PERFORMANCE OF A ROTARY STRAW AND GRAIN SEPARATOR

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PERFORMANCE OF A ROTARY STRAW

AND GRAIN SEPARATOR

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PREFACE

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CHAPTER I

INTRODUCTION

Since 1883 when Hiram Moore demonstrated the forerunner of the modern-day combine-harvester, design engineers have been striving to improve its capacity and efficiency. Virtually all the cereal grain grown in the United States and Canada is now harvested with these machines. However, the combine-harvester must be further developed to utilize new and existing principles for grain separation for more efficient performance rather than to depend on the machine's physical size to handle large feedrate capacities.

The function of the combine-harvester is to remove the seed from the grain crop with minimum grain loss and physical seed damage (1). In the grain harvesting process, the four basic operations performed by the machine are: (a) cutting and feeding, (b) threshing, (c) separation, and (d) cleaning.

Operation of the Straw Walkers

Most combine-harvesters utilize a straw walker system to separate the grain from a mat of threshed straw and convey the crop residue to the rear of the machine. In theory as the threshed material flows over the straw walker surface, it is vigorously agitated and accelerated to sift the grain out of the straw. But, most separation takes place at the front portion of the straw walkers where the expansion of the material occurs as it is ejected from the raddle by the separator beater (Figure 1). The separation of the grain from the straw must be credited to the interface between the straw walkers and the threshing components (2).

The inadequacies of the straw walkers as a separation mechanism arise when the material is conveyed and agitated. Gravity, in addition to the walking action, insures that most of the grain remaining in the straw is firmly impacted in the mass of straw and chaff. This impermeable mat of material is conveyed out of the rear of the machine, hence grain losses over the straw walkers.

Combine Grain Loss Performance

The four major sources of grain losses occur at: (a) the cutterbar or pickup, (b) the threshing cylinder, (c) the cleaning shoe, and (d) the straw walkers (3,4,5,6). Grain losses are affected by machine adjustment and crop conditions but depend mainly on the design of the particular combine. Losses from the rear of the machine (straw walkers and cleaning shoe) are related to the percentage of separation and the amount of material breakup at the threshing cylinder which determines the relative loads placed on the walkers and shoe.

The most significant non-design factor that affects combine performance and grain losses is the crop feedrate through the machine. Grain loss-feedrate relationships have been obtained from field efficiency tests conducted by farm equipment manufacturers, governmental agencies, and universities at various locations in the world. A general relationship may be expressed in the form of

$$PCLOSS = K * FEDRAT^{N}$$

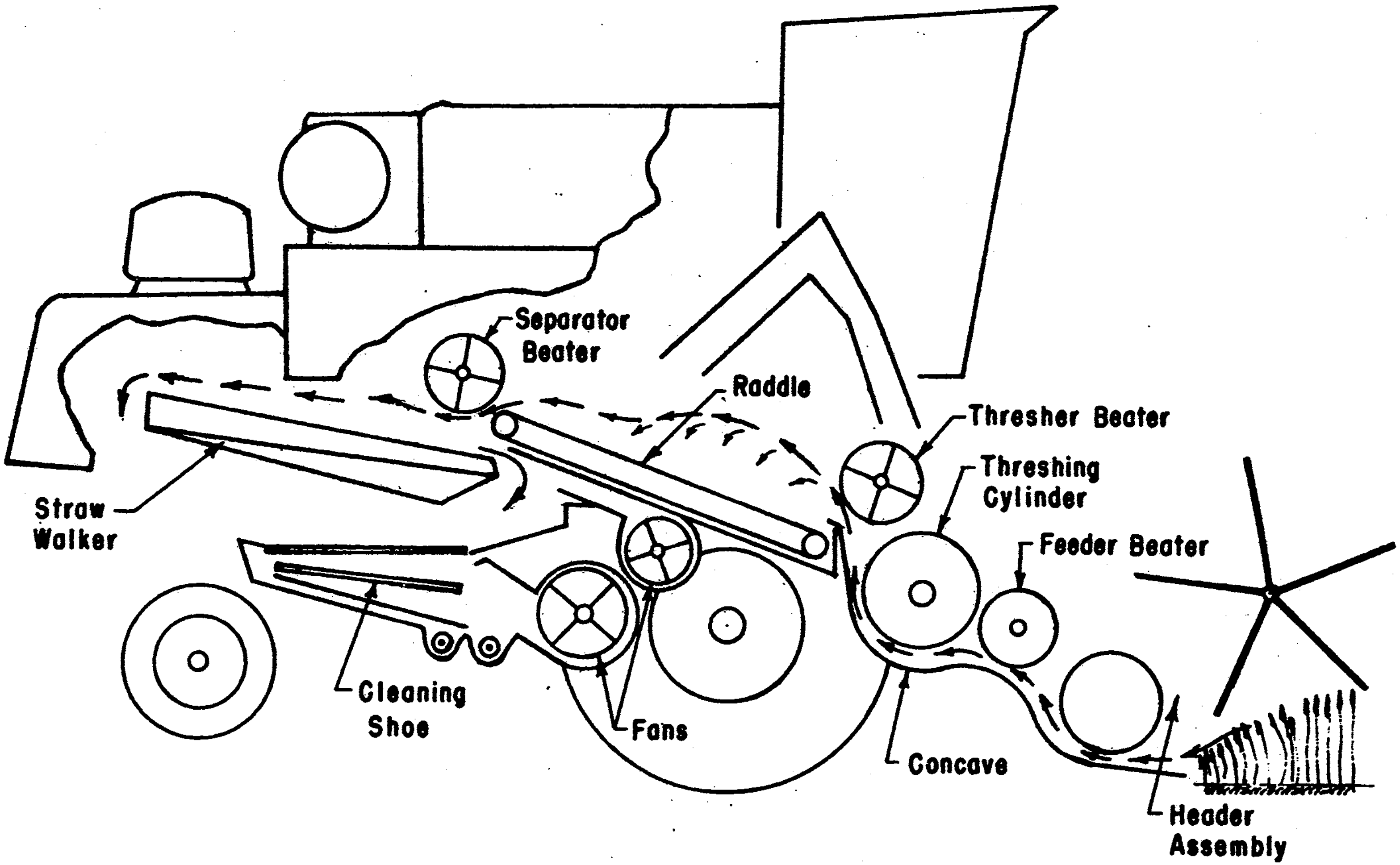

Figure 1. Schematic Cross-Sectional View of a Combine-Harvester

where

PCLOSS = grain loss (per cent of total yield)

FEDRAT = feedrate (pounds per minute of straw and chaff passing through the machine)

K & N = constants whose values depend upon the crop and the particular combine

This relationship may be used to describe grain losses for the threshing cylinder, cleaning shoe, and straw walkers (Figure 2). These relationships have been verified by test findings that grain losses increase in an exponential manner with increasing feedrates. Loss curves can be calculated from the loss functions developed by Nyborg (6) to describe grain loss performance dependent upon the machine and crop conditions. These functions may be stated in the following manner:

(a) cylinder loss = f (cylinder speed, concave clearance, rate of work, moisture content, crop),

(b) walker loss = f (straw breakup, amount of tailings, rate of work, crop),

(c) shoe loss = f (rate of work, straw breakup, crop),

(d) total loss = f (rate of work, crop variables) where total loss = walker loss + shoe loss + cylinder loss.

To handle high feedrates, a plausible solution is to develop a mechanism to more efficiently separate the grain from the straw to reduce grain losses as compared to walker losses.

This study involved the development of a rotary separating mechanism for the combine-harvester in an attempt to reduce separation losses as compared to the losses that occur with contentional straw walkers. The mechanism accelerated and stretched the threshed material to allow the grain to fall out of the mat of crop residue.

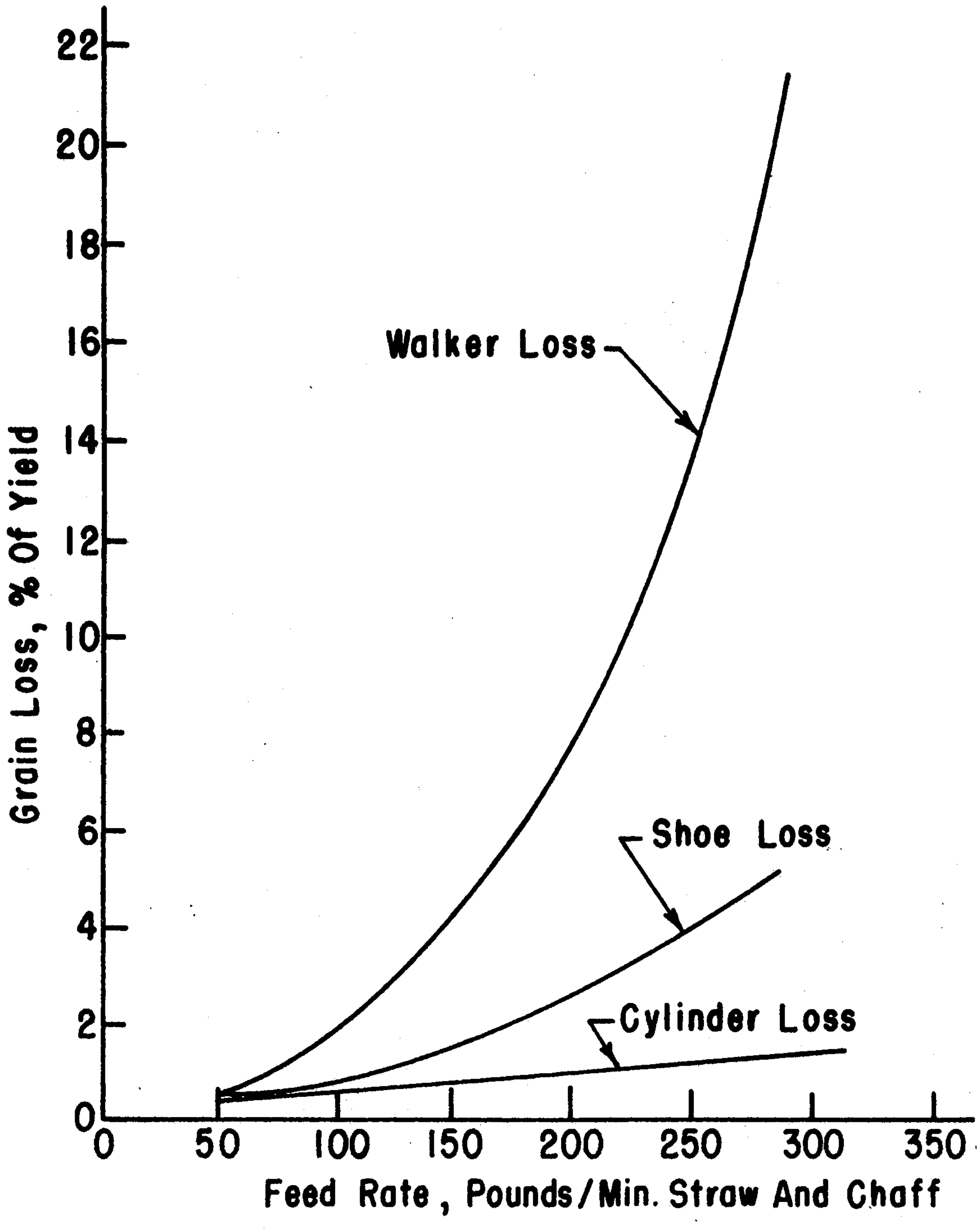

Figure 2. Loss Curves for a Combine-Harvester in Barley (Nyborg)

This study was not designed to give a complete picture of all design and operating parameters since this would have been too involved for the time allocated. A study which involves air flow as an aid to separation would be essential to a thorough understanding of the practical significance of this rotary separator.

