestigious award of $110,000 from American Society of Chemical Engineering, Petroleum Research Funding. This fluid mechanics project is a rich source of fundamental research in Mathematics and Physics. This project led me to receive NSF CAREER award based on many open questions that I raised in the Physics of suspensions that must be answered to build a firm foundation in the physics of soft matter. Having Dallas involved in such a research allows him to grow as a scientist at this young age.

My PhD student is defending in December, and I have all confidence in Dallas that as an undergraduate he can perform PhD level research and continue this research. I will mentor Dallas directly and I am hopeful that I will place Dallas in the first top 10 graduate schools in the United States for his graduate study. I worked with another undergraduate student at OHIO closely for two years and he is now at Johns Hopkins University perusing his PhD. According to my observation of Dallas academic progress, Dallas would make an excellent recipient of the Provost support.

Shall you require further information, please do not hesitate to contact me.

Sincerely Yours,
Sarah Hormozi