Dehumidification Grain Dryer

Federal Manufacturing & Technologies

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G. W. Bohnert

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Final Report/Project Accomplishments Summary

CRADA Number KCP-94-1007, DOE TTI No. 94-KCPP-003-XX

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A prime contractor with the United States

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Dehumidification Grain DryerProduct Formulations Using Recycled Tire Crumb Rubber

Project Accomplishments Summary

CRADA Number KCP-94-1007, DOE TTI No:94-KCPP-003-XX8

Date: 3/30/989/30/97

Revision: 0

A. Parties

The project is a relationship between:

AlliedSignal FM&T

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PO Box 419159

Kansas City, MO 64141-6159

Grain Systems, Inc.Recycled Rubber
ResourcesCompany Name

R.R. 2, Box 161600 Blee Industrial DriveCompany
Address

Elm Creek, NE 68836

Macon, MO 63552City, State, ZIP

B. Background

Depending upon the weather conditions, cereal grain is often dried after harvesting to prevent spoilage during storage. Since field losses increase as the crop is allowed to dry naturally, early harvesting at higher moisture levels followed by artificial drying is advantageous. However, grain drying is energy intensive and therefore represents a significant cost to the grain producer.

In the US, approximately 5 billion bushels of corn are dried annually. Conventional grain dryers are natural gas or propane fired, typically consume 3,000 BTU/pound of water removed, and thus add between 8 to 13 cents per bushel to the grain production costs. Drying temperatures within these dryers often exceed 220° F, which can stress grain kernels, resulting in breakage and reducing their value.

A new technique developed during this project dries grain with mildly heated, dehumidified air in a closed-loop process. This proposed technique uses about one-tenth the energy and dries grain at a lower temperature, producing less damage to the kernels. Approximately 250 million automotive and truck tires are discarded each year in the U.S. The very properties that ensure a safe ride and long service life make the disposal of these scrap tires difficult. In spite of this, scrap tire recycling/reuse has rapidly grown from 10% in 1985 to over 90% today. The majority of scrap tires that are recycled/reused are burned for fuel in power plants and cement kilns. Since tires have somewhat higher heating value than coal, this would at first seem to be an acceptable option. But burning scrap tires recovers only 25% of the energy originally used to manufacture the rubber. An alternative is to use the scrap tires in the form of crumb rubber, by which 98% of the original energy is recovered. This project sought to explore potential formulations of crumb rubber with various thermoplastic binders, with one goal being developing a material for a low-cost, high-performance roofing composition. [What was the state-of-the-art of the product/process prior to initiation of the project? Why was the project needed (e.g., performance, quality, cost, time to market)? Describe the strengths and interests of each party and how they are complementary with respect to the project.]What KCP expertise was needed and how did it complement the partner's capabilities?]

C. Description

This grain drying system reduces the moisture content of grain using mildly heated, dehumidified air in a self-contained, closed-loop process. The drying process can be designed for either batch or continuous flow. In operation, the process air is first dehumidified by the evaporator coils of a refrigeration system, then heated by the condenser coils, and finally forced through the bed of grain to be dried. As the heated, dehumidified air passes through the grain bed, it warms the grain, evaporates moisture, and transports the moisture away. The now saturated air from the grain bed is directed through a heat exchanger, then back through the evaporator coils, both cooling and condensing water out of the process air. The latent heat energy necessary to evaporate moisture from the grain is recovered by subsequent water condensation on the evaporator coils. Theoretical calculations predict energy requirements near 300 BTU per pound of water removed, or about one tenth the amount for a conventional gas fired dryer.

The entire grain drying system is enclosed in an insulated, concrete dome or other suitable structure. Efficiency of the process is enhanced by using an air-to-air heat exchanger between the evaporator and condenser. A trim condenser is incorporated within the refrigeration system to reject excess heat outside the system boundary, providing balance to the system. Because the entire process is self-contained, an added advantage to this drying technique is that inert gas such as N₂ or CO₂ can be introduced into the process air stream, producing an oxygen-deficient atmosphere which will inhibit insect infestation. This latter point is becoming more important as hazardous chemical insecticides and ozone-depleting chemicals like methyl bromide are being phased out for pest control.

The feasibility of this novel process was initially predicted by an energy balance drawn up for the entire system. This mass and energy balance is shown in Figure 1. Predictions from this calculation show that to dry 25% moisture content corn to 15.5% moisture requires only 295 BTU for every pound of water removed. This requires 64 hp for the compressor and 14 hp for the circulating fan for every 100 bushels/hr of corn to be dried. Approximately 7 pounds of water would be removed per bushel of corn during this example. Figure 2 shows a conceptual drawing of what the process might look like in practice, within a totally enclosed, concrete dome.

