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Tailings Dust Emissions Reflections

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Tailings Dust Emissions

WERC 2017

TASK # 3

The Dust Busters

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Tailings Dust Emissions

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The Dust Busters

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Personal Contributions to Tailings Dust Emissions Project

As team coordinator of the Dust Busters for the WERC competition Task 2: Tailings Dust Emissions, I had an integral role throughout the entire timeline of the project, facilitating all deliverables and ensuring that effective communication was maintained. The ultimate goal of task 2 was to find a practical solution to minimize dust emissions from mine tailings storage facilities. However, the primary objective of developing this solution was twofold. First, the task specified that each team must investigate the potential of agglomerating the tailings into gravel-like peds to create an erosion resistant layer on top of the existing storage facility. Secondly, teams were asked to investigate current dust control techniques as well as develop alternative (and more effective) dust control technologies and strategies. For our solution, the Dust Busters proposed the use of a diluted commercial vinyl copolymer spray that would reduce the dust control treatment costs by \$110,000 to \$600,000 per year in comparison to the current technique of a Magnesium Chloride spray. While we were able to develop a tailings ped using 1.5 weight percent concrete and a pelletization device, we deemed this objective to be impractical due to the abrasiveness nature of the tailings material and the unnecessarily high capital/operating costs for a waste stream.

The process of developing this solution began in late October of 2016, when each member began individual literature searches prior to the project kickoff in January and was appointed a role. I gladly accepted the nomination for team coordinator, as I felt that I had the appropriate organizational and leadership skills to drive the momentum on the team. My literature search focused on current dust control techniques. For this search, I collected a wide array of reports on industry standards for dust control, mine incident reports, and research articles on innovative new technologies. Since no one on the Dust Busters had prior experience with the mining operation, I also used this time period to research the basics of the mining industry, including defining key terms (like tailings) that would later become commonplace in the project. As team coordinator, I ensure that each team member was aware of their assigned topic and was effectively collecting the relevant information. Over winter break, I worked with Sam Horn to coordinate a visit to the Freeport McMoran Chino Mine which team members Sam Horn, Joe Griffin, Josh Mueller, and Ryan Bernard would be taking during the first week of the spring semester. I also worked with Dr. Penney to properly sign the team up for the WERC competition.

The bulk of the project's work began on January 9th, when we kicked off the WERC competition with a work week during the week immediately prior to the start of the spring semester. During this week, it was my role to make sure that each team member had a task to accomplish. I led brainstorming sessions, and assigned independent research topics and bench scale experimentation responsibilities. My personal research focused on disc pelletizers, continued research into current techniques, and determining the morphology/composition of our tailings sample using the light microscope in Dr. Hestekin's lab and the SEM-EDX in the nanotechnology building. Organization during this week was imperative, as I made sure that everyone was on the same page about the status of our research. During this week, our team collected a lot of important information from industry experts on various equipment and materials. We also requested several samples to be used for testing. It was my role to make sure that all of this information was properly documented so that it could be referenced in the future. Since the mine visit was scheduled for the

following week, I worked closely with the team assigned to attend the visit to ensure that all plans were finalized for the trip, including developing a list of relevant information to be collected during the visit. It was also during this time that my role as team coordinator started to include conflict resolution. From this point on, any conflicts that arose in the group, whether they were team members refusing to agree with the proposed plans of the group or team members failing to participate, were handled by me in order to ensure that the team worked as effectively as possible.

For the remainder of the semester, I continued my key role of maintaining the communication of the group, organizing the research plan and management of information, and delegating specific tasks to individual team members. When communication began to suffer during group meetings, I began creating a power point agenda prior to each meeting to make sure that all relevant information was presented and documented for future reference. This was done by creating a master agenda for each meeting focusing on what needed to be discussed and accomplished before the next meeting. Each team member would send me any relevant information they had found or topics they felt needed to be discussed. I would then compile everything into a master presentation to keep each group meeting focused and productive.