Research Objectives

1. Design and construct a mechanism having a series of rotors and a concave screen to separate grain from a mat of threshed crop material.
2. Evaluate the rotary separator experimentally to test the hypothesis that such a mechanism can accelerate and stretch the mat of threshed material to more efficiently separate the grain from the material.
3. Evaluate the apparatus experimentally in the laboratory to determine if this separator will reduce separation losses.
4. Evaluate the principal design factors of the separator to determine which have the greatest effect on the reduction of grain losses.

CHAPTER II

REVIEW OF LITERATURE

Separation of Grain from Straw

A fundamental study of straw walker performance was conducted by Zoerb, Reed, and Bigsby (7) in the laboratory. Tests were conducted with a stationary test stand consisting of a cylinder and concave assembly plus the straw walker assembly with provisions to collect grain and chaff below the concave and walkers, and the residue of straw and grain from the rear of the walkers.

The effect of (a) straw/grain ratio, (b) straw length, (c) walker slope (fore, aft, and cross-wise), and (d) windrow configuration on walker performance was evaluated. From the performance tests, the separation of grain from the straw may be described by a decaying exponential function along the length of the walker. Thus, the required length for a desired efficiency may be determined from the following natural logarithmic equation,

$$L_{eff} = \frac{\ln\,(100 - \text{EFFICIENCY REQUIRED})}{b}$$

where L_{eff} = required walker length for a given straw walker separation efficiency

b = ratio of the grain remaining on the walkers to the grain onto the walkers.

It was concluded that the feedrate material other than grain (M.O.G.)/GRAIN ratio had the greatest effect on walker efficiency, whereas straw length and walker slope had little effect. Also, the windrow configuration exerted a great influence on the material distribution on the walkers, but no significant effect on walker efficiency.

The time interval necessary for separation depends upon: (a) seed size in relation to the size of the openings between straws, (b) straw layer thickness, (c) coefficient of friction between the seed and straw, (d) seed density in relation to the straw density (8). While increased agitation increases the size of openings between straws, the rate of travel over the walkers controls the straw layer thickness and the time available for separation.

Inadequacies of Conventional Straw Walkers and Schemes to Correct Them

Grain losses over the rear of the straw walkers, the limiting factor in achieving maximum feedrate, is one of the most important problems facing combine designers. The generally accepted belief holds that the total straw walker area and the design of the walker elements are the two key factors affecting the overall performance (2). But rather, the problem arises due to the inability of the straw walker system to keep pace with the output of threshed material from the cylinder (9).

From field performance tests, walker losses may be attributed to the manner of crop presentation to the cylinder and the separation performance of the cylinder and concave. If the cylinder and concave are working well, approximately 75 per cent of the grain passing through the combine passes through the concave. In California, Goss (4) found that when the machine is overloaded, the walker losses occur because the concave was not separating the grain and approximately 50 per cent of the grain passes onto the straw walkers.

The problem of the concave being "out of balance" with the straw walkers occurs only at high feedrates. This phenomenon arises because: (a) as the feedrate increases to the cylinder, the proportion of grain passing through the concave decreases because the grain cannot penetrate the thicker mat of material, and (b) the straw walker efficiency decreases with walker length such that most of the grain falls through the first one-third of the total length. The decrease in walker efficiency may be attributed to the following causes (a) the straw forms an impenetrable mat as it moves along the walkers, and (b) the shorter and leafier fraction of the crop residue gravitates to the straw walker separating surface to form an impenetrable mat.

Various straw walker shapes and mat types are available to improve separation, but all seem to have about the same efficiency. Combine manufacturers have added risers, kickers, and add-on sections, but these additions do little to improve separation and, in some cases, reduce conveying ability.

Other Straw Rack Mechanisms

To improve separation, Radle (10) in 1923 was assigned a patent for the design that employed a raddle, a pickup mechanism, and a straw rack. The pickup device gave the threshed material an abrupt reverse motion to allow the grain to fall through a raddle slot while the straw was deflected onto the rack. Further, the separator mechanism slightly compressed the straw as it was picked up from the raddle and then permitted it to expand. By the successive compression and expansion of the straw, the entrapped grain was freed.

To control the flow rate of straw through the combine, and at the same time, to increase the separation action that the grain is subjected to, an invention was patented by Hopkins (11) in 1955. To achieve the objectives, the mechanism employed a plurality of vertical adjustable straw retarders to regulate the flow rate and direction of straw over the rack. Finally, a pair of straw rakes, mounted above the straw retarders, intermittently agitated and moved the straw along over the rake to be discharged.

Another design, patented by Kline (12) in 1957, incorporated a series of tiers to form a straw rack. Shafts with attached fingers comprised a straw agitator and lifter while rack arms connected between the separator frame and the shafts are the activators which impart the motion of the tier to the agitator. The mat of threshed material is thrown upward by the fingers when the tier moves rapidly rearward. This action scattered and loosened the mat which then feel on the rack and fingers to allow the grain to fall out of the straw.

In 1971, Witzel and Olieman (13) received a patent for the design to increase the straw walker efficiency. The agitation system employed a wobble-drive mechanism that consisted of a plurality of straw-engaging fingers coaxially mounted on a shaft. These tines rotated and oscillated to act on the material passing lengthwise over the walkers to separate the grain from the straw.

Other Separator Mechanisms

In 1904, Kramer (14) received a patent for the design of a grain separator. The mechanism used a straw-grain separation means in such a manner that each successive member moved faster than the previous one. The method prevented the thick accumulation of straw and allowed the grain to be easily shaken from the straw. The separator used a combination of three beaters to agitate and accelerate the material and two straw carriers (raddles) to complete the separation process.

In the design of a separator, patented by Blewitt (15) in 1910, one of the threshing components was a series of cylindrical kickers that were located at the rear of the concave grate extension. These kickers were to be effective in dislodging the grain from the entangled straw.

G. and N. Beam (16) received a patent in 1913 for the development of a threshing machine that was comprised of a vibratory straw deck consisting of a series of transverse bars mounted on endless chains. Located above the deck, two pairs of rotary kickers throw the straw rearward and allowed for more complete separation. A rotary kicker at the end of the deck stripped the straw from the deck bars.

For the design of a grain separator, Sheard (17) in 1960 was assigned a patent. The separator used an apron conveyer to carry the threshed material rearward from the cylinder to a raddle rack. The straw is lifted and carried rearward by the raddle that collected the grain while carrying the straw to the rear of the machine. Several beaters were located above the raddle and operated to thoroughly separate the grain from the matted straw.

Denison and Harrington (18) in 1972 were assigned a patent for a combine that employed a rotary separation system. The system utilized three separating units that consisted of an impeller and an open concave to permit a continuous control of the threshed material. The separating units were placed in such a manner to provide a serpentine path so that both sides of the mat were exposed to the open concave of each successive separating unit. Thus as each successive impeller engaged the material and moved it across the concave, the grain was discharged through the concave.

CHAPTER III

DESIGN AND CONSTRUCTION OF THE SEPARATION SYSTEM

The principle of accelerating and stretching the mat of threshed material to separate straw and grain was utilized in the design specifications. The first step in the design procedure was the selection of a mechanism to accelerate the material. From a review of mechanical devices, four alternative types of mechanisms were available: (a) a series of variable-pitch chains (19 and 20), (b) a series of conveyor belts and rotors (21 and 22), (c) a series of walking beam conveyors (23), and (d) a series of rotors.

The decision was made to construct the separator utilizing a series of rotors with concaves, because the concave has a relatively constant separation efficiency throughout its length (9).

Preliminary Conveyor Study

To gain a better understanding of the design alternative, a cotton stripper conveyor (Figure 3) was utilized to study straw conveyance with a series of rotors. The conveyor consisted of a series of six spike-toothed cylinders to move the material over successive concaves. The rotors were placed on one-foot centers and had a horizontal axis of rotation perpendicular to the direction of material flow. The rotors had their axis in a common horizontal plane, and each succeeding rotor turned at 20 per cent greater speed than the previous rotor (24).

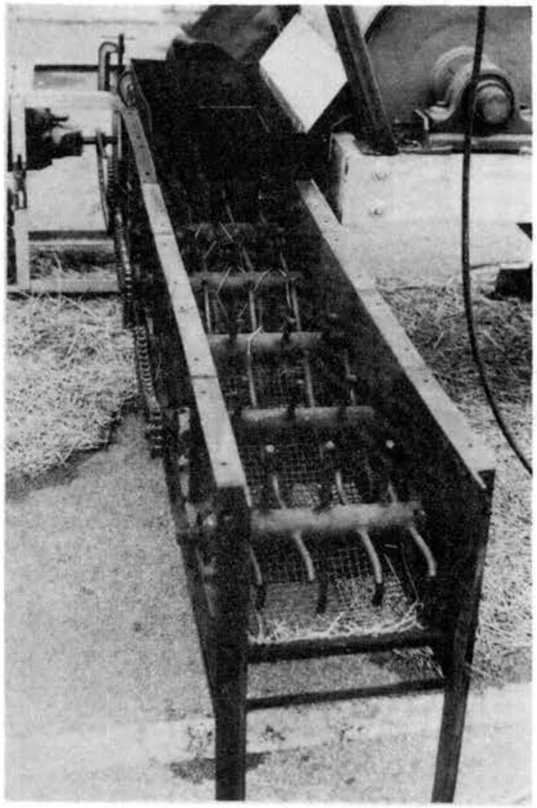

Figure 3. Cotton Stripper
Conveyor

Qualitative tests using the conveyor provided valuable insights for the separator design specifications. It was clear that a series of rotors could accelerate and stretch a mat of straw to allow the grain to separate. The test runs emphasized the need to feed the straw into the separator normal to the plane of the rows of teeth. To prevent straw from wrapping around the hubs, teeth from successive rotors should overlap. To minimize straw breakup, the concaves should be constructed as a continuous assembly rather than individual sections due to the knife-edge effects at the junction of two concaves, shown in Figure 4. Further, it appeared that the ends of the teeth should be bent back to provide a sweeping and carding action rather than a tearing action to minimize straw breakup and that four rows of tines per rotor were sufficient in moving the material.

