Unbalanced Airflow Effects On Multi-Trailer Peanut Dryers[1]

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ABSTRACT

Airflow rates through each plenum port of 71 peanut dryers were measured *in situ* and ranged from 5 to 15 m^3/min/m^3. Dryers with one fan, or two fans in tandem, and with four or more plenum ports had lower airflow rates through the two ports closest to the fan(s) than through the other ports unless there was a V-shaped baffle in the plenum. Airflow rates were nearly equal in dryers with baffles. Simulation results for curing peanuts from 25 to 10% moisture content predicted a reduction in curing time from 61 to 46 h as airflow rate increased from 5 to 10 m^3/min/m^3. Little reduction in curing time resulted from increasing airflow rates above 10 m^3/min/m^3. Electrical energy consumption increased from 17 to 246 kWh/trailer and LP-gas consumption increased from 135 to 274 L/trailer as airflow rate increased from 5 to 15 m^3/min/m^3. Installing a baffle in a dryer to balance the airflow rates to individual drying trailers resulted in seasonal curing time and energy savings ranging from 0.5% to 3.5% for dryers with average airflow deviations. Economic return from installing a baffle in a dryer should pay for the cost of installation in one to three years.

Key Words: Airflow, dryer, curing, peanuts, computer simulation, energy consumption.

Typical commercially-built peanut dryers used by Virginia and North Carolina growers consist of a fan and burner unit attached to the end of the dryer plenum [1.8-m diameter horizontal steel cylinder], with two to four trailer port openings along each side of the plenum. Either a single fan or two fans parallel-mounted are used on each dryer. These fans are propeller-type or vane-axial with three to nine blades and are driven by 3.7 to 15 kW electric motors. A LP-gas burner downstream from each fan heats the air entering the dryer plenum. Heated air exits the plenum through ports which can be opened or closed by a sliding gate. Ports are spaced 3 m apart with openings approximately 74 cm square. The first plenum port is approximately 1.8 m downstream from the heated air entrance. A flexible canvas duct is used as a transition between the plenum port and the trailer.

In the Virginia-Carolina growing region, the moisture content of peanut pods at the start of in-trailer curing will typically be between 20 and 30%, wet basis (w.b.). Trailer curing continues for two to four days until the average moisture content of the peanut kernels is 10% or less. At 25% pod moisture content, the minimum recommended airflow rate for trailer curing is 10 m^3/min for each cubic meter of peanuts in the trailer (14). A typical peanut trailer is 4.3 m long, 2.3 m wide, and is filled to a 1.5 m depth; consequently, the minimum recommended total airflow per trailer is 148 m^3/min.

Vaughan *et al.* (17) found that in dryers with four to eight ports, less air flowed through the two ports closest to the fan than in the remaining ports, unless a baffle was installed in the dryer plenum. They reported that a six-trailer dryer with a 7.5 kW fan had airflow through individual trailer ports ranging from 10% below to 7% above the mean port airflow (balanced airflow) without a baffle, and ranging from 2% below to 3% above the balanced airflow with a baffle. Similarly, for a six-trailer dryer with a 5.6 kW fan, individual port airflow ranged from 29% below to 15% above the balanced airflow without a baffle, and from 3% below to 10% above the balanced airflow with a baffle. Due to this non-uniform airflow distribution, peanuts in some trailers were receiving less than the minimum recommended airflow.

Blankenship and Pearson (4) found that time required to cure a trailer of peanuts increased as airflow rate decreased. Blankenship and Chew (3) reported that LP-gas consumption decreased when airflow rate decreased. The difference in moisture content between peanuts at the bottom and top of a trailer increases as airflow rate decreases (2). Milling quality decreases when low airflow causes the bottom peanuts to be overdried in order to get the average moisture content for a trailer to 10% (8).

This study determined how unbalanced airflows in multi-trailer peanut dryers affect the curing process, and how installing a baffle to balance the airflow can improve performance. Specific objectives were:

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1. Determine degree and range of port airflows in commercial dryers by analyzing airflow data collected *in situ* from at least 60 units on Virginia farms.
2. Determine functional realtionships between airflow rate and curing time, energy use, and moisture content distribution based upon results of a simulation using a bulk curing model.
3. Determine the effects of balancing airflow on curing time and energy use, and thus determine the annual payback for installing a baffle to balance the airflow in a multi-trailer peanut dryer.

