CORN DRY-MILLING: EFFECT OF BEALL DEGERMINATOR TAIL-GATE CONFIGURATION ON PRODUCT STREAMS[1]

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ABSTRACT

Product streams from pilot-plant runs on a No. 0 Beall degerminator equipped with annular tail-gate opening of variable position and fixed area or of only variable area, are compared with products from V-notched slide or conventionally hinged tail gates for a range of machine throughputs and tail-gate openings.

In general, as the area of an annular tail gate was increased, throughput increased. Recycle (+3½) increased only slightly as the area of the tail gate was increased from 4 to 25 sq. in., but at the maximum opening of 35 sq. in., it was increased to almost 10%. The percentages of other fractions changed little. Oil content of the −4+6 and −6+8 grits and oil available for recovery remained in the same range, except in the area of maximum opening where oil content of the grits increased and oil recovery decreased.

A variable-position, fixed-area, annular tail gate gave progressively less −6+8 grits and less oil available for recovery and progressively greater throughput, recycle, and oil content in the −4+6 and −6+8 grits as the annulus opening was moved away from the degerminator shaft.

The corn dry-milling industry has, at various times, experimented with the effect on degerminator product streams of "sharp" and "blunt" rotor studs, rotor speed, screen size and sharpness, number of screens, and rotor position, but few attempts have been made to determine the effects of tail-gate location and configuration on product streams. Therefore, the effect on degerminator streams of annular and V-notch tail gates as a function of their position and area was studied. A comparison is also made with the conventional hinged tail gate commonly used.

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Materials and Methods

Materials. Grade No. 2 yellow corn of the 1960 crop was used for these studies.

Processing Methods and Equipment. The equipment used was a No. 0 Beall degerminator (1) equipped with a "blunt" rotor operated at 845 r.p.m. in the 50% closed position, three screens having 14/64-in. round-hole perforations, and a 15-h.p. motor. For the various tests, the degerminator was fitted, in turn, with a hinged-type tail gate, a V-notched slide-type gate, a variable-area annulus gate, and a variable-position, fixed-area, annulus tail gate; all are diagrammatically represented in Figs. 1, 2, 3, and 4 respectively.

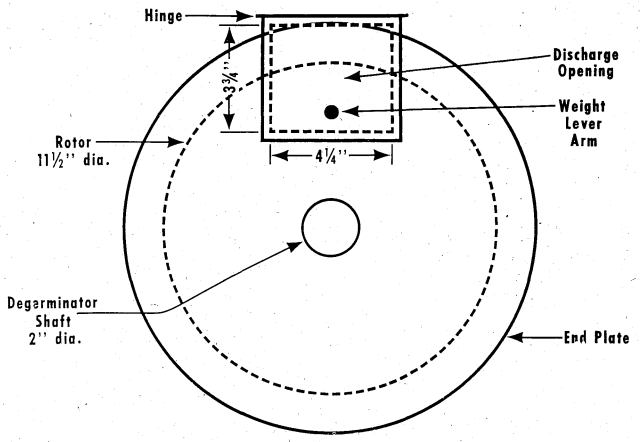

Fig. 1. Conventional hinged tail gate.

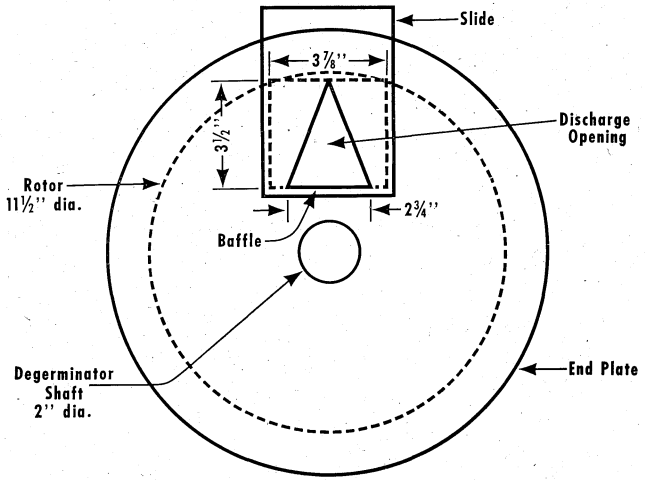

Fig. 2. V-notched tail gate.

