FINAL TECHNICAL REPORT

INTRODUCTION:

Drying Technology, Inc. was awarded a grant for the purpose of extending DELTA T dryer/moisture control technology into additional industries. Ultimate purpose of the grant was to save energy and improve efficiency in the process industries. Results indicate that these objectives have been met and will continue as this new technology is duplicated in the present industries and also is extended into other industries as well.

UNIQUE ADVANTAGE OF THE DELTA T:

The DELTA T dryer/moisture control system is a patented method for controlling moisture content from industrial dryers, both batch and continuous. It is based on the models,

\[ M = K_1(\Delta T)^p - K_2/S^q \text{ for continuous dryers} \]
\[ M = K_1(\Delta T)^p - K_3(D)^r \text{ for batch dryers} \]

that enable the determination of moisture inside hot, dirty and space-limited dryers, where it would be impossible or impractical to install conventional moisture sensors. There are no moisture sensors on the market that are as flexible with regards to installation inside dryers. The importance of being able to measure moisture inside the dryer renders the present practice of using feedback control systems obsolete, and it eliminates the need for expensive feedback loops. As a consequence of this advantage, the DELTA T enables the narrowing of the moisture distribution which, in most cases, allows the average moisture content to be increased. As a result, production is increased, unit energy consumption is decreased, and quality is improved. A rule of thumb is for every 1% increase in average moisture content of the product, the energy consumption can be decreased about 10% and the production can be increased about 7.5%.

SCOPE OF THE GRANT:

Originally, we proposed to install trial DELTA T control systems on four different applications in three industries: (1) carpet drying, (2) a Yankee hood dryer and a lime mud kiln in the pulp & paper industry, and (3) a pharmaceutical dryer. For reasons beyond our control, we had to change from the pharmaceutical dryer to a pet food dryer.

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RESULTS OF THE TRIAL INSTALLATIONS:

A) Installation of a DELTA T on a Carpet Dryer at Shaw Industries, Cartersville, GA.

This has been quite successful. It has been operating since February 1992 and results reveal energy savings of 17.4%. After adjustments are made for production increases, the energy savings are estimated at about 20%. This translates into approximately 9 billion BTUs per year. Total energy savings if all dryers were controlled by the DELTA T can be estimated by use of the savings factor of 12.5 BTU/Sq Yd/Oz. Additionally, production was increased by about 15%.

In an effort to make this technology known to the industry, the following activities have been performed:

1) A paper (copy attached, exhibit A) reporting the results of the installation on a carpet dryer was given at the High Tech. Textile meeting in Greenville, SC, June 1993.

2) Drying Technology, Inc., rented a booth at the first Carpet Machinery Show held in Dalton, GA. in 1994 and will be going back in 1995.

3) A paper, Control of Moisture Content in Textile Dryers, was published in the July 1994 issue of American Dyestuff Reporter. (Exhibit B)

4) Several advertisements have been placed in Carpet & Rug, Floor Focus and in American Dyestuff Reporter. (exhibit C)

5) We have obtained representation in the textile industry.

6) We may export our first DELTA T for the carpet industry to Canada and Mexico during 1995. We have two excellent contacts who are quite interested. We already have increased our exports to Canada in the forest products field during 1994.

All of the above activities have enabled us to quote several jobs. We have one rental purchase system going in on a fabric tenter frame dryer at Burlington House Finishing, Burlington, NC, July 1995. We expect a few sales during 1995 that will further demonstrate the effectiveness of the DELTA T to the industry.

B) Lime Mud kiln Control at Temple-Inland Paper Mill, Evadale, TX.

A lime mud kiln in a paper mill converts the calcium carbonate by-product to calcium oxide which is then used in preparation of the chemicals (sodium hydrosulfide and sodium hydroxide) that are used for pulping the wood. Wet calcium carbonate mud is fed into one end of a rotating drum and flows counter to the flow of hot air entering from the
opposite end of the kiln. Present control systems usually control the hot end temperature by manipulating the gas valve. The cold end temperature is controlled by manipulating the exit gas damper. A coupling effect is created between the two loops as well as a large lag. Such systems are infrequently placed on automatic control.

Our approach was to recognize that as the mud travels through the kiln it first goes through a drying stage, followed by heating, calcining and burning stages. The kiln length is finite and in order to obtain a product that is properly calcined and burned, the length of each zone must not interfere with the other. Therefore, the drying zone must be properly controlled. We accomplish this by treating the kiln as a dryer and measuring the delta t across the kiln and use this parameter for controlling the coldside temperature by manipulating the draft damper.