Another important role I had throughout the semester was delegating tasks. I kept a dynamic master list of everything that needed to be accomplished throughout the timeline of the project. Whenever a team member completed a task, I would delegate a new task to be accomplished, ensuring that no team member was ever left wondering what they needed to be working on. I also helped develop a research plan by dividing the team into two research tracks: pelletization led by Sam Horn (Zak Galligan, Josh Mueller, and Ryan Bernard) and slurry/spray techniques led by Joe Griffin and myself (Natalie Tucker and Julie Jameson). These two tracks ensure that the research conducted was split between team members and allowed the team as a whole to more effectively cover the vast amount of research and experimentation required for this task. Each team was instructed to take detailed notes and data, and to summarize their findings during the group meetings. As team coordinator during this experimentation and research heavy period, it was integral for me to be aware of what each team member was doing (and concluding) so that we were on track to finalize our proposed solution. Besides delegating, communicating, and organizing, I also personally helped prepare all of the slurry/spray solutions, complete the wind and rain resistance tests, make economic cost calculations, and conduct background research on the materials (polymers and chemicals) used in the spray/slurry samples.

The next major time period of the WERC project entailed the completion of all competition deliverables: the final paper, safety and summary sheet, poster, and the development of the bench scale and oral presentations. I led the development of the final, comprehensive paper. To accomplish this task, I delegating writing assignments to team members that had the most individual expertise on that particular section. Personally, I contributing writing to the nature of the materials sections and pieces of the spray and slurry sections. Once each team member completed their assigned sections, I was responsible for compiling each sections and completing the preliminary review to make sure that flow and formatting was consistent. After a preliminary review, I coordinated multiple group reviews (several with our advisors present) to go through the document word-by-word to ensure that no details were left out and that all the language and formatting was consistent and to our desired level of quality. After the final group review, I completed the last check for consistency and submitted the final document. With the assistance of Sam Horn, I also wrote the safety summary sheet highlighting all safety concerns of our proposed

bench scale presentation. After confirming its accuracy and scope with the rest of the team members, I also submitted this document (with the needs assessment form) to the WERC competition officials. Julie Jameson was tasked with putting together the poster; therefore, I worked closely with her to ensure that all important details were included and that printing of the posters was smoothly accomplished.

At the competition itself, I played a key role by serving as one of the four presenters during our oral presentation, and coordinating the bench-scale demonstration. Along with the other presenters (Joe Griffin, Natalie Tucker, and Sam Horn), I spent hours prior to leaving for the competition in New Mexico prepping the presentation and its accompanying power point slides. I personally presented the underflow slurry injection component as I had closely worked on that component of the background research and experimentation. This preparation included becoming experts on every component of the project, the background of the mining industry, and our proposed solution in an effort to field any and all questions effectively that judges could pose to us. As team coordinator, it was my designated duty to field the questions during the presentation if the other presenters did not feel they could answer the question (a role that I completed during the presentation with no problems). I also helped coordinate the bench scale demonstration along with my fellow team members, determining which components of our experimentation were the most imperative to showcase during the competition. We determined to showcase our proposed solution of topical spray of a vinyl copolymer by showing the crust it forms, demonstrating how it would be applied, and proving its efficacy with a wind test. Afterwards, our demonstration including highlighting the technology and results of the slurry injection and pelletization technologies, but no tests were conducted on site (they were not deemed necessary to prove our point). Each team member was given a role, whether that be speaking about a particular component, preparing samples, holding the post, demonstrating equipment, or fielding questions. My main role was explaining the topical spray background and application method, as well as fielding questions as needed.

Our team's hard work and determination proved to be effective, as we successfully earned first place in our task, scoring the highest points in all four scoring categories (Paper, Presentation, Poster, and Bench-Scale). While I believe that my commitment to details, communication, and organization led to an effective and timely completion of the task at hand, I owe the success of our project to the commitment and dedication of the entire team. Through the WERC competition, I saw myself grow as a leader, a determined worker, and a problem solver. Our team successfully tackled a problem that we had no prior experience with, and which arguably used very little of our chemical engineering knowledge. However, through this experience, we learned to become experts in a new field, gaining confidence in our abilities to take on, and succeed with, any problem or challenge that is presented to us. I believe that this project has exponentially improved our skillsets, preparing us for our future careers more than any coursework could have.

2017 WERC Reflection

I had the opportunity to participate in the 2017 WERC Environmental Design Contest at New Mexico State University. Our team participated in the Tailings Dust Emissions task. Our objective was to evaluate and review existing control measures to mitigate dust emissions and to create a gravel layer comprised of the tailings material.