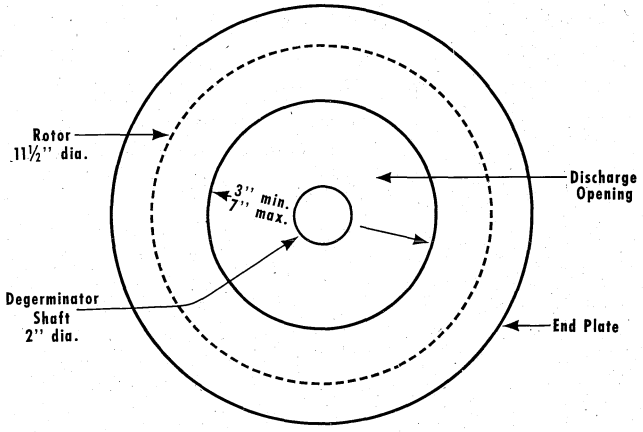

Fig. 3. Variable-area annular tail gate.

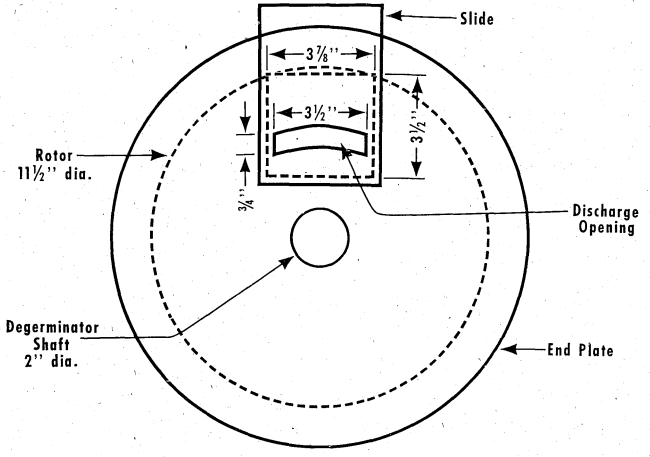

Fig. 4. Variable-position annular tail gate.

The corn of 13–14% initial moisture was tempered in batches of approximately 6 bu. to 19.6–20.8% final moisture, with a total temper time of 2.0 to 2.9 hr. Tempering was accomplished in a batch mixer with required water injected over a period of 10 to 30 min. Upon completion of the tempering step, the corn was transferred to the degerminator supply hopper and fed to the degerminator at a controlled rate sufficient to load the motor to a 15-h.p. level. Representative samples of the throughs and tails streams were collected for each run, and these samples were subjected to a product evaluation analysis.

Analytical Methods — Product Evaluation. Evaluation of the effectiveness of hull and germ release from the endosperm fraction and

determination of particle size distribution were made by means of screening, aspiration, and flotation for separation of hull, loose germ, and endosperm in a manner described by Brekke *et al.* (1).

Results and Discussion

Product characteristics for the variable-area annulus tail-gate pilot-plant runs are shown in Table I.

TABLE I

PRODUCT CHARACTERISTICS VS. AREA OF VARIABLE ANNULUS GATE

Gate opening, sq. in.	4	9	16	25	35
O.D. of annulus, in.	3	4	5	6	7
Throughput, bu./hr.					
Gross	23.4	25.5	28.7	34.8	44.5
Net	23.4	25.5	28.6	34.0	40.3
Oil, lb./bu. corn					
Gross	1.22	1.18	1.21	1.07	1.04
Net	1.22	1.23	1.23	1.09	1.14
+3½ Recycle	0.2	0.2	0.4	2.3	9.5
Grits[a], %					
−3½+4	0.5	0.6	0.9	1.6	2.5
−4+6	21.3	21.0	18.8	23.8	21.8
−6+8	32.1	32.1	32.0	30.8	30.7
−8+25	13.9	12.6	14.3	13.3	15.0
−25+Pan fines	14.5	16.3	15.1	14.7	12.8
Oil, % m.f.b.					
−3½+4	0.59	0.44	0.62	0.86	1.31
−4+6	0.54	0.48	0.45	0.51	0.70
−6+8	1.00	0.88	0.86	0.96	1.15
Attached hull,					
−4+6 grits, %	34	30	41	37	32
Hull fraction, %	7.0	7.6	8.2	7.1	6.2
Germ fraction, %	10.51	9.68	10.21	8.46	9.37

[a] Grit fractions in Tables I–V are expressed as percentage of net feedstock, and hull fractions as percentage of gross feedstock.

With increasing gate opening, throughput increased. The +3½ recycle fraction increased only slightly up to mid-opening, but at the maximum opening increased to almost 10%. The −3½+4 fraction showed a small but steady increase. The percentage of −4+6, −6+8, and −8+25 grit fractions and attached hull remained relatively constant. The −25 m. fines decreased somewhat.