Design and Construction of the Separator

After studying the operation of the small cylinder conveyor, the decision was made to design a separating mechanism that consisted of a series of six spike-toothed rotors to move the threshed material over successive concave screens.

Rotor and Concave Screen Assembly

Each rotor had an effective diameter of 18 inches. Three of the six rotors had 28 tines, while the remaining three rotors had 24 tines. The tines were mounted on a hub of 2.875 inches in diameter and 24 inches in length. The 0.5 inch round tines were welded four inches on center in rows of six or seven tines per row, depending upon the rotor, with the row axis parallel to the longitudinal axis of the hub.

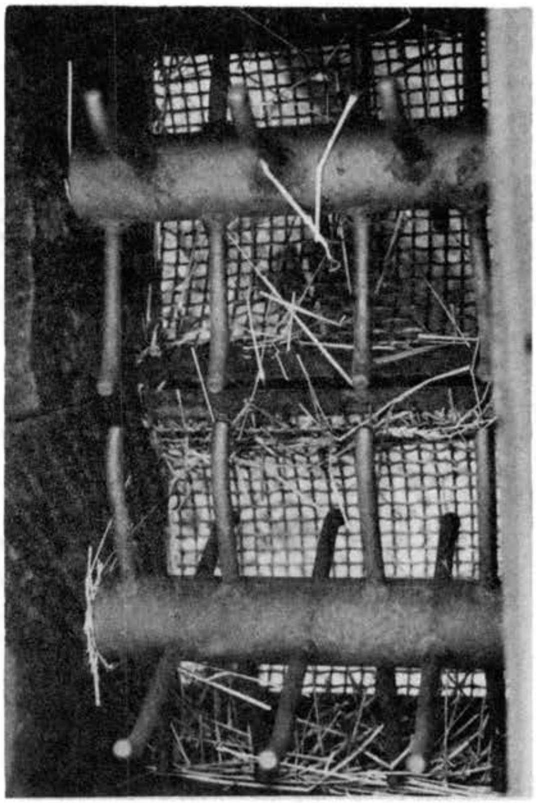

Figure 4. Straw Breakup at the Junction of Concave Sections

There were four rows per hub equally spaced 90 degrees apart around the hub. In the rows having six tines, the end tines were placed two inches from the ends of the hub; while the rows having seven tines, the end tines were placed one inch from the ends of the hub and three inches from the adjacent tines. All tines had a 45 degree reverse bend at the tip to make them less aggressive and to provide a sweeping action. A separator rotor is shown in Figure 5.

Four concave screens, two plane bottom screens and two concave bottom screens, were required for the experimental testing. These screens were constructed from two types of material, shown in Figures 6 and 7. The 0.5 inch square mesh wire cloth was made of woven steel wire 0.063 inch in diameter to provide 0.47 inch openings. The flattened expanded metal consisted of diamond shaped openings 0.25 inch by one inch. The distance from center to center of the bridges was 0.5 inch by 1.25 inches.

The concave bottom screen consisted of six concaves and five transition grates. The concaves had a 9.5 inch radius of curvature, while the grates had a 5.5 inch radius of curvature. The first concave had a wrap of 90 degrees, while the remaining five had 60 degrees of wrap. The total length of the screen surface was 98.25 inches. The 24 inch width of the concave bottom screen provided 2320 square inches of separation surface.

The plane bottom screen had a total length of 94.00 inches of screen surface. The first 10 inches provided 60 degrees of wrap while the remaining 84 inches had zero degrees of wrap. The 24 inch width of screen provided 2260 square inches of separation surface.

The rotor-concave screen assembly was constructed in such a

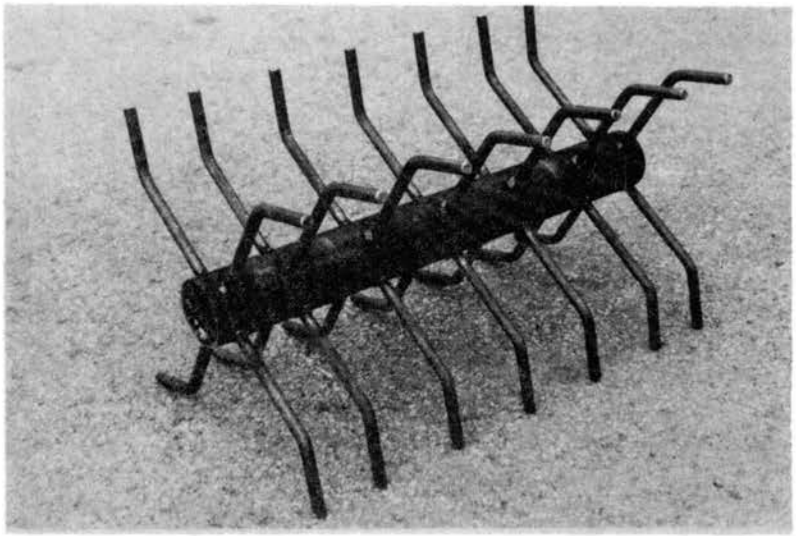

Figure 5. Separator Rotor

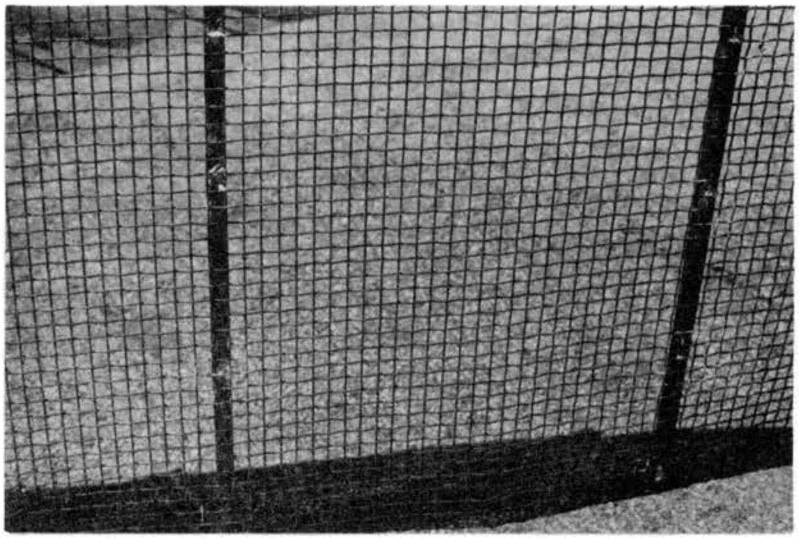

Figure 6. One-Half Square Inch Wire
Cloth Screen

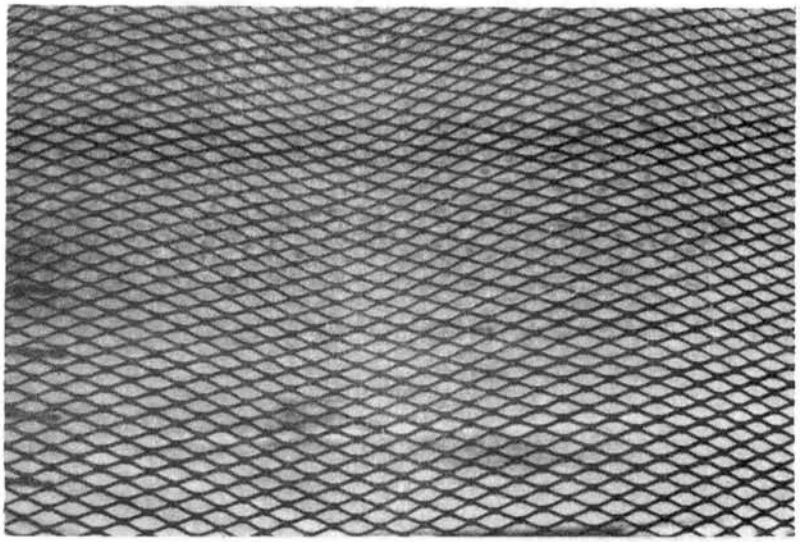

Figure 7. One-Half Inch Flattened Expanded Metal Screen

manner that the rotors were placed on 15-inch centers to provide a three-inch overlap of adjacent rotors (Figure 8) to prevent straw from wrapping around the rotor hubs and had a horizontal axis of rotation perpendicular to the direction of material flow. Also, the clearance between the concave screen and the rotor tines was made adjustable to provide a spacing of zero to two inches. The mixture of straw and grain was accelerated and stretched over the first concave by the first rotor and passed on to the next rotor. This procedure was repeated by each successive rotor until the straw was discharged at the end of the separator while the grain fell through the screen openings under each rotor. The length of the rotor-concave screen assembly was 93 inches. Figures 9 and 10 show the two rotor-concave screen arrangements.

Separator Housing Assembly

The separator housing consisted of an angle frame and sheet metal sides to support the rotors and the concave screen. The frame was constructed from two bearing support members, and two upper and two lower frame supports which were connected by support braces. Figure 11 shows the separator housing assembly. A slot was cut in each of the lower support braces to provide a means to adjust the clearance between the tines and concave screen, shown in Figure 11. Concave pins, which were drawn against the lower brace, held the concave screen in position. The separator sides were made from galvanized sheet metal.