Our group did preliminary research over the winter break. I researched existing control measures for dust emissions in New Mexico. I spoke with two industry, dust mitigation experts that supplied me with old EPA reports on the subject of mitigating dust emissions. These old EPA reports contained an analysis of mitigation methods used back in 2002. These documents aided in selecting the materials we used during our investigation. I also spoke with several employees at the New Mexico Air Quality Bureau, AQB. They informed us who monitors the dust emissions at mining facilities and how they monitor those emissions.

Three teammates and I had the opportunity to tour the Freeport McMoran Chino Copper Mine in January. We got a tour of the mining operation, the electrowinning operation, and the tailings storage facility. We had a Q&A session with a Freeport McMoran employee who oversees the tailings storage facility operation. The information gathered during this time proved instrumental in our success during the WERC project.

I was the purchasing coordinator and slurry/topical spray research leader during the WERC project. As purchasing coordinator, I had to maintain the budget for the team and approve all purchases for the project. As the slurry/topical spray research leader, I coordinated with members of the team on future testing and what we discovered from previous testing. I made decisions on how we should perform tests and how we present the results.

Throughout the project I focused primarily on slurry and spray sample testing. We would create slurry and spray sample trays for testing. For each sample, we had to ensure we had proper compositions of the slurry samples and of the potential solutions we were adding to these samples. The samples were made at a variety of different compositions to ensure adequate testing was performed. These samples

were then loaded into our wind apparatus where I would subject the samples to elevated wind velocities using a leaf blower, while another member of the team would measure the wind velocity using an anemometer. I performed some preliminary testing near the beginning of the project concerning the tailings material. I performed a Rotap analysis to understand the particle size distribution of the material. Our team leader, Emily, and I also analyzed the tailings material with an ESEM-EDX to know the chemical composition of the tailings material.

A large portion of my time in early March was dedicated to helping write the paper. I wrote several portions of the paper as well as editing the overall paper. Members of our team and I would sit together and read the paper line by line and approve each word and phrase. This process was repeated several times to ensure we had the best paper possible.

I was one of the presenters during the WERC contest at New Mexico State in April. My portion of the presented material was the background information on the Freeport McMoran Chino Mine operation and our planned experimental program. The four presenters, including myself, practiced this presentation innumerable times from late March all the way to the morning of the competition. During our poster presentation, I supplied all the background information so the judges, students at competing colleges, and facilitators could understand our project without reading our paper.

Overall, the WERC competition was a great experience that I will never forget. Working on a project that could potentially impact the mining industry proved to be an exciting task. The lessons I learned while working on this project will help me in my future career and life.

Sam Horn

WERC Task 3- Tailings Dust Emissions

Reflection and Contribution

To meet the task objective of forming a gravel-like substance out of tailings to cover the Tailings Storage Facilities that Freeport-McMoRan operates, we first wanted to identify key pieces of equipment that could perform this duty. Agglomeration drums, briquetting machines, and pellet mills were all solids handling equipment considered. My main role in obtaining a solution for this project was to handle all bench scale models, learn about available full-scale equipment, and talk to vendors that would be able to put us in the right direction. Agglomeration drums are large rotating drums that have binders injected into the center of drum. With enough residence time and binder material, the desired material will form small clods. The tailings material we were dealing with composed mostly of sand. Sand is hard to get to stick together without a very large amount of binder and a large residence time inside the drum. This was proven in the bench scale in the lab, and after talking with chemical engineers at an agglomeration company, it was ruled out because of high capital and operating cost, as well as its ineffectiveness of agglomerating the tailings. Briquetting machines operate by using two counter-rotating drums with cavities in them, and the material is fed into the center of the two drums, where the drums compress the material and form briquettes. This is a common process used to make charcoal briquettes. I had the opportunity to talk with the vice president of operations at a briquetting manufacturing company, and he informed me that they have tried in the past to briquette sand-like material similar to tailings with no success. Trying to have George machine one of these units on the bench scale would take a lot of labor and design, so this machine was ruled out as an option because of negative industry feedback and high capital cost. Tailings is a waste stream for the mining process, so all capital expenditure was kept at a minimum for the recommended solution. The final piece of