Materials and Methods

In Situ Testing of Peanut Dryer Fans

Procedures given in ASAE Standard S488 (1) were used to measure port airflows in 71 peanut dryers *in situ* in Virginia. Rather than using the plate design suggested in the standard, plates used to emulate the resistance of a trailer of peanuts were constructed using two layers of 11.8 meshes/cm (30 meshes/in.) galavanized steel wirecloth supported by a 1.9 cm (0.75 in.) grid wire screen. Kulasiri *et al.* (11) showed that the wire screens produced a resistance to airflow curve equivalent to a trailer filled with peanuts, and were more durable than the cheesecloth specified in the standard. Briefly, the procedure was as follows. Collars with the calibrated resistance plates attached to the downstream side were placed on stands in front of each plenum port (Fig. 1). The canvas duct which normally connects to the trailer plenum was connected to the upstream side of the collar. Pressure drop across the resistance plate was measured with an inclined manometer, and this pressure was referenced to a calibration equation to obtain total flow out each port. Barometric pressure was obtained from the Agro-environmental Monitoring System (AEMS), which has three recording sites across the region where the tests were conducted. Barometric pressure from the weather station site nearest the test site (grower's farm), and dry bulb and wet bulb temperatures measured with thermistors at the fan inlet, were used to correct measured airflow to airflow at standard conditions [dry bulb temperature = 20 C, relative humidity = 50%, and barometric pressure = 101.3 kPa].

Dryers with up to eight ports were tested. All equipment (8 collars with calibrated resistance plates, stands, and instrumentation) was loaded onto a pickup truck for transport to the grower's farm, and tests were conducted by two college students.

Balanced airflow rate for each dryer was defined as the mean of the individual port airflow rates. For consistency, port airflow is presented as m³/min per m³ of peanuts in a typical peanut trailer, defined as a trailer 4.3 m long and 2.3 m wide filled to a 1.5 m depth.

$$Q_b = \left(\sum_{i=1}^{N} Q_i \right) / N \qquad [1]$$

where,

Q_b = balanced airflow rate for the dryer ($m^3/min/m^3$),
Q_i = individual port airflow rates ($m^3/min/m^3$), and
N = number of plenum ports on the dryer.

Percent deviation from balanced flow at the *i*th port was defined by:

$$DEV_i = 100[Q_i - Q_b)/Q_b] \qquad [2]$$

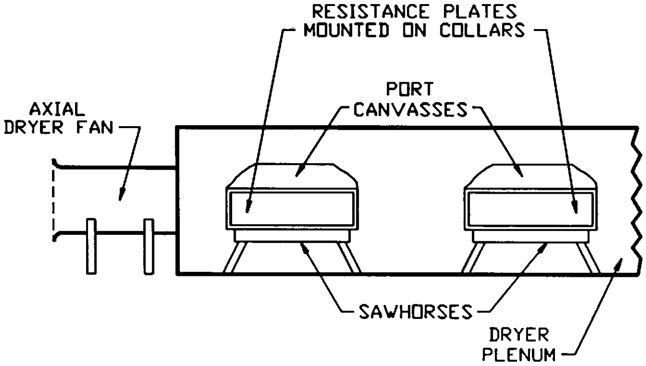

Fig. 1. Commercial dryer with resistance plates in place for *in situ* testing.

where,

DEV_i = deviation from balanced flow at the ith port (%).

Simulation of Peanut Curing

A grower knows which trailers on his dryer take longer to dry, and intuitively knows that these ports have lower airflow. In order to compute the "cost" of this lower airflow, both in terms of lost dryer capacity and possibility of reduced quality due to the slower drying rate, a procedure was developed to relate drying differences to airflow rate.

Butts *et al.* (6) reported that PEADRY8, a deep bed simulation model developed by Colson and Young (7), predicted curing time more accurately than an earlier model developed by Troeger and Butler (16); consequently, PEADRY8 was used to evaluate the influence of different airflows. Individual simulations were run assuming the dryer was started at 8:00 p.m. on each of 34 days (9/25 to 10/28) using three years of weather data (1988-1990) recorded by the AEMS. A 15 min. computational interval was used, and the simulation terminated when the mean kernel moisture content in the trailer reached 10%. The fan was assumed to add a rise of 0.5C above ambient temperature. An additional 8.0 C temperature rise was assumed to be added by the LP gas burner except that the heated air temperature was limited to a maximum of 35 C, as recommended by Lambert (12) and Planters (14). An inital pod moisture content of 25% was used, with initial kernel and hull moisture contents of 26.0% and 22.1%, respectively, based upon a meat content (percent kernels) of 73%, dry weight basis. The kernel and hull moisture contents represent those that would occur with harvest following windrow curing and are not equilibrium conditions. Simulations were run for 11 airflow rates, ranging from 5 to 15 m³/min/m³. These airflows were chosen to cover the range of airflows measured at individual ports in the 71 dryers tested.

