DEW SIMULATION FOR HAY BALING OPERATIONS PURPOSE, PROCESS AND CONTROL

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ABSTRACT

To overcome problems relating to the maintenance of proper moisture conditions of hay during hay baling operations the Dew Simulation Process has been developed and patented. This is a controllable process which allows the creation of ideal baling conditions at any time of the day or night as long as the hay to be baled is sufficiently dry at the time of baling. Dew Simulation is accomplished by the use of a tractor, a mobile steam generating system and a hay baler equipped with a steam injection system. These three major components are attached together in series and work as a single unit with one operator. As the operator commences the baling operation, a controlled volume of steam produced by the steam generating system is injected into the hay as it is lifted from the windrow and passes through the feed system of the baler. The steam utilized to treat the hay passes through a series of nozzle equipped manifolds which are located at various positions above and below the pick-up mechanism and feed chamber of the baler. As the hay is baled the operator is able to monitor bale moisture and make necessary steam flow adjustments from the tractor seat on the fly to maintain consistent ideal baling conditions even in varying ambient conditions which occur during different times of the day or night..

Key Words: alfalfa, baling, baling moisture, precision farming, hay quality, quality control, steam, dew, dew simulation

THE PROBLEM

In Hay Production Operations the producer is faced with many obstacles as he attempts to harvest, cure, bale and store high quality feed. Weather, atmospheric conditions and machinery requirements are a few of the major challenges. Hay is especially challenging with one of the most difficult conditions being the proper moisture requirement for the baling process.

Until now, the producer has had to rely almost totally upon the natural dew process to get proper moisture conditions for hay baling operations, especially in Alfalfa and similar leafy legume type forages.

In the more arid western states of the U.S. and other dry areas of the world this becomes a devastating problem at times when atmospheric conditions just will not allow dew formation. Baling such forages dry causes a huge loss of the most valuable leafy portion of the forage, the shattering of the stemmed portion, loss of protein and other feed values, extreme difficulty in loading, hauling and feeding and great losses in market value.

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Conversely, at other times the problem makes a 'radical' swing in the other direction with good dew conditions for baling coming on early in the evening, only to become to wet within an hour or so, forcing the operator to stop and wait to bale until the next day or to face expensive crop spoilage.

Very seldom can a producer count on natural dew to provide what would be considered as "Near Perfect" baling moisture. Even the window of "Tolerable" baling moisture is usually quite small during any 24 hour period. Consequently, producers who wish to put up reasonably good quality hay crops are forced purchase enough tractors and hay balers to complete baling processes within the small window of time when tolerable moisture conditions prevail. Even in the best of operations there is normally a substantial percentage of hay crops either lost or heavily devalued due to moisture problems.

THE SOLUTION

Dew Simulation in agricultural hay production is a process of adding moisture in the form of steam vapor to dry crop material during the baling process. In baling operations where a small amount of moisture is desirable in the tissues of dried forages, Dew Simulation empowers producers to effectively maintain high quality moisture conditions consistently in forage feeds such as alfalfa and grass type forages.

The Dew Simulation process uses steam as the main reactive moisture source because

The properties of steam enable it to be absorbed instantly by dry plant tissue.

2. Steam has a volume of approximately 1000 times more volume by weight than water as a liquid and thus allows thorough treatment of the hay with steam vapor as it is baled without over wetting.

Utilizing the high volume of the injected steam in a well-designed injector arrangement every surface of the plant tissue comes in contact with steam vapor. Because of the temperature differential between the injected steam and the dry plant tissue as the steam makes this contact, it immediately condenses on the cooler surface of the plant tissue causing instant absorption. This process provides baling moisture of a very high quality and allows for adding more or less moisture as ambient conditions demand, on a predictable, controllable and consistent basis.

Prior attempts by farmers to put moisture into their dry windrows of hay before baling, by spraying it with a small amount of water prior to baling have had little success since the absorption rate is so slow and penetration of the moisture into the plant tissue within a practical time frame is impossible.

THE METHOD

Though quite simplistic in principle the Dew Simulation process is extremely effective in changing dry, brittle hay to an ideal soft, slightly moist state for baling. This effect is created instantly during the baling process.

Research and field testing has proven that while steam absorbs very rapidly into dry hay tissue it also evaporates off from these same plant tissues very quickly. This is especially true in dry, windy conditions. Under most conditions it is not possible to effectively steam treat hay for baling while it lies in the windrow ahead of a hay baler. Sufficient moisture will not remain in the hay long enough to pick it up from the windrow, move it through the feed chamber and into the bale chamber.

Thus through the Dew Simulation Process as defined here, steam is delivered to the dry hay through a series of injection manifolds mounted at various points above and below the baler pickup mechanism and feed chamber. As the hay is lifted from the windrow and is moved through the feed chamber of the baler a continuous, controlled amount of steam is injected to bring the hay to a predetermined moisture level. The softened hay is then moved into the bale chamber or flake forming chamber (as in some large square balers) where it is compressed at which point the small percentage of added moisture is retained in the hay.