equipment investigated was a pellet mill. Pellet mills are commonly used to produce livestock feed and wood pellets. They operate by using rollers to push the feed material through a rotating die where a blade cuts the pellets to a desired length. These units operate under a narrow window of water content in the solids. This posed potential problems for the tailings material we were dealing with because it is free draining. If the tailings slurry lost its flow during the operation of the unit, the water would decant from the tailings, thus clogging the machine. Although feedback from experts in all three industries was skeptical, we continued our investigation by using pelletizing to create a gravel like substance to cap the Tailing Storage Facility so that we could complete the task thoroughly, although it wasn't an economical nor practical option. To create the pellets in lab for testing, we used a cylindrical punch and die in conjunction with hydraulic shop press. Cement was mixed with the tailings slurry at 1.5 weight percent and then put into the cavity of the die. The punch was inserted and pressure was applied to form the pellet. The pellet cap's duty was to mitigate dust emissions. Cement was the chosen binder because it passed a rain resistance test. New Mexico is subject to large monsoons, so a binder that could hold a pellet together even during rain was needed. Enough pellets had to be made to create a three-inch layer across the loose tailings. The three-inch layer was determined to be the minimal thickness of pellets to reduce dust from blowing during a high wind event. To test the pellet cap's ability to control the blowing dust, we constructed a wind tunnel to keep the velocity profile uniform and contained. The tunnel was constructed out of plywood and polycarbonate, and it was rectangular. A leaf blower generated wind velocities just over 60 miles per hour for testing. At the end of the project, pelletizing, or creating a gravel-like substance was ruled to not be a practical solution for dust mitigation. To create the gravel like substance, operators would have to be added, process changes implemented, and not to mention a 1.35 million dollar operating and maintenance expense per year. The next dust mitigation technique I was involved in was slurry injection. In this process, we took the tailings slurry and ran it through a pugmill mixer with a binder, once this slurry hardened after leaving the mixer, it created a

dustless crust that capped the Tailing Storage Facility. This process was much simpler than the pelletizing process and much cheaper, so we decided to build a bench scale pugmill mixer. A pugmill mixer was chosen because its ability to push the material while providing adequate mixing. As mentioned before, this material is difficult to move, and any other style of mixer would not suffice. For the bench scale model, two high density polyethylene augers were used for the mixing. We used plywood for the box to contain the augers and a feed hopper was built on top for entry of the material. The discharge of the box was just a hole in the bottom at the end of the augers where the mixed material could fall down a chute similar to a concrete mixing truck. A small motor was used to drive the augers with a belt system, and a variable speed drive was used to control the rate at which the augers turned. George helped in the design and construction of this unit.

All in all, doing a thorough job from start to finish on creating a gravel like substance showed that we can address the task, realize it wasn't the best option, and instead of forcing it to work, look into alternative solutions at mitigating dust control. At the competition, we had the shop press and pelletizer, the wind tunnel and leaf blower, and a demonstration of how we sprayed our recommended polymer emulsion on the tailings. There was another team that had a similar solution and economical evaluation to us, but they had no bench scale demonstration. We believe that our ability to show all the work we had done through the bench scale demonstration helped us win the competition for Task 3 Tailings Dust Emissions.

Julie Jameson
Honors Chemical Engineering Student

My contributions to the 2017 WERC – Tailings Dust Emissions Task #2 team were copious. As team quality control coordinator, I had extra duties that needed to be completed as well. My main contributions to the team were reaching out to companies for different chemicals, researching New Mexico dust regulations, assuring our deliverables were exceptional, and creating the poster, pamphlet, and PowerPoint for the competition.

Although my assigned responsibility for preliminary research was New Mexico dust regulations, I took it upon myself to reach out to companies to get samples of dust control products. The first product I obtained was Halliburton's AquaGel. I had the opportunity to drive to Halliburton's plant in POCASSET, Oklahoma. The next product that needed to be tested was a lignosulfonate. I got in touch with EnviRoad, LLC to get a commercial dust control suppressant consisting of a lignosulfonate/bitumen blend. I also contacted Domtar to get a sample of their Biochoice Lignin but never got a response from the company. Another product that had promising results was Barite. Barite is a commercial product consisting of barium sulfate that is used to weight drilling muds and cement slurries. I was also able to obtain this from Halliburton's plant in POCASSET, Oklahoma. Other team members were also able to get commercial products to test so we had a plethora of chemicals to investigate.