Trailer size used for the simulations was 4.3 x 2.3 m, filled to a depth of 1.5 m. Bulk density was assumed to be 210 kg of dry peanut pods per m³ of trailer volume (15). Trailer net weight was 3560 kg when adjusted to 10% moisture content.

Curing time was defined as the time required to cure peanuts from 25% pod moisture content to an average kernel moisture content of 10%. There is no price advantage to cure peanuts below 10% moisture content; therefore, a grower maximizes profit by selling peanuts at 10% moisture content.

Energy Consumption for Simulated Cures

Static pressure rise across a dryer fan is dissipated by pressure drops through airflow ductwork and peanuts, and is calculated as follows:

$$SP_f = C_1Q^2 + C_2Q^{1.618} \qquad [3]$$

where

SP_f = static pressure (Pa),
Q = airflow ($m^3/min/m^3$),
C_1 = 0.63, Brooker *et al* (5), and
C_2 = 3 for peanut depth and moisture content used in simulation, Steele (15).

Substituting Eqn. (3) into the expression for fan power given by Booker *et al.* (5) gives,

$$E_f = C_3Q^3 + C_4Q^{2.618} \qquad [4]$$

where,

E_f = fan electric power (kW),
Q = airflow ($m^3/min/m^3$), and
C_3, C_4 = empirical coefficients.

Assuming that one-thrid the total pressure drop was through the ductwork (10), and that a 1.5 kW fan motor operating at 80% efficiency will provide 10 m³/min/m³ airflow to a 4.3 m x 2.3 m trailer filled to a 1.5 m depth, the coefficients are C_3 = 0.00063 and C4 = 0.003. Total electrical energy required for each trailer dried was obtained by multiplying Eqn. (4) by curing time (h).

Heat energy inputs were calculated from airflow rate, air specific volume, air specific heat, and temperature rise for each time step of the simulation and summed over the total curing time. Air leakeage from the dryer plenum was assumed to be 3% of the total (17) and that from the trailers was assumed to be 6% of the total (18). Heat loss by conduction through the dryer walls was assumed to inversely proportinal to airflow rate: 6, 3, and 2% at airflow rates of 5, 10, and 15 m³/min/m³, respectively. Heat requirement calculated for the simulated deep-bed drying was added to heat loss due to air leakage, and heat conduction from the plenum and trailers, to obtain a total heat requirement,

$$E_t=E_b\,[1+(L_{A1}+L_{A2}+L_c)/100] \qquad [5]$$

where,

E_t = total heat requirement (kJ/kg 10% peanuts),
E_b = heat requirement calculated by the simulation (kJ/kg 10% peanuts),
L_{A1} = heat loss due to air leakage from the dryer plenum (% of simulation energy),
L_{A2} = heat loss due to air leakage from the trailers (% of simulation energy),
L_c = conduction heat loss from plenum and trailers (%).

Total heat requirement was used to obtain LP-gas consumption as follows:

$$LPG = 100E_t/(\varepsilon_b \times HHV) \qquad [6]$$

where,

LPG = volume of LP-gas required to cure one trailer of peanuts from 25 to 10% moisture content (L),
ε_b = burner combustion efficiency (assumed 90%), and
HHV = higher heat value of LP-gas (25,500 kJ/L).

Milling Quality Evaluation

Using data published by Davidson *et al* (9) the following regression was derived to relate percent splits occurring at a shelling plant to moisture content for peanuts subjected to average harvesting, handling, and curing practices.

$$S_p = 59.8 - 12.2mc + 0.922mc^2 - 0.0242mc^3 \qquad [7]$$

(R^2 = 0.99, std. error = 0.2 percentage points)

where,

S_p = predicted splits (%), and
mc = peanut kernel moisture content (%).

The final kernel moisture contents of each of 10 layers in the deep bed were used to predict the percentage of splits, and a mean value for the cure determined. The percent splits would be different if other than average harvesting, handing, and curing practices were used (9). Since peanuts generally lose moisture during storage, use of Eqn (7), based upon moisture contents immediately after curing, is a conservative estimate of splits that would occur in peanuts shelled after storage.