To facilitate the observation of the separation process, two rectangular openings were cut in each side of the housing at the third

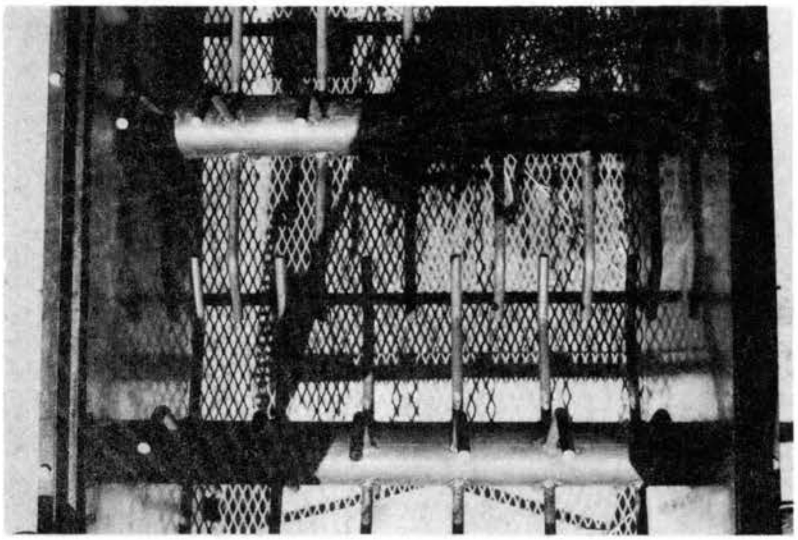

Figure 8. Overlap of Adjacent Rotors to Prevent Wrapping

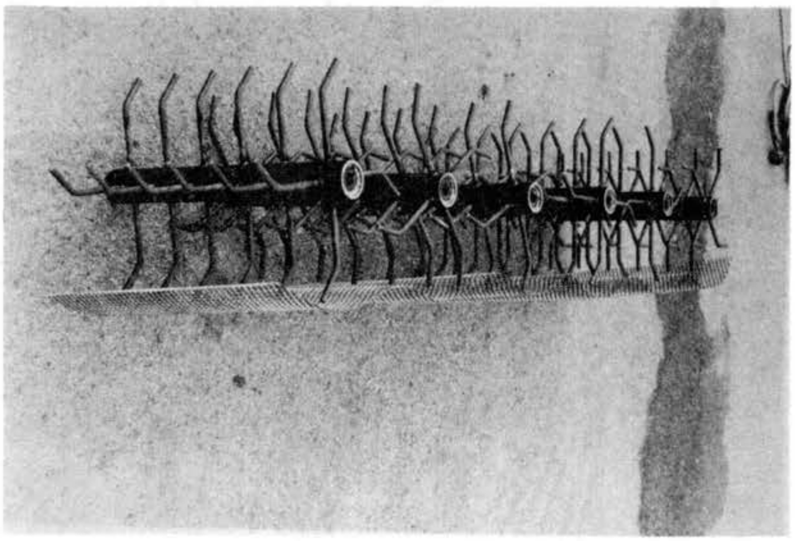

Figure 9. Relative Position of the Rotors and Concave Bottom Screen in the Separator

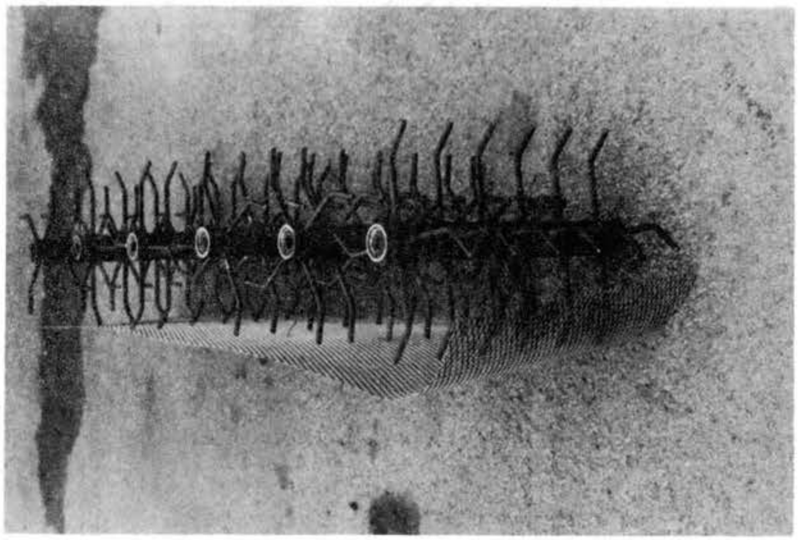

Figure 10. Relative Position of the Rotors and Plane Bottom Screen in the Separator

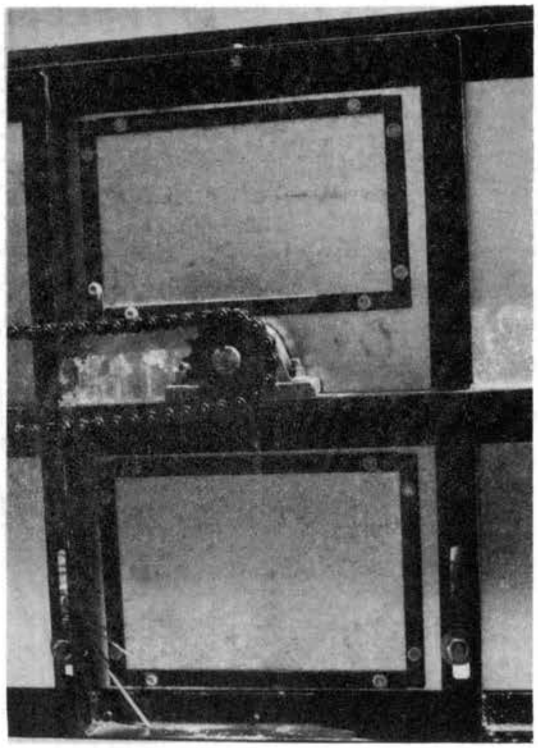

Figure 11. Separator Housing Assembly with Replacable Panels for Taking Pictures and Showing the Adjustable Concave Supports

rotor position, shown in Figure 11. Removable plates were then mounted over the openings to be replaced by 0.25-inch clear Plexiglas so that high speed motion pictures could be taken of the process.

Figures 12 and 13 show the top and side views of the assembled rotary separator test stand.

Catch System

A drawer-type catch tray with rollers rested on a track below the concave screen (Figure 14). In the tray were six catch boxes for collecting the grain and chaff that fell through the concave screen. Two aluminum boxes were used to collect the material that was discharged from the rear of the separator.

Conveyance System

Grain, chaff, and straw mixtures were delivered to the front of the separator by a belt conveyor. The conveyor's driver pulley was driven at 7.33 RPM by a gear reducer from a 2-HP electric motor to provide a peripheral belt speed of 39.5 feet per minute. The conveyor had a belt width of 24 inches and an effective length of 142 inches with 17 inch sides to provide an 18 second charge of material to the separator.

Power System

The power input to the separator was a 3-HP Reeves Variable Speed Transmission, Model VED-GH, with an output of 600 to 4200 RPM. The variable speed transmission was connected to the separator by 50 pitches of No. 50 roller chain. A step-down ratio of 3.6 was employed

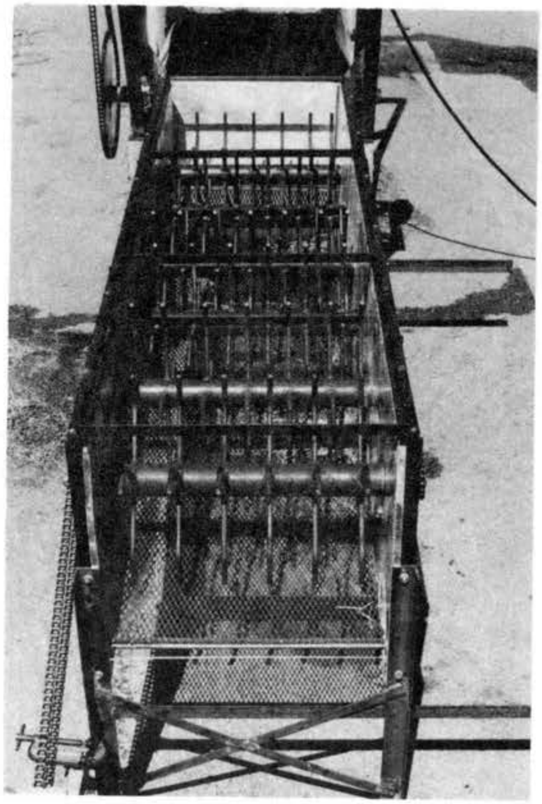

Figure 12. Top View of the
Separator

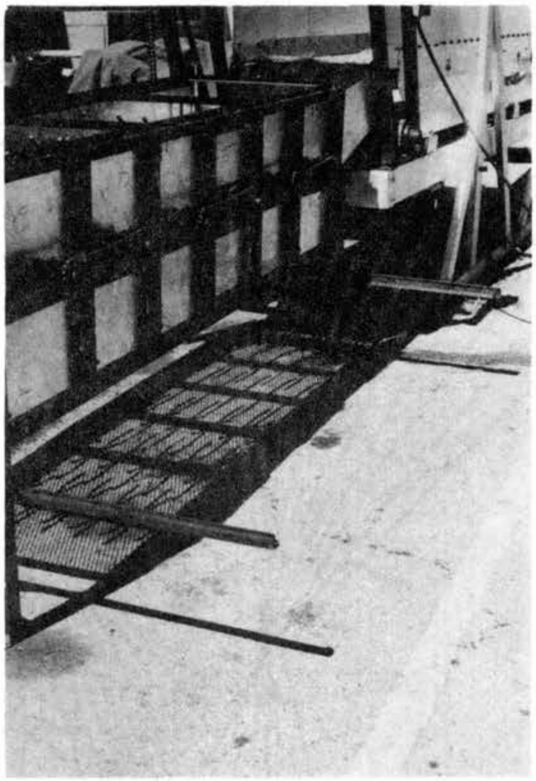

Figure 13. Side View of the Separator

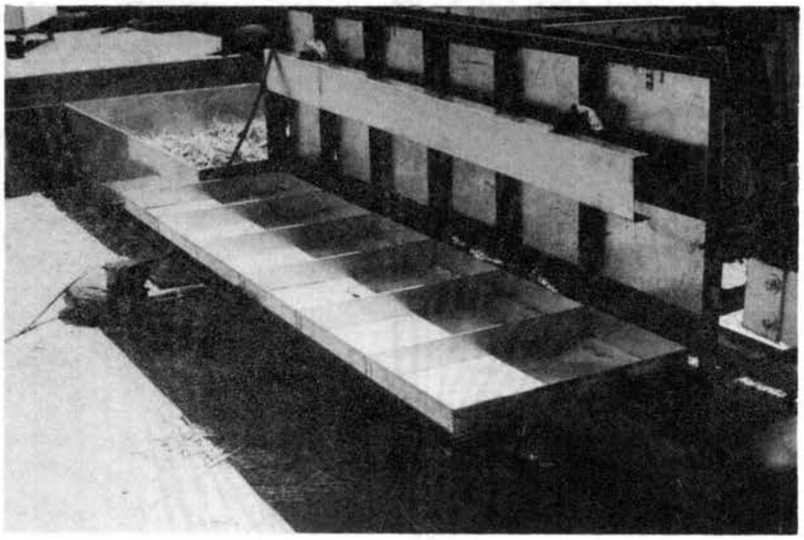

Figure 14. Catch Tray Assembly

with a 15-tooth and a 54-tooth sprockets.

The rotor speeds were successively stepped-down by 10 per cent of the discharge rotor speed with a 15-tooth and an 18-tooth sprockets that were connected by 47 pitches of Number 50 roller chain. This step-down provided that the sixth rotor rotated at twice the speed of the first rotor. The two speed combinations of the rotors were: (a) 85 RPM for the first or input rotor and 170 RPM for the sixth or discharge rotor, and (b) 105 RPM for the first rotor and 210 RPM for the sixth rotor.