This final moisture level in the bale is then monitored as the bale is pushed through the bale chamber to enable the operator to make adjustments to the steam application rate as needed to maintain a consistent moisture level in his bales from start to finish. Remote monitoring and control functions of the machinery are accessible to the operator on the go through metering and control components mounted near the drivers seat.

The convenience and effectiveness of the Dew Simulation Process is truly astounding. It adds a level of control and flexibility that has never been possible before. We believe this new technology will revolutionize commercial hay production in the western United States and in other arid areas of the world.

THE ADVANTAGES

Dew Simulation overcomes many of the hay production problems of the western U S. in several ways.

First: Using Dew Simulation a producer can bale hay at any time after the hay is dry with no need to wait for natural dew to form. Addition of moisture through this process can be regulated according to the need, meaning that a baler can usually be operated for 24 hours a day if necessary (including normal machinery maintenance) except in cases where natural dew becomes too heavy.

Second: The Dew Simulation process is the first method developed that will allow the monitoring and maintenance of consistent moisture percentages in the finished product from the first bale to the last one during an extended time frame.

Third: Dew Simulation makes automated bale handling and hauling operations cleaner and easier and minimizes hay dust, during baling, handling, transport and feeding operations. Each flake of the bale is more defined and compact, minimizing leaf loss and waste during handling and feeding. This improved bale quality is possible because when using steam to moisturize the hay as it is baled you can simulate a very high moisture level of around 20-25% while baling, without raising the actual moisture level above 15%. This effect is consistently replicated as long as the hay is well cured and natural dew is not too heavy at baling time.

Fourth: Dew Simulation provides very significant benefits with regards to storage and truck and ship transport of hay. As mentioned above, using this process to provide your baling moisture, you can normally bale with a 20-25% moisture reading which provides excellent baling conditions. Yet within just a day or two the moisture reading of the same bales will drop to less than 15%, an acceptable level for storage and shipping. Also, when using steam, bale density can be increased by 30 to 50% if desired, while baling at the same speed and utilizing the same horsepower. Increased bale density allows many more tons of hay to be stored under valuable barn space and fewer bales needed on trucks to reach legal weight limits.

Fifth: Dew Simulation can cut a producer's tractor and baler requirements by 50% or more because the window of time when baling can be done is expanded from a normal length of 4-6 hours when natural dew is normally present, to nearly 24 hours in any given day. Thus the cost of the Dew Simulation machinery and the cost to operate it is more than offset in reduced overall machinery and labor requirements.

Sixth: Most hay farmers in the west have endured periods of harvest time when there simply is no natural dew for several days or longer. The loss in the value of a good crop of hay can be devastating to the bottom line. With this process a farmer who bales hay will never again have to choose between baling without dew or selling his over dried hay short for $20-40 less per ton. Any Farmer who is skilled in farm finance knows that it is the extra few dollars per ton of hay, the additional ton per acre, or the little bit of added efficiency that really makes the difference in his profit margin.

COST OF OPERATION

I have calculated the cost of operation of the Dew Simulation Process on a "Cost per Ton of Hay Processed" basis under maximum steam application conditions. Therefore the actual cost of operation is usually somewhat less than the following figures because there will be times under marginal ambient conditions when less steam will be applied to the hay to bring it up to an ideal moisture content for baling.

Under very dry and adverse conditions you will normally add 80 to 100 lbs. of steam per ton of hay to achieve "Ideal" moisture levels for baling. This will require #2 diesel fuel consumption of 1 to 1.25 gallons per ton of hay to convert the water to steam.

Cost of operation per Ton of Hay Processed at maximum steam application.

Fuel Cost/ton @ $1.00/gal.	$1.2500
Average Cost/ton to soften water for boiler	$.0060
Average Cost/ton to chemically treat boiler water for scale suspension	$.0600
TOTAL COST PER TON	$1.3160

COST OF SUPPORT EQUIPMENT

The only support equipment necessary would be a soft water treatment setup and possibly a water storage and/or transport setup.

Commercial high capacity water softener systems capable of treating up to 5000 gallons of water per charge at the rate of 100 gallons per minute are available for $3000-$4000. These could be utilized without a nurse tank by mounting the transfer tank of the softener on a small trailer or skid so it can be taken to any field to load the steam generator supply tanks directly from an irrigation mainline in the field as needed. A softener of this type could conceivable service two 1 Ton Baler/Steamer units or four 3 string Baler/Steamer units.

Of course residential type softeners could be used in conjunction with mobile or stationary nurse tanks. These smaller softeners are typically $15-$20 per month to rent or $1000 -$1500 to purchase.

Nurse tanks are available from $300 for 1000 gallon tanks to $800 for 2500 gallon tanks.