Performance of Unbalanced Dryers

Curing time, fan energy, fuel requirements, and uniformity of moisture content were compared for multi-trailer dryers assuming both balanced and unbalanced airflow. Dryers with four, six, and eight trailers were considered separately. For comparison purposes, each dryer was assumed to have a balanced airflow of 10 m³/min/m³. Airflows for each port in unbalanced dryers were calculated using the average percent deviations from balanced flow for each size dryer (4-trailer, 6-trailer, or 8-trailer) to obtain a "typical" performance scenario. Data from the dryer with the greatest percent deviation from balanced flow was used to obtain a "worst case" performance scenario for each size dryer.

Growers operate their dryers with different management strategies; therefore, two options were used to compare results between a balanced and an unbalanced dryer. The "commerical" option would apply to operators who cure peanuts commercially and operate their dryers continuously, immediately replacing trailers in which curing is complete with trailers to be cured. This option would also apply to growers who empty peanuts from their trailers into trucks for transport to the buying station, thus blending peanuts from all trailers together. For the commercial option, an average curing time was calculated for the unbalanced dryers and used to calculate fan energy and fuel requirements, assuming that fan power and rate of fuel consumption remained constant.

The "individaul trailer" option would apply to growers who market peanuts directly in the trailers in which they were cured. For this option, trailers were assumed to be removed from the dryer as they finished curing. The dryer operated with some ports closed until curing was complete in all trailers. Curing time for this comparison method was defined as the time until the last trailer finished. Fan energy and fuel requirement were calculated using this curing time. Generally, trailers at all ports except the two closest to the fan required approximately the same amount of time to cure. When ports for these trailers were closed, airflow for the remaining two ports was assumed to increase to 15 m³/min/m³. Airflow rates for 6-trailer and 8-trailer dryers with only two ports open would be greater than 15 m³/min/m³, but the actual rate is unknown.

Results and Discussion

Airflow Distribution in Multi-Trailer Dryers

4-Trailer Dryers

Airflow rates were below the minimum recommended value (10 m³/min/m³) in 55% of the ports on 4-trailer dryers (Table 1). Balanced airflow ranged from 7.5 to 11.2 m³/min/m³, with a mean of 9.6, while individual port airflow rates ranged from 6.3 to 13.1 m³/min/m³. All but one of the dryers without baffles had less air flowing through the two ports closest to the fan. Mean airflow deviations for each port ranged from 9% below to 8% above the balanced airflow for thirteen 4-trailer dryers without a baffle. The dryer with the greatest airflow deviation had port airflows ranging from 25% below to 21% above the balanced airflow.

Table 1. Summary for in-situ measurement of airflow in multi-trailer peanut dryers.

Dryer size	No. tested	Percent with airflow rates less than 10 m³/min/m³	Airflow rate	
			Range	Average
-------Individual port airflow rates------				
2-tr.	12	50	8.3 - 14.8	10.6
4-tr.	56	55	6.3 - 13.1	9.6
6-tr.	210	90	4.8 - 11.3	8.2
8-tr.	104	55	4.8 - 13.4	9.6
All[1]	397	75	4.8 - 14.8	8.8
-------Balanced dryer airflow rates-------				
2-tr.	6	67	8.5 - 14.3	10.6
4-tr.	14	57	7.5 - 11.2	9.6
6-tr.	35	91	6.4 - 10.9	8.2
8-tr.	13	46	7.2 - 12.4	9.6
All[1]	71	75	6.4 - 14.3	8.8

[1] Includes results for three 5-tr. dryers.

6-Trailer Dryers

Airflow rates were below the minimum recommended value in 90% of the ports on 6-trailer dryers. Balanced airflow ranged from 6.4 to 10.9 m³/min/m³ across all fan designs and motor sizes, with an average value of 8.2, which was significantly less than the average for 4-trailer or 8-trailer dryers. Individual port airflow rates ranged from 4.8 to 11.3 m³/min/m³. Five dryers with 5.6 kW fans and 20 dryers with 7.5 kW fans were tested. Balanced airflow ranged from 6.5 to 8.5 m³/min/m³, and averaged 7.6 m³/min/m³ for fans of both sizes. Seven dryers with two 3.7 kW parallel fans had significantly higher balanced airflows, ranging from 8.1 to 10.4 m³/min/m³ with a mean of 9.1 m³/min/m³. One dryer with an 11.3 kW fan had a balanced flow of 10.9 m³/min/m³ while another dryer with a larger fan (15kw) had a lower balanced flow (9.7 m³/min/m³). Fan design rather than motor size determined the airflow delivery.