The rotary separator test stand with the catch, conveyance, and power systems are shown in Figure 15.

Auxiliary Equipment

A "Clipper" seed cleaning mill, manufactured by A. T. Ferrell and Company, Saginaw, Michigan, was used to clean the debris from the grain catches. Numbers 6 and 13 sieves were used in the mill for cleaning the grain.

A Toledo Scale, Model 2081, with a 200 pound capacity, manufactured by the Toledo Scale Corporation, Toledo, Ohio, was used to weigh the grain samples.

To measure the rotor speed combinations, a hand-type tachometer was used to determine the speed of the sixth rotor. The tachometer was made by the Metron Instrument Company of Denver, Colorado.

Two 8-inch Tyler sieves, Number 4 (0.187 inch) and Number 5 (0.157 inch) were used to sift the grain on the charge of M.O.G.

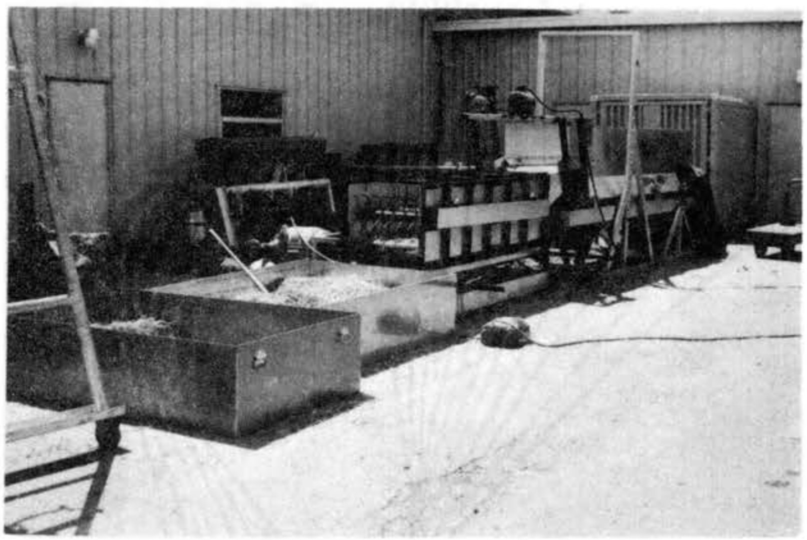

Figure 15. Rotary Separator Test Stand with the Catch, Conveyance, and Power Systems

CHAPTER IV

EXPERIMENTAL PROCEDURE

This chapter contains the description of the test material, the method of procedure, the experimental design, and the material breakup and consistency tests. A detailed procedure is also given for conducting a grain loss test for the rotary separator.

Test Material

Wheat was chosen as the test material. MacAulay (25) reported that wheat material does not change its physical properties with repeated handling. The straw used in this experiment was harvested during the 1972 season and was stored as bales. The straw was agitated twice by the separator before the tests were conducted so that it would be similar in nature to the straw leaving the threshing cylinder. The grain used for the tests was hard red winter wheat. The wheat was grown at Stillwater, Oklahoma, but the variety was unknown.

Method of Procedure

Variable Factors

The purpose of this research was to determine the effect of three design factors upon the separation of grain from straw and the reduction of grain losses with the rotary separator.

To determine the time interval necessary for separation, two rotor speed combinations were selected as variables. The 2-speed combinations are presented in Table I.

TABLE I

SPEED COMBINATIONS FOR THE SEPARATOR ROTORS

ROTOR	SPEED COMBINATION (RPM)	
	I	II
1 (Input)	85	105
2	102	126
3	119	147
4	136	168
5	153	189
6 (Discharge)	170	210

Two types of concave screens were selected to determine the effect of surface area upon separation. The plane bottom and concave bottom screens were used, which respectively had areas of 4980 and 5220 square inches. Finally, two kinds of screen material were selected to determine the effect of varying amounts of screen openings upon separation. The two screen materials, flattened expanded metal and wire cloth, provided approximately 60 and 80 per cent openings, respectively.

Combine tests report the performance on a percentage loss versus feedrate basis. The test results are normally plotted on a graph and a loss curve is drawn which concisely presents the performance information.

To evaluate over a wide range of feedrates, the variables studied in this experiment were tested at five feedrates, at intervals of 50 LB/MIN, from 250 to 450 LB/MIN of material other than grain (M.O.G.). The feedrates and screen areas presented in the text were for a 53 inch separator width and were adjusted by direct proportion from the 24 inch experimental separator width.

Factors Held Constant

Due to the number of factors believed to effect the separation process of the rotary separator, it was decided to hold constant the number of tines per row and the number of rows of tines per rotor. After operating the separator with concave clearances of 0.5 and 1 inch, the clearance between the concave screen surface and the tines was set at 0.5 inch in order that the tines were effective in moving the material over the concave screen.

The conveyor belt was maintained at a peripheral speed of 39.5 feet per minute for all of the tests conducted during the experiment. At a speed of 39.5 feet per minute, the 142 inch conveyor was emptied in 18 seconds.

The variability of the straw and chaff material could have an influence on the test results, but an attempt was made to limit the variability by reusing the same straw for each set of tests.

The role of the M.O.G./GRAIN ratio has been found to have an effect on straw walker performance. For the tests, the M.O.G./GRAIN ratio was set at 2.0 as was suggested by Temple (26).

Design of Experiment

The experiment was designed to compare the grain losses that occurred with the rotary separator. The comparisons were made with two rotor speed combinations, two concave screens, two screen materials, five feedrates, and two replications on the basis of grain loss performance curves obtained by varying the feedrate from 250 to 450 LB/MIN in 50 LB/MIN increments.

The factors resulted in 40 treatment combinations per replication. The tests were conducted on a randomized block design. The four concave screens were selected as the blocks since time was a limiting factor and changing the screens took considerable time. The rotor speed combinations and feedrates were randomized by accepted statistical methods to determine the order of tests. The concave screens were randomized within each replication.

Straw Breakup Tests

During the first part of the test program, a series of runs were made to measure the amount of straw breakup, in order to determine the number of times the straw could be reused. The runs were made with the flattened expanded metal plane bottom screen in the separator, while the rotor speed was maintained at 200 RPM. The procedure consisted of running 42.5 pounds of straw through the separator. The breakup material was weighed and recorded. The procedure was repeated seven times, and the results are presented in Table II. From the tests, it was concluded that the same straw would be used for the 10 tests for each concave screen.

TABLE II

SEPARATOR STRAW BREAKUP

RUN	BREAKUP (LB)
1	1.85
2	2.10
3	2.65
4	3.05
5	3.20
6	3.20
7	3.20

Consistency Tests

The last step in the preliminary testing program was checking the consistency of grain losses that occurred at a specified feedrate. A 300 LB/MIN M.O.G. feedrate with a 2.0 M.O.G./GRAIN ratio was chosen. The flattened expanded metal plane bottom screen was used, and a rotor speed on the input rotor of 200 RPM was maintained. The losses that occurred for the first test were 58.8 per cent.

From this test, the decision was made to modify the rotor speed combination to allow a greater separation time. Finding that the straw walker crank speeds ranged from 170 to 210 RPM (8) and calculating the peripheral speed of the straw walkers, the decision was made to operate the separator rotors at (a) 85 RPM for the input rotor and 170 RPM for the discharge rotor, and (b) 105 RPM for the input rotor and 210 RPM for the discharge rotor.

Two sets of consistency tests were conducted and the data are presented in Table III. From the consistency tests, the following conclusions were made that the straw should be run through the separator at least twice to fluff the straw and that the same lot of straw should be used for each set of tests to reduce variability.

TABLE III

GRAIN LOSS CONSISTENCY TESTS

TEST	PER CENT GRAIN LOSS	
	REP. 1	REP. 2
1	19.5	41.8
2	10.6	20.0
3	12.8	17.6
4	6.0	6.0
5	---	6.0

Test Procedure

To insure consistency in evaluating the grain loss that occurred for each test, the following procedure was maintained:

1. Weigh the predetermined amount of straw and chaff (M.O.G.).
2. Place the M.O.G. on the conveyor belt (Figures 16 and 17).
3. Weigh the predetermined amount of grain.
4. Sift the grain uniformly over the M.O.G. (Figure 18).
5. Turn on the variable-speed motor and adjust the variable-speed transmission to provide the predetermined separator rotor speed combination.
6. Slide the catch tray into the catch position.
7. Turn on the conveyor motor.
8. Allow the mixture of M.O.G. and grain to move through the separator and the grain to fall through the concave screen (Figures 19 and 20).
9. Turn off the conveyor and variable-speed transmission motors.
10. Place the chaff and grain from the six catch boxes into individual bags.
11. Weigh and record the weights of the six bags of chaff and grain.
12. Clean the chaff from the grain for each of the six bags of catch material.
13. Weigh the six bags of cleaned grain and record the weights.
14. Calculate the grain loss that occurred for the test.
15. Convert the concave screen area by the factor of 53/24 and the M.O.G. feedrate by the factor of 53 X 60/24 X 18 to obtain the values for the 53 inch combine separator width.