Many farms will already have storage tanks and/or water trucks

COST COMPARISON OF EQUIPMENT

This is an analysis which cannot be conducted scientifically because there are too many variable factors in the equation. Some of the variables are:

Timely removal of the crop being harvested to allow irrigation and regrowth of the next hay crop as soon as possible

2. Whether or not a producer can keep a consistent cutting schedule between crops to maximize feed values
3. The ability or inability to bale large quantities of high quality hay ahead of afternoon or evening thunder showers
4. The ability or inability to bale high quality hay when natural dew formation is insufficient
5. The ability or inability to raise feed values substantially in hay crops above what can be achieved even with perfect natural dew conditions

These are just a few factors that can make a substantial difference in the bottom line of a producer. As you know, the lack of the right equipment in the agriculture industry can cost far more than the cost of the right equipment. When 1000 tons of hay are devalued by $30-$40 per ton just because there was no natural dew for a few days or a week (a common scenario) a heavy toll is taken. Dew Simulation gives the producer a greater ability to do all of the things listed above much easier.

However, to attempt a standard cost comparison. The following would be likely scenarios:

On a 2000 Acre Hay Farm which uses 1-ton balers cutting and raking are not the hold-up since these two operations can be done in a large window of time each day if managed properly. Baling is the most common problem since under conventional methods the window of tolerable baling conditions is usually quite small at 3-6 hours per day.

Scenario A

Includes 4 Tractor/1-Ton Baler combinations @ $200,000 each = $800,000 outlay to try to meet baling demands under a conventional system. The baling capacity is 30 ton/hr per unit. Even all this equipment still would not guarantee ideal baling conditions at any time. Note the likely number of days needed to complete the baling of each crop. In many cases a 10 day baling time of the first crop could substantially reduce 4th crop yields due to lost growing days at the end of the season.

1st crop @ 3 ton/acre = 6000 ton = 50 hrs/unit	@ 5 hrs/day	=10 days baling time
2nd crop@ 2 ton/acre = 4000 ton = 33 hrs/unit	@ 5 hrs/day	=6.5 days baling time
3rd crop@ 2 ton/acre = 4000 ton = 33 hrs/unit	@ 5 hrs/day	=6.5 days baling time
4th crop @ 1 ton/acre = 2000 ton = 17 hrs/unit	@ 5 hrs/day	=3.5 days baling time

Scenario B

Includes 2 Tractor/Dew Simulator/1-Ton Baler combinations @ $280,000 each = $560,000 outlay to meet baling demands under the Dew Simulation System. The baling capacity is 30 ton/hr per unit. This system would guarantee Ideal baling conditions at all times, barring rain or disaster. The ability of this producer to complete all 4 crops of hay in 5 days each would lengthen his 4th crop growing time as well as allow him to start water sooner and help keep his cutting intervals consistent.

1st crop @ 3 ton/acre = 6000 ton = 100 hrs/unit	@ 20 hrs/day	=5 days baling time
2nd crop@ 2 ton/acre = 4000 ton = 66 hrs/unit	@ 13 hrs/day	=5 days baling time
3rd crop@ 2 ton/acre = 4000 ton = 66 hrs/unit	@ 13 hrs/day	=5 days baling time
4th crop @ 1 ton/acre = 2000 ton = 33 hrs/unit	@ 7 hrs/day	=5 days baling time

The value of the hay in Scenario B would very likely be at least $10.00 higher on average due to all the possible factors. The added crop value for the year would be an additional $160,000.00. Considering hay quality, feed value, cutting schedules, capital outlay etc., what is the real difference in the cost comparison?

HAY TEST COMPARISONS

Those users who have run side by side feed tests on hay baled with the Dew Simulation Process vs. hay baled with good natural dew have consistently found that the hay baled using Dew Simulation has higher feed value ratings. Data collected from several users in 1997 indicate the following increases in side by side comparisons. These increases in feed values are likely due to better leaf retention in the steam treated hay.

-Crude Protein is from 1-3% higher in steamed hay
-TDN Value is 1-3 points higher in steamed hay
-Relative Feed Value has ranged from 10-30 points higher

We have not done enough testing to establish a firm conclusion at this time on feed value comparisons. However we fully expect to find a consistent increase of feed value in steamed hay over natural dew baled hay.

SUMMARY

Dew Simulation as discussed here has been under developement since 1994 and was field operable through a prototype in 1995 with a 3-string baler. In 1996 two, more advanced prototypes were successfully tested on a 3-string and a 1-Ton square baler respectively. In 1997 nine more upgraded units were built and placed in Idaho, Utah and Nevada. This process has proven very effective in all these areas as a revolutionary new concept in commercial hay production. On one operation in Idaho two units coupled with 1-Ton square balers are servicing over 3000 acres of hay. This may portray some idea of the effectiveness and efficiency of the process.

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