The poorest airflow distribution was measured in a dryer with a single 106 cm diameter, 6-blade fan driven with a 5.6 kW motor. The dryer had no baffle. Airflow ranged from

38% below to 16% above a balanced flow of 8.5 m^3/min/m^3. The port with minimum airflow had a flow of 5.3 m^3/min/m^3, or approximately half the recommended flow. This 5.3 m^3/min/m^3 was flow out the port, not through the peanuts. If a typical peanut trailer with average leakage was attached to this port the flow through the peanuts would be 4.7 m^3/min/m^3. This result from the experimental testing program dictated that the minimum airflow in the simulation study be 5 m^3/min/m^3.

8-Trailer Dryers

Airflow rates were less than recommended in 55% of the ports on 8-trailer dryers. Balanced airflow across all fan designs and motor sizes ranged from 7.2 to 12.4 m^3/min/m^3. Individual port airflow rates ranged from 4.8 to 13.4 m^3/min/m^3. As with the 6-trailer dryers, 8-trailer dryers without a baffle had a wider variation in airflow. The poorest distribution occurred in a dryer with a 112 cm, 7-blade fan driven with a 15 kW motor. This dryer had no baffle and port airflow ranged from 41% below to 20% above the balanced airflow of 8.1 m^3/min/m^3.

Summary of Experimental Results

Overall, 75% of the ports tested had airflow rates below the recommended minimum of 10 m^3/min/m^3 (Table 1). Although no effort was made to insure the randomness of dryers tested, the large percentage of dryers with below average airflow indicates a serious problem .Low balanced airflows and poor airflow distribution combined to create some very low airflows at individual ports. Complete test results were reported by Baker *et al.* (2).

Influence of Airflow on Curing

Curing Time

Averaged over 34 cures in each of 3 years (a total of 102 simulations) curing time decreased from 61 to 43 h as airflow rate increased from 5 to 15 m^3/min/m^3. Curing time decreased from 61 to 46 h as airflow rate increased from 5 to 10 m^3/min/m^3. Increasing airflow form 10 to 15 m^3/min/m^3 only reduced curing time by 3 h (Fig. 2).

At the recommended minimum airflow rate of 10 m^3/min/m^3, curing time ranged from 39 to 60 h over the three years, depending on the weather conditions during curing. On a percentage basis, curing time ranged from 18% below to 27% above the overall average curing time. Seasonal average curing times were nearly the same for 1988 and 1989, 47.7 and 47.4 h, respectively. In 1990 the seasonal average was 44.2 h.

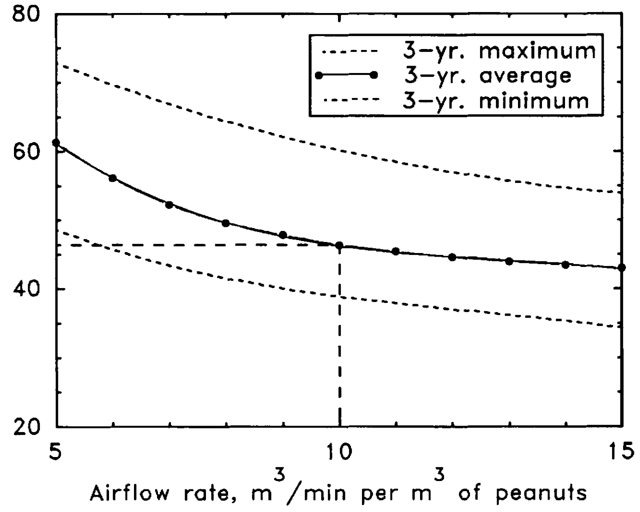

Fig. 2. Curing time calculated for 102 simulated cures using weather data for 1988, 1989, and 1990.

Energy Requirement

Electrical energy required per trailer increased from an average (across 102 cures) of 17 to 246 kWh as airflow rate increased from 5 to 15 m^3/min/m^3 (Fig 3.). Increased fan power requirements at the higher airflow rates influenced the electrical energy total more than a decrease in curing time. For an airflow rate of 10 m^3/min/m^3, energy required for the fan ranged from 73 to 113 kWh over the three years, depending on length of curing time, which was a function of weather conditions during the cure. Seasonal variations were the same as for curing time.