We have successfully operated the control system. Energy use comparisons are not available but indications are that we could probably decrease energy consumption by 2 - 4% if placed on a more up-to-date kiln with the capability of measuring fuel consumption. One problem encountered during the study was the requirement to maintain Total Reduced Sulfur below a setpoint value. This constraint militated against making the kiln energy efficient. We were unable to sell the customer a DELTA T control system because of the age of the kiln. We have not been able to obtain as much data as desirable; however, our view is that we have proven that the DELTA T applies quite well to this operation, know how to design a control system, and we intend to perform the following activities in an effort to exploit this application:

1) Write a paper and present to TAPPI, Technical Association of the Pulp & Paper Industry, for publicity purposes.

2) Continue advertising as before (exhibit D).

3) Attempt to place a DELTA T system at a mill on a rental/purchase plan.

C. Installation of a DELTA T on a Pet Food Dryer at Doan Products, Temple, Texas.

We installed a DELTA T on a pet food dryer at Doan Products, Temple, Tx. This system has been monitoring the operation for some time and was placed on control the week of December 12, 1994. Preliminary indications are that it is performing quite well and energy savings of from 8 to 13 billion BTUs per year can be saved. As a result of this installation, we have accomplished the following:

1)Received a request for a rental/purchase proposal from Ralston-Purina, a large pet food company. I visited their main office in late November 1994.
2) Received numerous inquiries from other pet food companies as a result of advertising and participation in Powder and Bulk Solids Show in Chicago, Houston and Atlanta in 1993 and 1994.

3) Established a representative to call on potential pet food manufacturers in the Western States and part of the Midwest.

Our success in this field should open up this industry during the 1995.

D) **Installation of a DELTA T on A Yankee Hood Dryer at Thilmany Paper Co. in Wisconsin.**

This has not been a successful venture because the customer was not willing to allow us to place the system on control. They claimed that the dryer was being shut down and it was not possible to run it on control after the installation was complete. The hardware was returned to us and we will try and place it in an industrial trial somewhere.

**SUMMARY OF RESULTS AND CONCLUSIONS:**

Overall, the grant has been beneficial in extending this energy-saving technology into other industries. The potential for further extension is almost unlimited. At least one-hundred process industries would profit from this new way of controlling dryers. All that is needed is to get the word out and demonstrate to them that it applies to their particular drying operation. We expect by about 1996 to see a geometric expansion rate.

At the present, we have over 100 DELTA T installations in such industries as forest products, rayon fibers, chemicals, carpet, food, pulp & paper and pet food. During 1995 we expect to increase DELTA T installations in established industries, add installations in those industries that have only one DELTA T installation and to extend into new industries.

We have established that:

1) The DELTA T is universally applicable to most products and dryer-types.

2) The DELTA T is superior to any type of dryer/moisture control system available at this time. It renders feedback control (most prevalent control) obsolete and eliminates the need for expensive feedforward loops.

3) It has the inherent ability to significantly improve dryer/moisture control which enables: (1) a reduction in energy, (2) an increase in production, and (3) improves quality.
4) It offers a unique method for sensing moisture content of products inside dirty, hot and space-limited dryers, using simple and rugged temperature sensors.

We recently entered into negotiations with Whirlpool Corporation concerning the use of DELTA T technology on their domestic dryers. We have purchased a home clothes dryer and presently conducting test runs. If successful, this could significantly reduce energy consumption and enhance US exports because of superior technology. They manufacture approximately one-half million units a year.

Additionally, we are presently negotiating with a major dryer manufacturer in the forest products industry regarding placing of a DELTA T on all new dryer installations as well as a sales agreement for retrofits. This will give us access to foreign market which we have not been able to handle because of the lack of proper expertise and staff. Exports should begin to expand if this agreement is reached.

Future plans are to contact a major US manufacturer of single loop off-the-shelf process controllers with the idea of producing a simple, economical dryer controller based on the DELTA T principle. This would speed up introduction to DELTA T technology into many other industries.

Finally, it may be concluded that the DELTA T has the inherent ability to save significant amounts of energy in all cases. Industrial drying consumes approximately one quad \((10^{15}\text{ BTUs})\) of fossil fuel energy annually. An expected reduction in energy consumption of from 15 - 20\% could be made by application of the DELTA T which would translate into savings of approximately 30 - 40 million barrels of oil per year.

John W. Robinson