Beyond mid-opening, oil content of the −3½+4, −4+6, and −6+8 grits increased with increased gate opening, and oil available for recovery decreased on a gross and net throughput basis.

The products from the variable-position annulus gate are tabulated in Table II.

As the fixed area opening was moved toward the outer periphery of the rotor, machine throughput and percentage of +3½ stock and −3½+4 grits increased. The −6+8 and −25 fractions decreased, and the −4+6 and −8+25 fractions showed a slight tendency to

TABLE II

PRODUCT CHARACTERISTICS VS. POSITION OF FIXED-AREA ANNULUS GATE

Opening, in. (from shaft centerline)	2¼	3¾	4¼	4½	4¾
Area, sq. in.	2¾	2¾	2¾	2¾	2¾
Throughput, bu./hr.					
Gross	20.4	26.4	35.0	42.9	50.2
Net	20.4	26.3	33.5	38.7	42.4
Oil, lb./bu. corn					
Gross	1.12	1.11	0.95	0.84	0.95
Net	1.12	1.11	1.00	0.93	1.12
+3½ Recycle	0.1	0.6	4.1	9.8	15.5
Grits[a], %					
−3½+4	0.4	1.6	2.9	4.3	4.9
−4+6	21.1	23.5	25.2	23.7	24.9
−6+8	33.9	30.9	28.9	29.7	27.7
−8+25	11.3	12.0	13.8	14.4	12.8
−25+Pan fines	16.5	16.4	14.4	14.2	13.7
Oil, % m.f.b.					
−3½+4	0.38	0.68	1.41	1.53	1.94
−4+6	0.34	0.46	0.52	0.63	0.79
−6+8	0.77	0.99	1.28	1.09	1.05
Attached hull, −4+6 grits, %	21	17	25	25	20
Hull fraction, %	7.0	7.4	5.6	6.4	5.8
Germ fraction, %	9.6	8.2	8.3	7.2	9.6

[a] Grit and germ fractions in Tables I–V are expressed as percentage of net feedstock, and hull fractions as percentage of gross feedstock.

TABLE III

PRODUCT CHARACTERISTICS VS. OPENING OF V-NOTCH GATE

Gate opening, in. (notch apex to rotor)	4¾	5¼	5¾	6⅜
Area, sq. in.	0.85	1.60	2.45	3.85
Throughput, bu./hr.				
Gross	22.3	28.2	34.4	45.1
Net	22.2	27.8	32.7	39.6
Oil, lb./bu. corn				
Gross	1.19	1.16	1.17	1.04
Net	1.19	1.18	1.23	1.19
+3½ Recycle	0.5	1.3	4.9	12.1
Grits[a], %				
−3½+4	1.2	3.0	3.7	6.7
−4+6	29.7	30.3	29.5	30.4
−6+8	24.6	23.3	23.9	22.8
−8+25	11.7	12.4	12.4	12.2
−25+Pan fines	16.0	15.4	14.1	12.1
Oil, % m.f.b.				
−3½+4	0.41	0.69	0.71	1.69
−4+6	0.50	0.57	0.57	0.65
−6+8	1.03	1.07	1.31	1.16
Attached hull, −4+6 grits, %	57	51	64	71
Hull fraction, %	7.4	6.1	6.1	5.1
Germ fraction, %	9.7	9.6	10.1	10.0

[a] Grit and germ fractions in Tables I–V are expressed as percentage of net feedstock, and hull fractions as percentage of gross feedstock.

increase. The percentage of attached hull showed no consistent trend.

Oil content of the $-3\frac{1}{2}+4$ and $-4+6$ fractions showed a progressive increase. Oil content of the $-6+8$ grits increased to mid-setting, then declined. On the basis of net throughput, gate position presumably had no significant effect on oil recovery.

Table III compares product characteristics of pilot runs in which the V-notch-type tail gate was used at various settings. As the area was increased, the percentage of $+3\frac{1}{2}$ and $-3\frac{1}{2}+4$ fractions increased along with throughput, attached hull, and oil content of the $-3\frac{1}{2}+4$, $-4+6$, and $-6+8$ grits. Meanwhile the yield of -25-mesh fines decreased. On the basis of net throughput, oil recovery remained constant regardless of the gate opening within the range investigated.