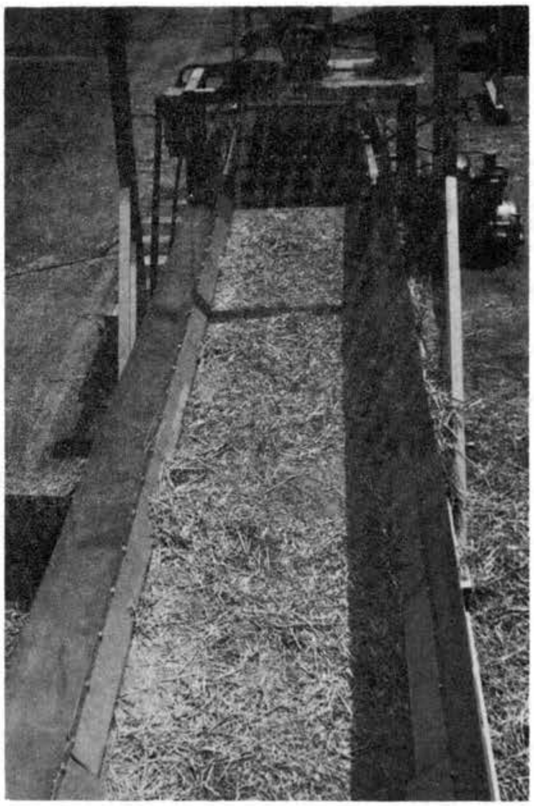

Figure 16. Placement of the Chaff on the Conveyor Belt

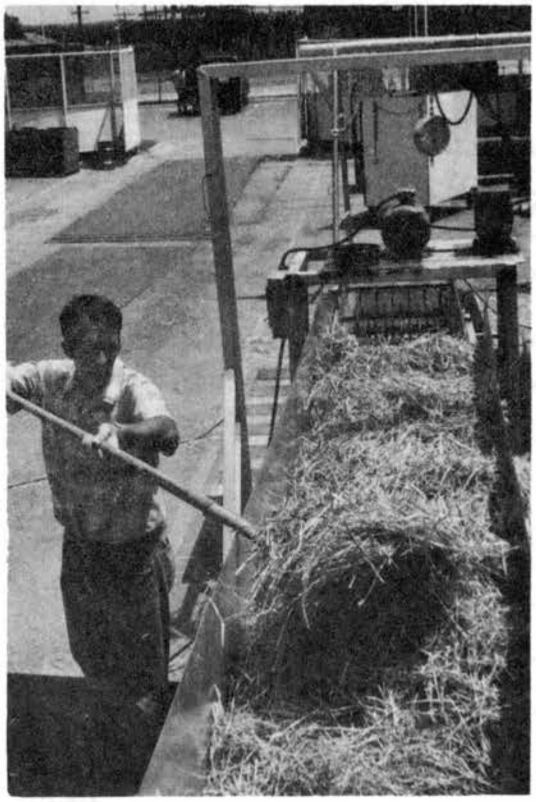

Figure 17. Placing the straw on the Conveyor Belt

Figure 18. Sifting the Grain
Over the Straw

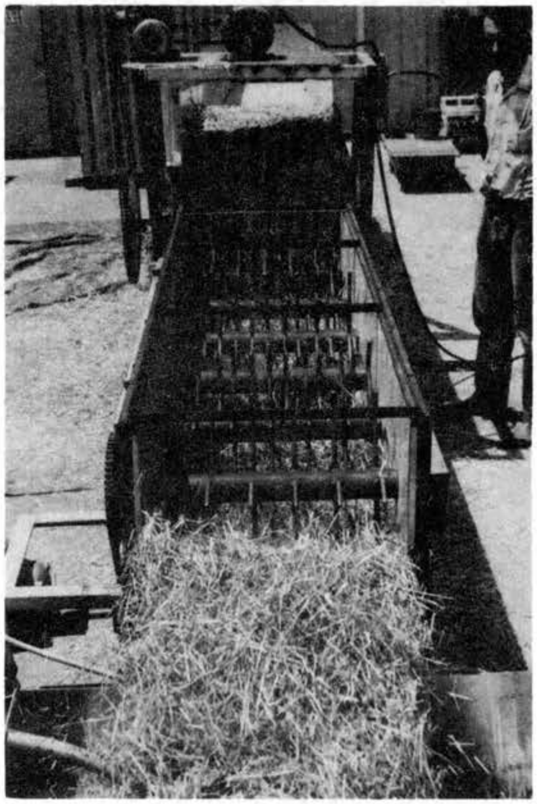

Figure 19. Running the Material Through the Separator During an Actual Test Run

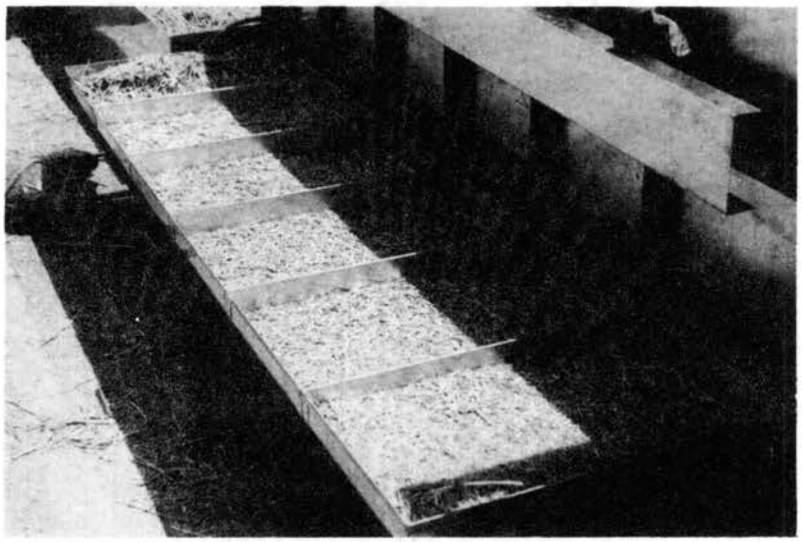

Figure 20. M.O.G. and Grain Caught in the Tray

CHAPTER V

PRESENTATION AND ANALYSIS OF DATA

Separation Efficiency Tests

In normal operation, the mixture of straw, chaff, and grain on the conveyor was carried to the front of the rotary separator where the separation process began. The free grain that was carried over the rear of the concave screen with the straw was termed grain loss and was used as a measure of separator efficiency and performance. The grain weights separated by each rotor were recorded for each test run, and the per cent grain loss was calculated. The loss data are presented in the APPENDIX. The grain loss was plotted against feedrate on semi-logarithmic scale for convenience and analysis, and the mathematical expression was obtained by regression analysis with the computer. The loss curves for the eight test comparisons are presented in Figures 21 through 26.

From the individual tests, the variation in the grain contents in the catch boxes gave a good indication of the amount of grain transported over the concave screen and the number of rotors necessary for separation. The contents of each box (average percentage of the four concave screens for the two replications) are presented in Figure 27. From the relation presented in Figure 27, the six separator rotors were able to separate 98 per cent of the total grain from the mat of material.

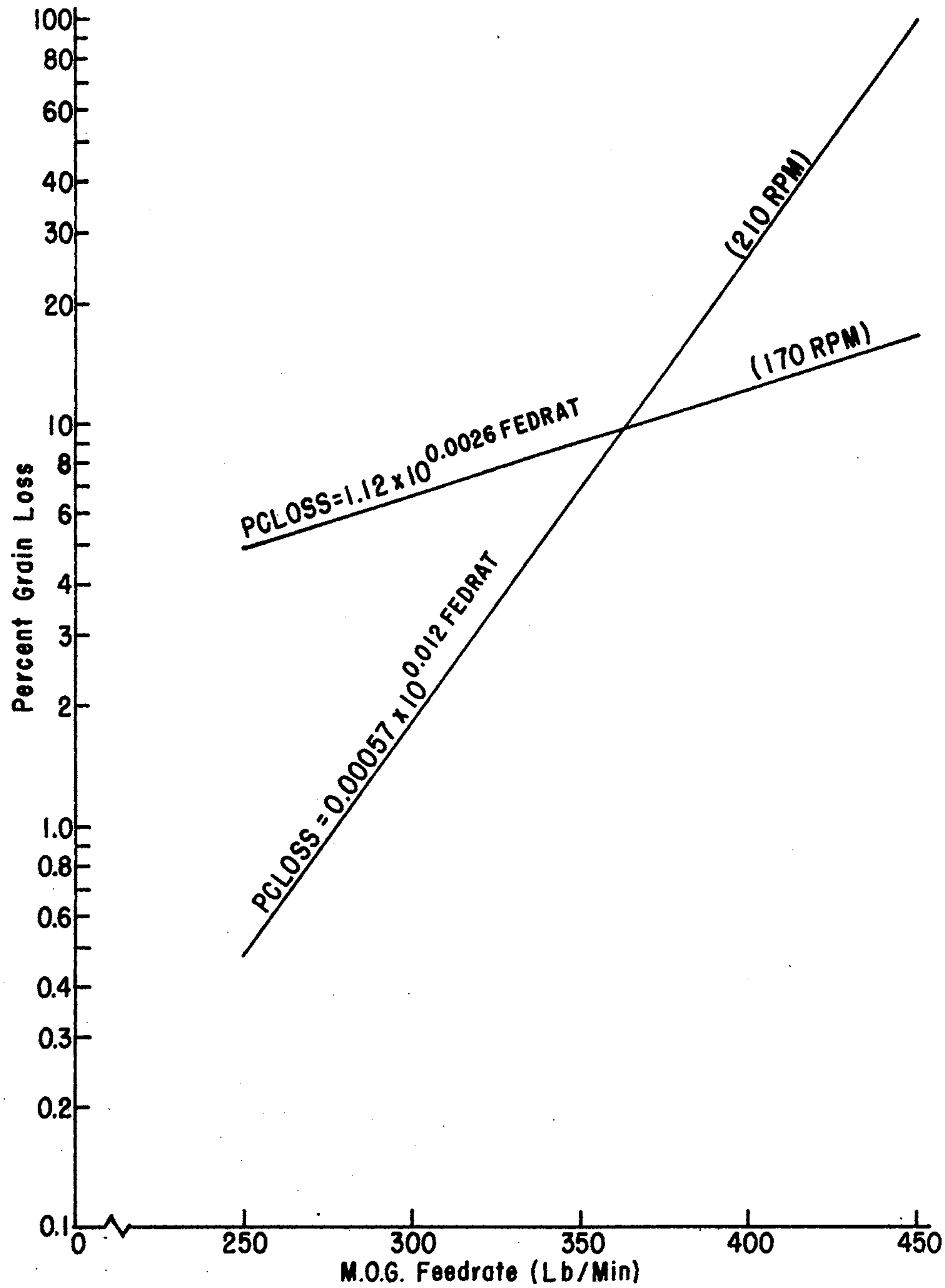

Figure 21. Grain Loss Versus M.O.G. Feedrate for the Flattened Expanded Metal Concave Bottom Screen (CB-FEM)