As I stated before, my main research goals were to understand and dissect New Mexico dust regulations. First, I contacted the Environmental Protection Agency's (EPA) Air Quality Division. They directed me to someone within in the New Mexico State Quality Air Bureau Division and gave me the locations where dust emission monitors are located within the state. Upon contacting New Mexico State Air Quality Bureau individuals, I found the regulations for the state but, better yet, I obtained the New Mexico Environment Operating Permit for the Chino Mine, which is the mine we used for our design basis. This allowed for complete understanding of the regulations as well as the actions the mine must take if there is visible dust in the air. This all may seem a little confusing, but ultimately the EPA and the New Mexico State Air Quality Bureau have quantitative concentrations of dust in the air that cannot be exceeded. EPA and the New Mexico State Air Quality Bureau place dust emission monitors around the United States to be checked that the concentrations are not exceeded. The mining companies, on the other hand, base their actions off qualitative visible eye observations. If there is visible dust in the air, then the mine takes preventative action. No actual measurement is taken at the mine. Nonetheless, I had many tangents while researching that ended up not

being useful, including looking up the practicality of buying a dust emission monitor. With that, I was still able to interpret the New Mexico dust regulations in accordance with the Chino Mine.

My next responsibility and contribution to the team was being named team quality control coordinator. As team quality control coordinator, I made sure everyone had done their preliminary research and if there were holes in the research, I made sure they were addressed. I also made certain every experiment was run consistently with our testing protocol and procedure as to ensure reliable data was being produced. With this role, I was also able to make sure each team member had done significant research on their assigned topic. Each team member then gave an adequate delivery of the topic at the next meeting. This was a highly rewarding position as it allowed me to take on a leadership role within the team.

The last major contribution to the team was assembling the poster, pamphlet, and PowerPoint for the competition. This included creating tables, constructing graphs, and inserting pictures. Although this may seem like a miniscule task, it was quite challenging and a vital part of our presentation at the competition. I spent many hours rearranging, formatting, and sizing the brochure, pamphlet, and PowerPoint to look aesthetically pleasing. Numerous editing sessions were included in my work which, in turn, helped guarantee no misspellings or grammar errors were within the poster, pamphlet, or PowerPoint. Furthermore, this included printing frequent rough drafts of the poster and pamphlet to make certain an exceptional deliverable was produced. This may have been a hard task, but it was all worthwhile to win first place.

My major contributions came with seeking out chemical companies, understanding New Mexico dust regulations, delivering quality work, and creating the poster, pamphlet, and PowerPoint for the competition. I am thankful that I was given the opportunity to be the team's quality control coordinator. We would not have won first place if it were not for the entire team's best effort. This is an experience I will always hold dear to my heart as it was a valuable learning experience in several aspects.

Ryan Bernard

Honors Thesis Contribution

The WERC research program was a very rewarding experience for me. This research required working with a large group of people to solve an environmental issue faced in industry. This task was solving the problem of dust emissions on tailings storage facilities. Since our group contained eight people, a lot of coordination and communication was involved in order to make sure the team was working effectively and moving toward the best solution to this problem. Early on in the project, I volunteered to be the Research Coordinator of the project and that is where I made my greatest contribution to the team.

Having eight people on this team, a lot of ideas were bounced around in meetings on how to solve the dust emissions issue. Being the Research Coordinator, it was my goal to make sure that the team was on the same page for what products and materials were to be tested and the experiments that needed to be conducted moving forward. The team started researching these many different possible solutions to the problem the week before the beginning of the Spring 2017 semester. At the time, I had begun to research lingsulfonate and a few other binders as possible solutions to our problem.

After this week of research had been completed, myself and three other individuals on our team went to a mine to learn more about our problem so that our solution would fit the problem exactly. This trip required going to Silver City, New Mexico. This was a very rewarding experience and vastly helped point us in the direction the team needed to go to solve this issue.

After this trip, many more possible solutions were available to the team. Myself and another team member constructed a chart that laid out all of these possible solutions visually so the team could easily keep track of the different solutions to be tested and experiments that needed to be conducted. With this chart of possible solutions, all that needed to be planned was the experiments that needed to be conducted to find the most practical solution.

I helped to brainstorm many possible ways to conduct these experiments and ultimately formulated a set of procedures of how these experiments should be conducted. I made sure that our team stressed the importance of quantitative results of all of the experiments we conducted so that the best solution could be easily chosen. At this point of our research, I suggested that we break off into research groups so that one team could focus on one of our possible solutions and another could focus on the other two.