The first part of this project involved Grain Systems, Inc. contacting the Nebraska Energy Office for financial assistance. This assistance was obtained based upon the calculations for predicted performance from AlliedSignal FM&T. Grain Systems also sought and obtained additional funding through EPRI (The Electric Power Research Institute).

Also contacted for advice and experience were researchers at the U.S. Department of Agriculture's Grain Marketing Research Lab (GMRL) in Manhattan, KS (Figure 3). Discussions were held several times regarding the techniques of drying grain, including airflow, pressure drops, insect infestation, mold development, grain flow in the dryer, among other topics. During the course of our discussions, these researchers saw merits in the proposed process and chose to construct a pilot plant unit for evaluation purposes. They initiated a CRADA with Grain Systems to support this project.

The site selected for the pilot unit was at the GMRL facilities at Manhattan. AlliedSignal FM&T contributed to the project by specifying and sizing the major pieces of equipment. A representative from Des Champs Lab in Natural Bridge Station, VA, also joined in the project, with the intent of constructing the bulk of the refrigeration and air handling ductwork. After some negotiation they did construct a frame with evaporator, condenser, and heat exchanger. Other equipment was purchased to complete the unit and the unit was completed in Manhattan. The process was started in March 1998, and temperatures were as planned. From this point, additional work will be performed by the USDA GMRL facility to fully characterize the unit.

Figure 1

Figure 2

Figure 3

D. Expected Economic Impact

There are 5 billion bushels of corn dried each year in the United States. Not all of this would be suitable for drying by this process, since lower drying temperature equates to longer drying times. However, at a savings of 10 cents per bushel, this still amounts to \$50 million, if only 10% of the total were dried by this technique. This process would have similar savings in paper, lumber, plastic resin industries, as well as other agricultural products such as peanuts, fruits, rice, beans, etc. [What were the direct benefits to the Participant? When, by Whom and to What extent will the results be applied? Discuss the impact to the company, industry, the economy in terms of jobs created, revenues, environmental benefits, etc. What are expected benefits to consumer/taxpayer? (See closeout manual)]

E. Benefits to DOE

This project has enhanced the skills of FM&T technical staff in areas of chemical process design, heat transfer technology, equipment specification, and refrigeration cycles. These skills developed during this project are useful at FM&T Bldg 15 Polymer Manufacturing Facility (drying of specialty polymers) and in the Materials Engineering laboratory. This work also complements FM&T's Quality policy goals of respecting the environment and reducing waste, through energy conservation.[What products or processes used in the manufacture of DP products were developed/improved as a result of this project. How does this project support strategic R&D goals, core competencies and plans at KCP? Discuss the value of the partnership. Was the technology developed faster/cheaper/better because of the partnership? Would FM&T have been involved in this type of project without a partnership? Why? Describe benefits that can be shared with the public (e.g. improved software codes that will allow weapons surety without the need for testing.)]

F. Industry Area

The industries benefiting from this project include farmers, grain processors, and manufacturers of grain handling equipment.[As appropriate, indicate industry(ies) benefiting from this project (i.e. automotive, aerospace, electronics, medical, software, etc.)]

G. Project Status

This project has been completed as scheduled.[Indicate whether the project was completed as scheduled or terminated.]

H. Point of Contact for Project Information

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I. Company Size and Point of Contact

Grain Systems, Inc. is a small business of fewer than 10 employees. The point of contact at Grain Systems is Daryl Calkins [(308) 856-4639]. [Provide names of industrial partners, annual sales, number of employees and the name, phone and fax numbers of personnel responsible for the project. Indicate which participant personnel would be willing to provide feedback regarding project success.]

J. Project Examples

The outcome of this project is a pilot plant unit capable of drying 10 bushels/hr of corn from 25% to 15.5% moisture content. This unit is available for display and demonstration at the USDA Grain Marketing Research Lab in Manhattan, KS.[Are there tangible items related to the project which could be used in a "show & tell" situation (e.g. congressional testimony)? If there are photographs which help tell the story, please provide a copy.]

K. Technology Commercialization

Grain Systems, Inc. will commercialize this process as pilot plant testing proceeds and displays the advantages of this process.[Is it expected that a product or process will be commercialized as a result of this project? If yes, provide a commercialization plan.]

L. Release of Information

I have reviewed the attached Project Accomplishment Summary prepared by AlliedSignal FM&T and agree that the information about our CRADA may be released for external distribution.

Original signed by Daryl Calkins 28 April 1998

Name: Daryl Calkins Date

Organization: Grain Systems, Inc.