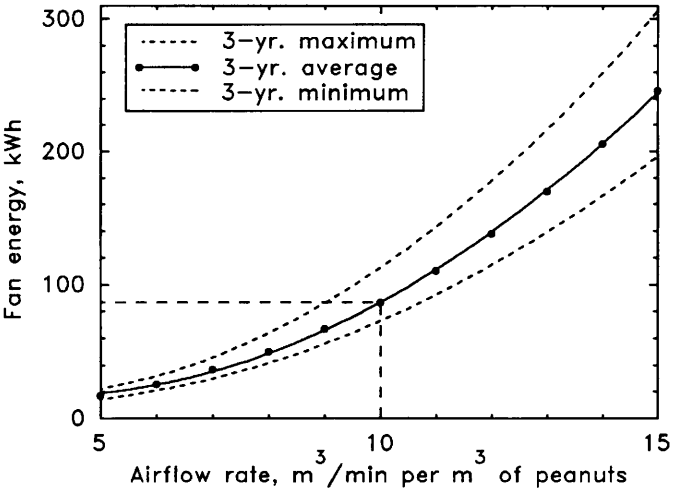

Fig. 3. Electrical energy required per trailer for 102 simulated cures using weather data for 1988, 1989, and 1990.

Fuel required per trailer increased nearly linearly from an average of 135 to 274 liters of LP-gas as airflow rate increased from 5 to 15 m^3/min/m^3. The increase in fuel required to heat the greater volume of air influenced total fule consumption more than the decrease in curing time. The following regression equation was obtained for fuel requirements as a function of airflow rate:

$$E_h = 83.4 + 8.96\,Q + 0.256\,Q^2 \quad (R^2 = 0.99, \text{ std. err.} = 0.6) \qquad [8]$$

where

E_h = fuel required per trailer (liters of LP-gas,), and

Q = airflow rate (m^3/min/m^3).

Using a cost of $0.08/kWh for electricity and $0.225/L for LP-gas, fuel accounted for over 75% of total energy cost. Average energy cost to cure a trailer increased from $32 to $81 as airflow rate increased from 5 to 15 m^3/min/m^3. At 10 m^3/min/m^3 the average energy cost to cure from 25 to 10% moisture content was $52 per trailer, or $15.5/Mg peanuts at 10% moisture content.

Uniformity of Curing and Percent Splits

The average difference in kernel moisture content between the top and bottom layers decreased from 6.1 to 2.6 percentage points as airflow rate increased from 5 to 15 m^3/min/m^3. With an airflow rate of 10 m^3/min/m^3, the difference between the top and bottom kernel moisture contents was 3.8 percentage points. As expected, there was less overdrying of the bottom layer with the higher airflows. Top layer moisture content was about 12% with an airflow rate of 10 $m^3/min/m^3$, which is above that safe for storage. Peanuts mix as they are unloaded from trailers and will soon equilibrate to the average moisture content in storage. Problems with mold growth may occur if peanuts are stored in trailers after curing, which sometime happens at the end of harvest.

Predicted percent splits in a commercial shelling plant [Eqn. (7)] decreased from an average of 6.9 to 6.2 as airflow rate increased from 5 to 15 $m^3/min/m^3$. Based on the data of McIntosh *et al.* (13), the corresponding range of percent splits in a grade sample sheller was 3.0 to 2.8. Differences in percent splits of this magnitude are relatively insignificant to the grower. Due to the volume of peanuts processed by a sheller, the 0.7 percentage point difference in splits may be significant.

Effects of Balancing Airflow

In all cases studied, small improvements in curing time, fan energy, fuel requirements, and uniformity of moisture content were obtained when airflow in a multi-trailer dryer was balanced. Balancing the airflow improved dryer performance more for dryers with the greatest measured airflow deviation, than for dryers with average airflow deviation. Energy and fuel savings per trailer increased as dryer size increased.

A dryer with balanced airflow would be easier to manage than a dryer with unbalanced airflow, and this benefit is much greater than the time and energy saving. With balanced airflow each trailer starts at the same time, cures at the same rate, and finishes at the same time, assuming peanuts in all trailers are at the same inital moisture content. The moisture content of peanut samples would need to be measured less often to insure all trailers are ready for market.