I joined the team that helped to focus on the pelletizing the tailings as a possible solution. On this team, I helped to make pellets to be tested in our experiments as well as helped perform many experiments to find the best binder for this solution. After a while on this team, we realized that this solution was not economically viable, so we completed all the necessary experiments to show that this solution was not only too expensive, but also not the best solution.

After proving this possible method as not the best solution, we helped the other team to solve for the best binder in our proposed solution, topical spray on the tailings. We helped this team conduct their tests given that there were many tests

for them to conduct due to the overwhelming amount of possible binders.

Ultimately, we found the best binder for topical spray.

Finally, I helped the team to write the research paper so that we could display our results in the best manner. This required me writing on the section my individual team completed and another part of the paper that suggested community outreach as a result of the research. The team then met up multiple times to proofread our paper and make necessary corrections.

With the completed research paper, slides, and experiment apparatuses, we attended the WERC competition in New Mexico. Here, I helped to run experiments in front of judges and peer reviewers. I also helped to Peer review other teams and grade them on their presentations. Our team won first place in our category at this competition.

This research project taught me about the importance of communication, hard work, and organization. In this project, we were given a problem we knew no previous knowledge about. This allowed us to learn about a problem and solve it from scratch. Given many problems in the future will mimic this process, it was a very rewarding experience.

Zakary Galligan

Honors Thesis Reflection

Tailings Dust Emissions

26 April 2017

Tailings Dust Emissions - Reflection

I was a part of an 8 member team that competed in the WERC competition at New Mexico State University. Our task was to mitigate dust emissions at mining facilities. At the beginning of the project in the fall of 2016 each team member was assigned research tasks to accomplish over the winter break. I was assigned to researching all commercial products related to dust control, especially in regards to tailings dust control. I researched over a dozen different commercial products and techniques to find the type of solution each uses to mitigate dust. I also contacted these companies in order to attempt to receive a sample of the product. I successfully obtained three samples. Two from a company named SoilWorks and one from a company named Enviroseal. These products were all different polymers that are used on tailings piles to prevent dust over long periods of time. I also scheduled a conference call with the CEO and Technical Manager of SoilWorks to receive more information on their products. I also kept in contact with SoilWorks throughout the life of the project to receive information on additional questions we had. This information was invaluable to the success of our team. One of the products I obtained from SoilWorks, Gorilla-Snot, was actually our team's final and proposed solution. This product is a vinyl copolymer that is sprayed to the top of tailings piles to form a rigid crust. We were able to perform a full economic analysis on the use of this product at a copper mine with the information I obtained from the representatives at SoilWorks. This successful experience dealing with a commercial vendor was very valuable and will help immensely in my career following graduation.

About halfway through the project, our group leader, Emily Degner, and advisors suggested that the team should split up into two separate groups (a topical spray group and a pelletizing group). I was a part of the pelletizing team and we researched different binders and compositions to make the most durable pellet possible. We tested binders such as bentonite, cement, lignosulfonate, and asphalt. The creation of these pellets took many hours of manual labor involving a push press in our laboratory. I was often tasked with spending multiple evening hours in the laboratory making the pellets. After our hard work, we discovered that a 1.5 wt.% cement pellet was the most economical and most effective pellet we could make. After this discovery we tested the efficacy of the pellets at controlling dust when exposed to high wind speeds. The pellets were determined to not be very effective at controlling dust, and therefore the idea was not recommended to be used at mining facilities.

I also helped the team in writing sections of the paper. I was also responsible for calculating many of the economic information in Microsoft Excel. This economic information was used throughout the paper, presentation, and poster.

I was also proud of the help I provided in preparing our team presenters for the competition. I attended every practice presentation session the team had and aided in the timing.

Reflection

Our team was tasked with determining the most efficient mechanism for mitigating tailings emissions while also minimizing both capital and operating cost. The mechanisms evaluated were pelletizing, adding a binder to the slurry, and applying a topical spray. In order to efficiently and diligently accomplish this task, we divided our team into two groups. One group evaluated the efficacy of slurries and topical sprays while the other group investigated pelletizing. Zak Galligan, Ryan Bernard, Sam Horn, and I made up the pelletizing team. A variety of binders were considered for the pelletizing process: lignosulfonate, bentonite, cement, asphalt, cornstarch, and spray starch. Pellets were produced using a punch and die apparatus along with a hydraulic press, which could generate a pressure of approximately 30,000 psi. After having conducted rain longevity, wind resistance, thermal resistance, and qualitatively friability testing on the pellets, it was determined that cement was the most effective binder for pelletizing.