For the conventional hinged tail gate, at various gate loads, Table IV shows product characteristics. As the gate loading was reduced,

TABLE IV

PRODUCT CHARACTERISTICS VS. HINGED TAIL GATE LOADING

Gate load, in. g.	510	413	193	120	68
Throughput, bu./hr.					
Gross	22.9	28.6	36.8	41.9	48.7
Net	22.7	28.2	34.9	37.8	40.5
Oil, lb./bu. corn					
Gross	1.18	1.20	1.17	1.18	1.08
Net	1.18	1.22	1.23	1.30	1.29
$+3\frac{1}{2}$ Recycle	0.6	1.7	5.1	9.6	16.7
Grits[a], %					
$-3\frac{1}{2}+4$	1.9	2.7	4.5	5.2	6.4
$-4+6$	29.3	29.9	30.7	30.5	30.3
$-6+8$	24.3	23.4	21.8	22.3	22.0
$-8+25$	10.1	10.9	10.7	10.5	11.8
-25+Pan fines	18.4	16.8	14.9	14.0	12.9
Oil, % m.f.b.					
$-3\frac{1}{2}+4$	0.56	0.53	1.19	1.04	1.78
$-4+6$	0.52	0.47	0.55	0.69	0.77
$-6+8$	1.10	0.97	0.87	1.06	0.99
Attached hull,					
$-4+6$ grits, %	38	34	56	67	68
Hull fraction, %	6.6	6.8	7.0	5.4	5.1
Germ fraction, %	9.4	9.7	10.0	11.5	10.6

[a] Grit and germ fractions in Tables I–V are expressed as percentage of net feedstock, and hull fractions as percentage of gross feedstock.

throughput and the percentages of recycle stock, $-3\frac{1}{2}+4$ grits, attached hull, and oil content of the $-3\frac{1}{2}+4$ and $-4+6$ grits increased and yield of -25-mesh fines decreased. The oil content of the $-6+8$ grits showed no consistent trend, and the yield of $-4+6$, $-6+8$, and $-8+25$ grits remained relatively constant regardless of gate opening. On a net throughput basis, oil recovery increased slightly, with a decreased tail-gate loading.

Conclusions

No individual tail gate tested was superior in all respects for best oil recovery, least attached hull, least grit oil content, and maximum yield of large-size grits.

On the basis of the end products desired, a tail-gate selection may be made from Table V, which compares products from each style of gate for a fixed throughput of approximately 35 bu. per hr.

TABLE V

PRODUCT STREAMS FROM HINGED, V-NOTCH, AND ANNULAR TAIL GATES WITH FIXED THROUGHPUT OF ABOUT 35 BUSHELS OF CORN PER HOUR

	Tail Gate			
	Hinged	V-Notch	Variable Position Annulus	Variable Area Annulus
Throughput, bu./hr., w.b.:				
Gross	36.8	34.4	35.0	34.8
Net	34.9	32.8	33.6	34.0
Recycle (+3½ m.) % G.F.S.	5.1	4.9	4.0	2.3
Throughs fraction, % G.F.S.	58	63	65	72
Hull fraction, % G.F.S.	7.4	6.4	6.7	7.2
Yields, % N.F.S.:				
−3½+4 grits	5	4	3	2
−4+6 grits	31	30	25	24
−6+8 grits	22	24	29	31
−8+25 grits	11	12	14	13
−25+Pan fines	13	14	14	15
Germ	10.0	10.1	8.3	8.5
Oil content, % m.f.b.:				
−3½+4	1.19	(1.0)[a]	1.41	0.86
−4+6	0.55	0.57	0.52	0.51
−6+8	(1.0)[a]	1.31	1.28	0.96
Oil in germ fraction, lb./bu. corn:				
Gross throughput	1.17	1.17	0.95	(1.2)[a]
Net throughput	1.24	1.23	1.00	(1.2)[a]
Attached hulls, −4+6 grits, % of sample	56	64	25	37

[a] Assumed value based upon expected level.

If maximum percentage yield of large grits (−3½+4 and −4+6) and maximum germ and oil recovery are required, either the hinged or V-notch gate is best. Both the variable position and the variable area gates were superior to the hinged or V-notch type for hull removal and yield of −6+8 grits. All gates tested gave comparable percentages of −8+25 grits and −25-mesh fines.

Oil content of the −4+6 grits did not vary significantly among the four tail gates, but −3½+4 and −6+8 grits from the variable-area annulus gate had the lowest fat content. The V-notch and variable-position annulus gates produced −6+8 grits of the highest oil content.

Literature Cited

1. BREKKE, O. L., WEINECKE, L. A., WOHLRABE, F. C., and GRIFFIN, E. L. Tempering and degermination for corn dry milling: A research project for industry. Am. Miller **89** (9): 14–17 (1961).