Annual payback for installing a baffle in a multi-trailer dryer is the sum of the value of energy saved and the value of the curing time saved. Assuming typical energy costs [$0.225/liter for LP-gas and $0.08/Wh for electricity], and assuming an operator using the commercial option will fill the dryer six time per year, calculated average seasonal savings for installing a baffle were $4.36 for a 4-trailer dryer, $10.35 for a 6-trailer dryer, and $16.34 for an 8-trailer dryer. Increases in LP-gas cost affected the annual energy savings more than increases in electricty cost (Table 2). Using a value of $6 per trailer-hour for space on a dryer, as suggested by one commercial dryer operator, the value of curing time saved per season was $28.80, $64.80, and $86.40 for 4-trailer, 6-trailer, and 8-trailer dryers, respectively. Total potential savings per season (value of energy saved + value fo dryer time saved) was approximately $33 for a 4-trailer dryer, $75 for a 6-trailer dryer, and $103 for an 8-trailer dryer.

Energy savings using the individual trailer option were greater than for the commercial option (Table 2). Using the same costs for LP-gas and electricty, annual savings were $24.51 for a 4-trailer dryer, $43.80 for a 6-trailer, and $67.46 for an 8-trailer. The value of savings in curing time was not calculated for this method because of typical grower would not be able to take advantage of this savings. For this reason, a value for curing time savings was not added to the energy savings for the individual trailer option. Based on energy cost savings alone, however, the cost of materials for installing a baffle (approximately $25) could be recovered in one year (excluding labor cost).

Table 2. Annual savings in energy cost for balancing airflow in multi-trailer peanut dryers with individual port airflow deviations equal to the average deviation for all dryers tested.

Fuel Cost ($/L)	Electricity Cost					
	$0.08/kWh			$0.12/kWh		
	Dryer Size			Dryer Size		
	4-tr.	6-tr.	8-tr.	4-tr.	6-tr.	8-tr.
	Commercial Option[1]					
0.225	4.36	10.35	16.34	4.64	11.07	17.50
0.25	4.78	11.34	17.90	5.06	12.06	19.06
0.275	5.20	12.33	19.46	5.48	13.05	20.62
0.30	5.62	13.32	21.02	5.90	14.04	22.18
	Individual Trailer Option[2]					
0.225	24.51	43.80	67.46	26.19	46.80	71.94
0.25	26.86	48.00	73.96	28.54	51.00	78.44
0.275	29.21	52.20	80.46	30.89	55.20	84.94
0.30	31.56	56.40	86.96	33.24	59.40	91.44

[1] Values assume a dryer is filled six times per year. Per trailer energy savings are the listed value divided by 6 N, where N is the number of plenum ports per dryer.

[2] Values assume a dryer is filled five times per year. Per trailer energy savings are the listed value divided by 5 N, where N is the number of plenum ports per dryer.

Summary and Conclusions

Seventy-one multi-trailer peanut dryers were tested *in situ* to determine airflow rates from each plenum port. In these dryers a total of 299 ports, or 75%, had airflow less than less than 10 $m^3/min/m^3$, the minimum recommended rate. Port airflow ranged from 4.8 to 13.4 $m^3/min/m^3$. To study the consequence of this airflow range, a bulk curing model (PEADRY8) was used to determine the effects of airflow rate on curing time, energy requirements, and overdrying of the bottom layer when curing time was extended to achieve the desired average moisture content for marketing.

The following results were obtained from 102 simulations using weather data from 1988, 1989, and 1990. Each simulation predicted the curing of peanuts form 25% moisture content to an average moisture of 10%.

1. Curing time was 61 h with 5 $m^3/min/m^3$ airflow, 46 h with 10 $m^3/min/m^3$, and 43 h with 15 $m^3/min/m^3$. Negligible reduction in curing time was achieved by increasing the airflow above 10 $m^3/min/m^3$.
2. Electrical energy increased from 17 to 246 kWh/trailer as airflow increased from 5 to 15 $m^3/min/m^3$. Increasing airflow from 10 to 15 $m^3/min/m^3$ increased electrical energy consumption by 170%.
3. LP-gas consumption increased from 135 to 274liters/trailer as airflow increased from 5 to 15 $m^3/min/m^3$. Increasing airflow from 10 to 15 $m^3/min/m^3$ increased fuel consumption by 37%.
4. More uniform moisture content as a consequence of higher airflow yielded small improvements in milling quality, which were of negligible value to growers by 1990 grading standards.
5. Assuming a management strategy that might be used by a commercial dryer operator, annual value of energy and curing time savings that can be achieved by installing a baffle to improve uniformity of airflow, was $33 for a 4-trailer dryer, $75 for a 6-trailer dryer, and $103 for an 8-trailer dryer.
6. Assuming a management strategy that might be used by an individual farmer, annual value of energy savings achieved by installing a baffle was $24.50 for a 4-trailer

dryer, $43.80 for a 6-trailer dryer, and $67.50 for an 8-trailer dryer.