To better understand the scale of the tailings operation, Sam Horn, Ryan Bernard, Joe Griffin, and I had the opportunity to travel to Silver City, New Mexico where we toured and took tailings samples from the Freeport-McMoRan Chino Mine. I was astonished by the immensity of the copper mine and the tailings storage facility. By experiencing the scale of the tailings operation, we were better able to understand the feasibility of each proposed solution to control dust, particularly in regard to pelletization. Due to the extremely high flow rates from the mine to the tailings storage facility, the sheer volume of the facility, and the abrasive nature of

the tailings, it was determined that pelletizing was likely to be an impractical solution. By seeing and walking along the tailing storage facility, we were more equipped to visualize and create a design basis to accommodate for the incredible volume of the tailings process.

Sam Horn and I also created the process flow diagrams for our proposed bench and full-scale process solutions. Process flow diagrams were produced for the hydrocyclone system, pelletization process, underflow slurry injection, and topical spray treatment. From the process flow diagrams and industrial quotes, both capital and operating cost were determined with the pelletization process being the most expensive and the topical spray solution being the least expensive. Therefore, a topical spray solution was determined to be the most economically feasible and effective mechanism for controlling tailings emissions due to wind sheering. Lastly, I wrote parts of the executive summary and design basis in our final report.

It was a pleasure being part of a team with such intelligent and driven individuals who sacrificed so much of their time in order to produce an extremely thorough report into the mitigation of tailings emissions – a report that would ultimately win first place in our category at the WERC design competition. I am thankful for Dr. Penny and Dr. Ackerson who give up their free time to faithfully and diligently help us as we sought to complete our task. I believe every team is just as good as their team leader/coordinator and we had a great one in Emily Degner. Being part of the design WERC competition was an honor and gave me incredibly valuable experience into solving real world problems. I will take this experience and apply it to my future industrial career.

Natalie Tucker

WERC Competition Project Reflection Essay

April 24th, 2017

To complete my honors thesis, I participated in the WERC Environmental Design Competition in collaboration with seven other senior chemical engineering students on the task of creating an innovative solution to mitigating tailings dust emissions at a mine. This essay will describe my personal contributions to the project during the semester as well as at the design competition.

The project began with researching and brainstorming ideas for the project. I contacted two dust control professionals in Colorado to request information on their current methods of dust control and how their technique was working for them. The contact from Gunnison County gave valuable information on magnesium chloride treatment that we later used in our experimental testing. I was also able to have her audit our paper for the competition as it required at least three auditors. In addition, I also did extensive research on pelletizing and briquetting. We ended up using a combination of the mechanics of the designs I researched in conjunction with other team members' ideas to design our bench scale and full scale pelletizing machine for the competition. For the testing, I contributed to making the spray and slurry samples by calculating an application rate of some of the products as well as physically making the spray and slurry samples. I helped with conducting rain resistance testing to prove the longevity of our product as well as conducting mass retention and dust visibility testing on our samples to prove the efficacy of our product. The testing of our products and analyzing the results of the tests was

how we chose our proposed solution, so it was incredibly important to the overall success of the project.

For the competition, we were required to write a paper explaining and defending our solution and how we came to it, as well as prepare a poster and pamphlet, and a PowerPoint presentation. To prepare for these portions of the project and reporting our proposed solutions, I contributed by calculating some of the operating costs for two possible solutions, the spray method and slurry method. I contributed to the paper specifically by researching the mechanisms and characteristics of many of the products that we tested and summarizing them in the paper. I also wrote the spray testing method portion. I put together the content for the spray method portion of the PowerPoint presentation to send to the team member who was putting the PowerPoint together. Finally, I designed and coordinated the polos that we wore at the competition for both of the University of Arkansas teams and distributed them to each team member.

At the competition in New Mexico I was one of the four presenters for the oral presentation that was worth 25% of our overall score. I also presented the poster for the peer judging portion of the competition.

This paper concludes my most significant contributions to the project as well as the success of our team at the design competition.