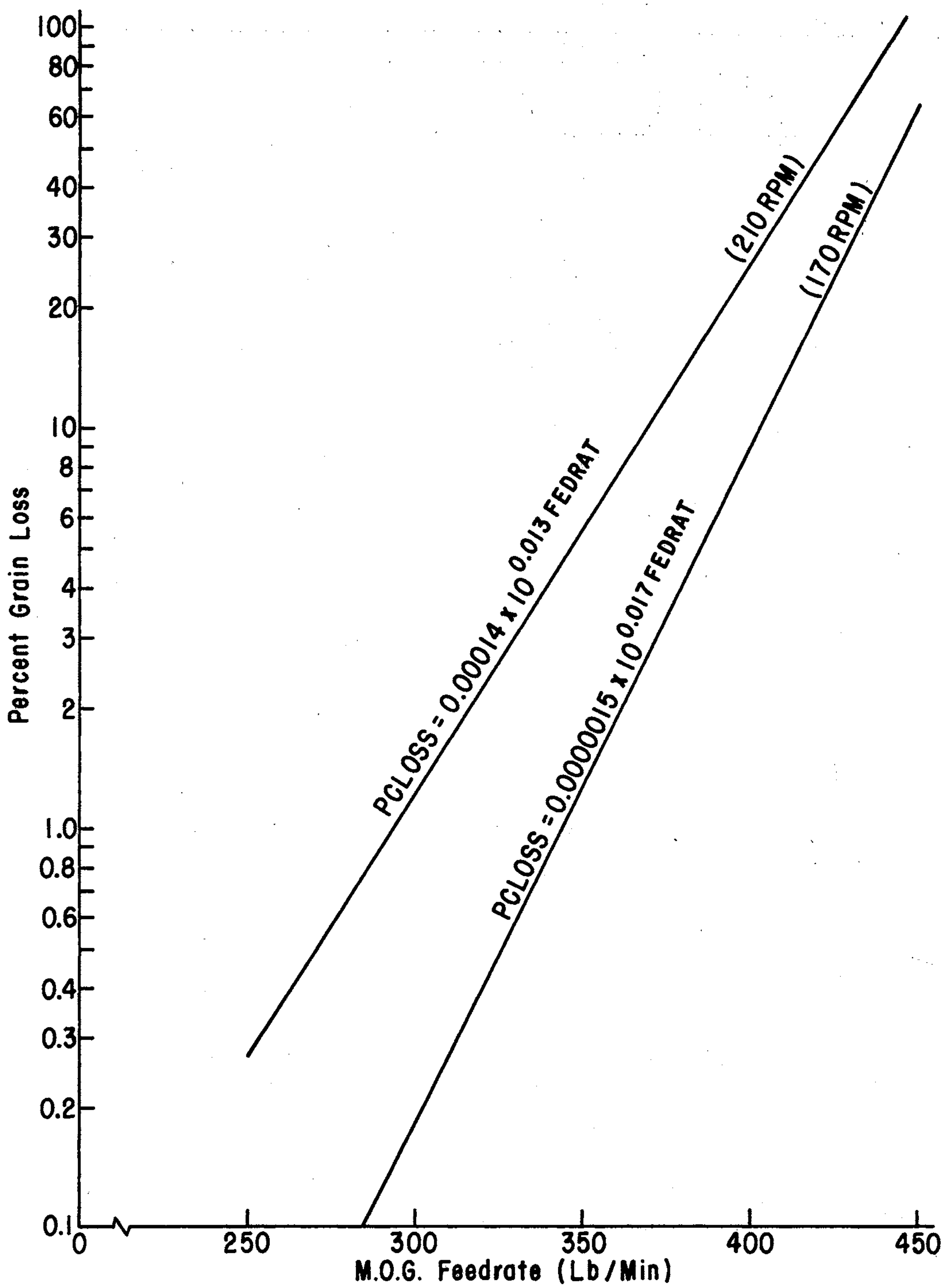

Figure 22. Grain Loss Versus M.O.G. Feedrate for the Wire Cloth Concave Bottom Screen (CB-WC)

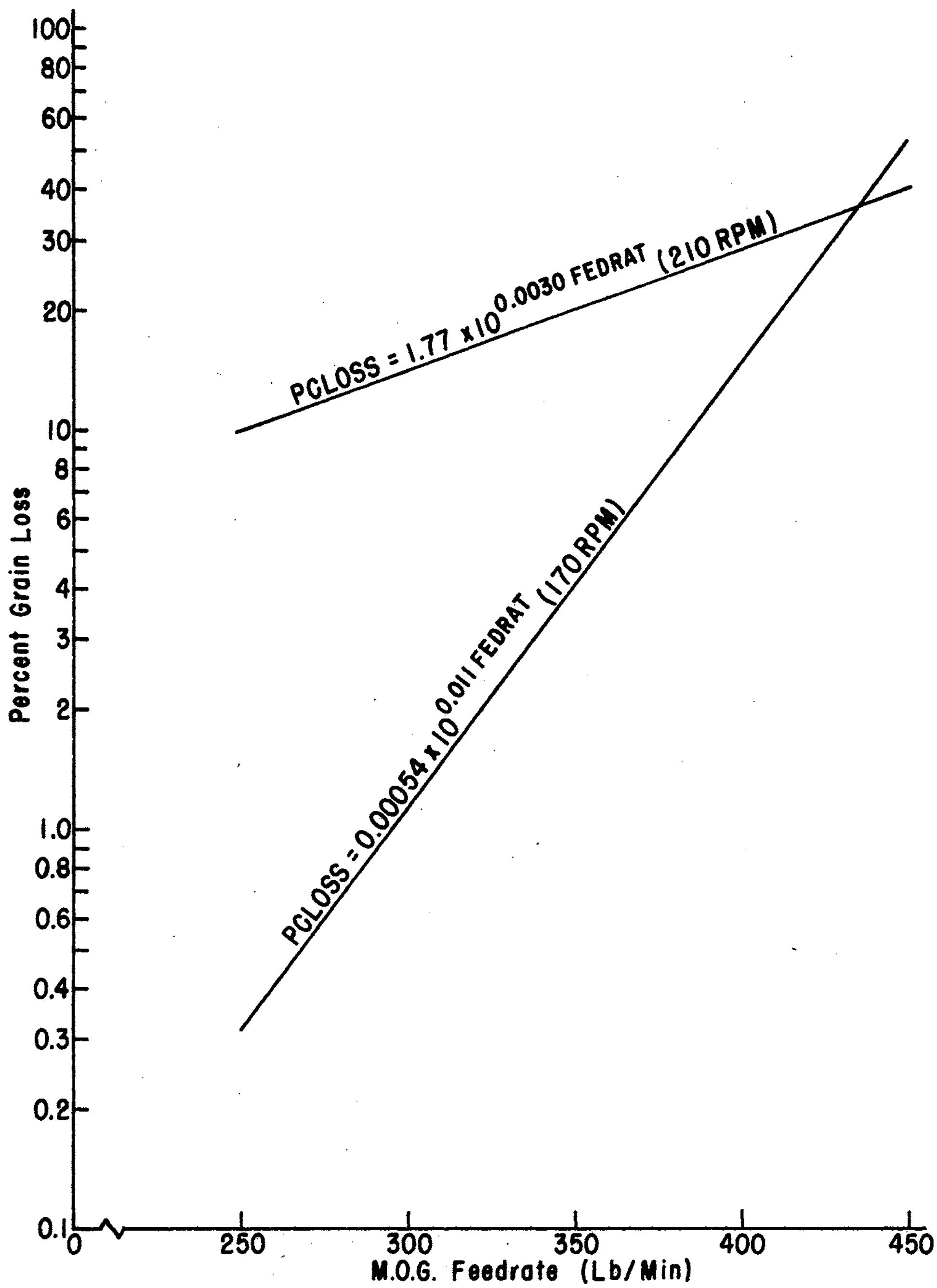

Figure 23. Grain Loss Versus M.O.G. Feedrate for the Wire Cloth Plane Bottom Screen (PB-WC)

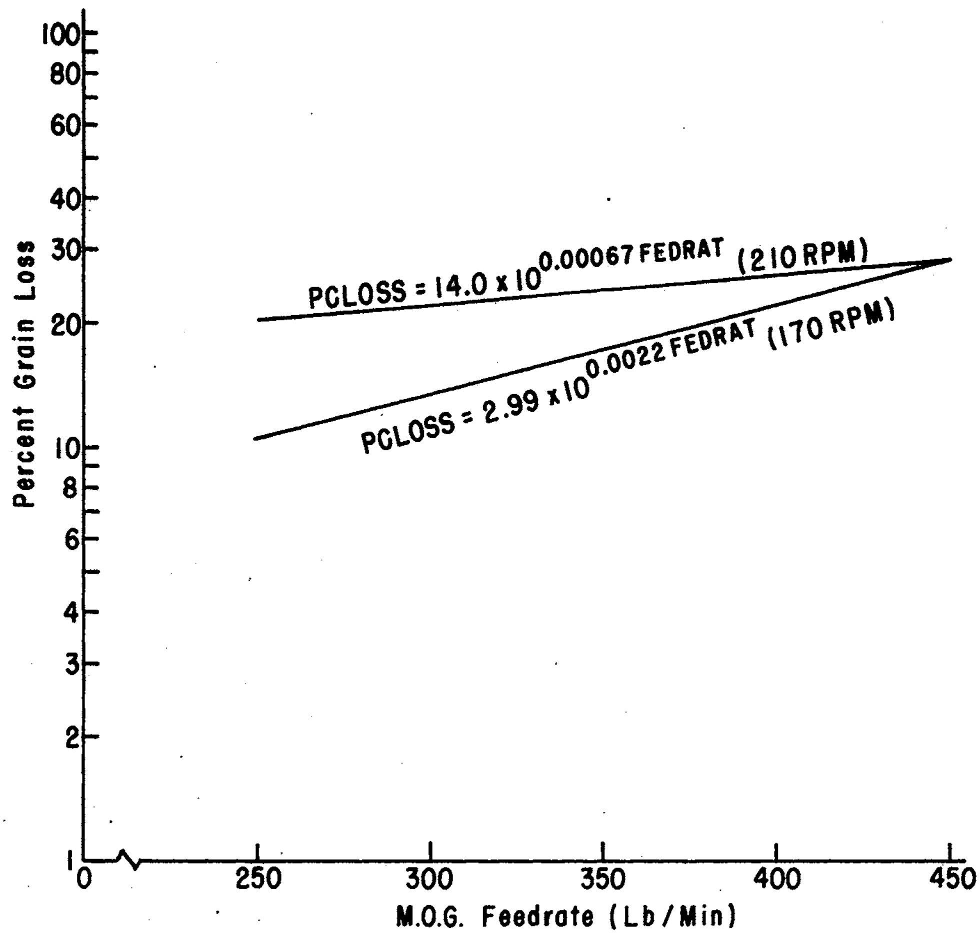

Figure 24. Grain Loss Versus M.O.G. Feedrate for the Flattened Expanded Metal Plane Bottom Screen (PB-FEM)