Based on the simulation results, Virginia peanut growers would benefit by increasing the airflow in their dryers to the recommended minimum rate of 10 $m^3/min/m^3$. There is little advantage to increasing the airflow above 10 $m^3/min/m^3$, as the reduction in curing time is not sufficient to give a dryer seasonal capacity increase that will offset the increased energy cost associated with higher airflow. There is sufficient economic return derived from an improvement in the uniformity of port airflow to pay for the installation of a baffle in one to three years.

Literature Cited

1. ASAE. 1990. Energy efficiency of peanut curing systems. ASAE Standard: ASAE S488: ASAE, St. Joseph, Mich.
2. Baker, K. D., J. S. Cundiff, and F. S. Wright. 1990. Unbalanced airflow effects on multi-trailer peanut dryers. Paper No. 90-6534. ASAE, St. Joseph, Mich.
3. Blankenship, P. D. and V. Chew. 1979. Peanut drying energy consumption. Peanut Sci. 6:10-13.
4. Blankenship, P. D. and J. L. Pearson. 1976. Effects of airflow rates on the rates on the drying and quality of green peanuts in deep beds. ARS-S-135.
5. Brooker, D. B., F. W. Bakker-Arkema, and C. W. Hall. 1974. Drying Cereal Grains. AVI Publishing Co., Inc., Westport, Conn.
6. Butts, C. L., J. M. Troeger, and J. H. Young. 1989. Comparison of two bulk curing models. Paper No. 89-6599, ASAE, St. Joseph, Mich.
7. Colson, K. H. and J. H. Young 1990. Two-component thin -layer drying model for unshelled peanuts. Transactions of the ASAE 33(1):241-246.
8. Davidson, J. I., Jr., P. D. Blankenship, and R. S. Hutchinson. 1970. Shelling and storage of partially dried (cured) peanuts. J. Amer. Peanut Res. Educ. Assoc. 2:57-64.
9. Davidson, J. I., Jr., T. B. Whitaker, and J. W. Dickens. 1982. Grading, cleaning, storage, and marketing of peanuts in the United States. pp. 571-623. in H. E. Pattee and C. T. Young, (ed.) Peanut Science and Technology, Amer. Peanut Res. and Educ. Soc. Inc., Yoakum, Tex.
10. Glover, J. W. 1977. Mechanical peanut curing. Bulletin no. AG-406, North Carolina Agricultural Extension Service, Raleigh, N.C.
11. Kulasiri, G. D., D. H. Vaughan, and J. S. Cundiff. 1990. Pressure drop simulator for peanut dryers. Paper no. 90-6035, ASAE, St. Joseph, Mich.
12. Lambert, A. J. 1969. Curing Virginia peanuts. Extension publication 269, Dec. 1969, Virginia Polytechnic Institute and State University, Blacksburg, Va.
13. McIntosh, F. P., J. I. Davidson, Jr., and R. S. Hutchinson. 1971. Some methods of determining milling quality of farmers' stock peanuts. J. Amer. Peanit Res. Educ. Assoc. 3:43-51.
14. Planters Life-Savers Co. 1990. Peanuts - A grower's guide to quality. Planters LifeSavers Co., Winston-Salem, N.C.
15. Steele, J. L. 1974. Resistance of peanuts to airflow. Transactions of the ASAE 17:573-577.
16. Troeger, J. M. and J. L. Butler. 1979. Simulation of solar peanut drying. Transacions of the ASAE 22:906-911.
17. Vaughan, D. H., J. S. Cundiff, and P. M. Winkelman, 1988. Efficient crop drying: phase I - peanuts. Final report AP4861, Agricultural Engineering Department, Virginia Polytechnic Institute and State University, Blacksburg, Va.
18. Wilcke, W. F., D. H. Vaughan, J. S. Cundiff, and F. S. Wright. 1989. Measuring air leakage from peanut drying trailers. Unpublished report, June 1989, Agricultural Engineering Department, Virginia Polytechnic Institute and State University, Blacksburg, Va.

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