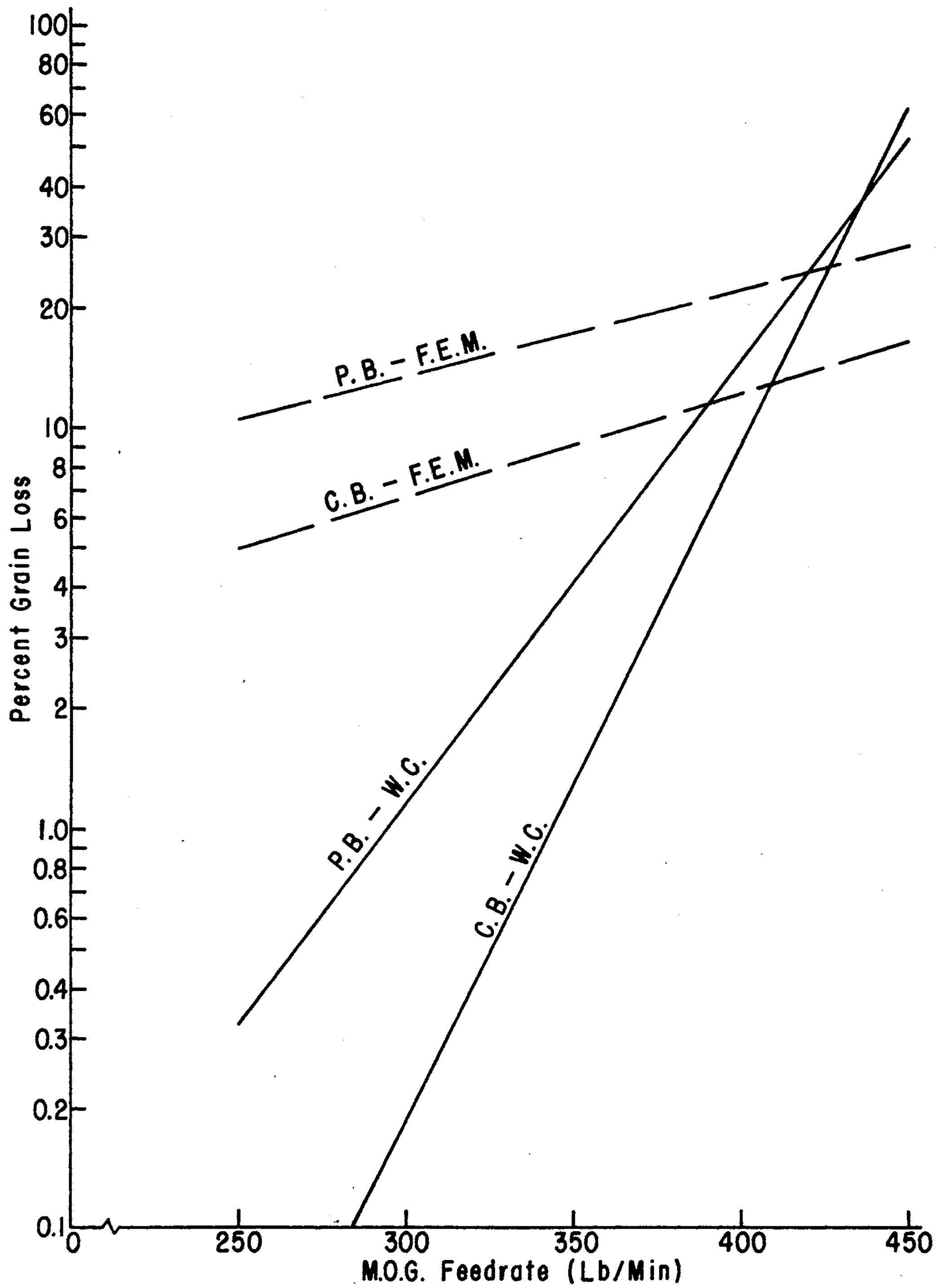

Figure 25. Grain Loss Versus M.O.G. Feedrate for the 170 RPM Rotor Speed Combination

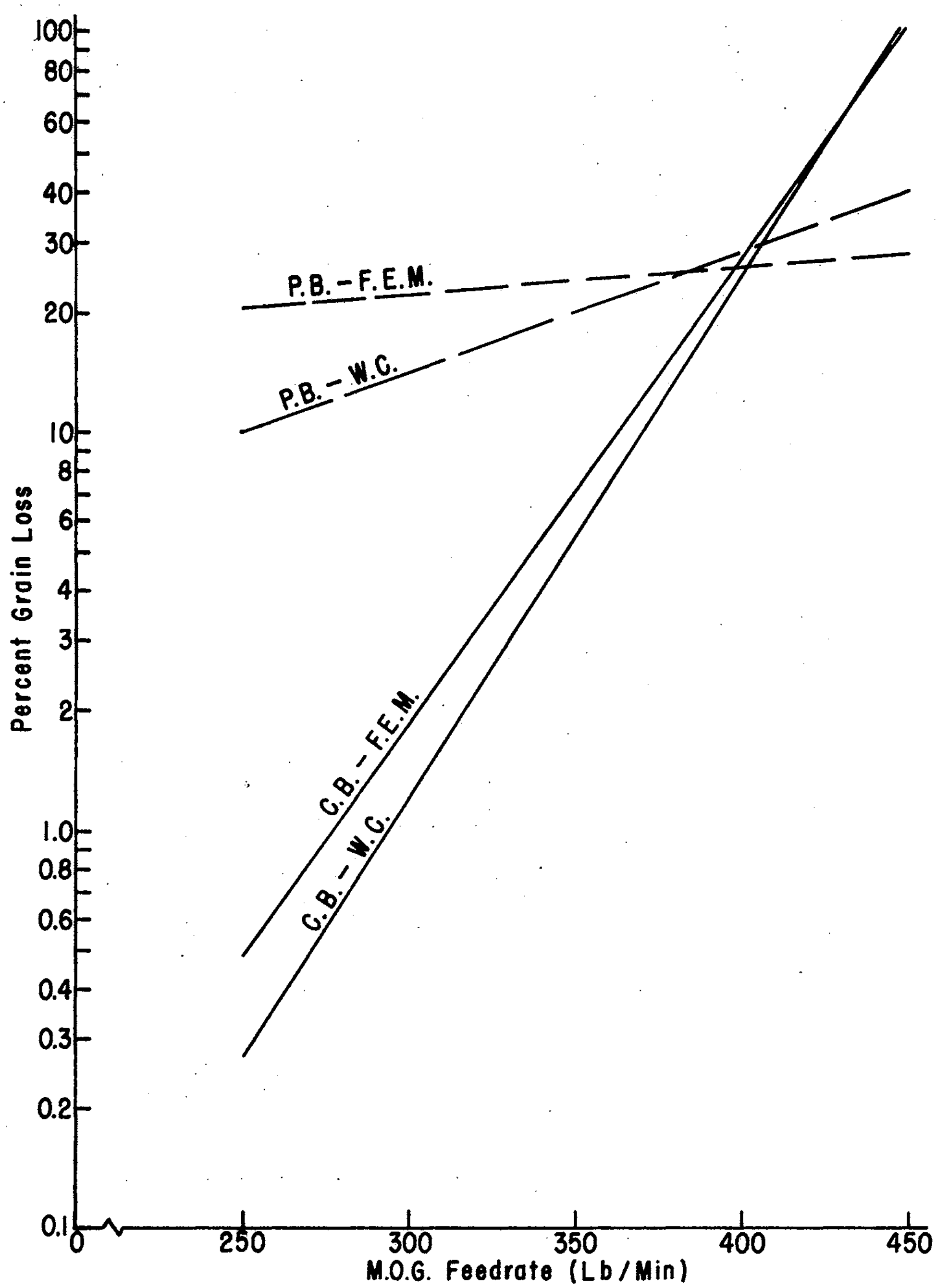

Figure 26. Grain Loss Versus M.O.G. Feedrate for the 210 RPM Rotor Speed Combination

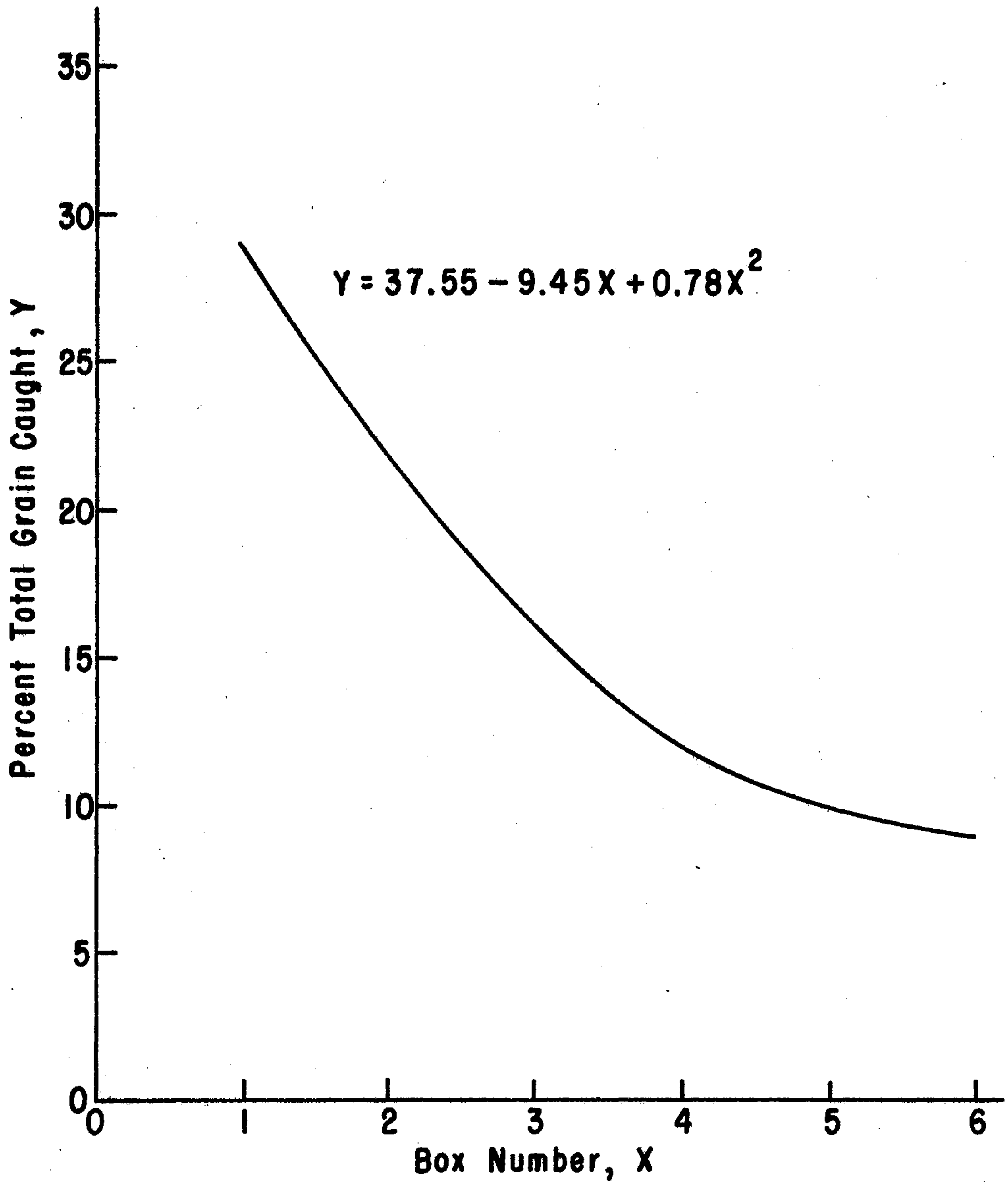

Figure 27. Per Cent Total Grain Caught Per Box

In order to determine the significance of the design factors: (a) rotor speed (ROTSPD), (b) concave screen area (CONSCN), (c) per cent screen openings, (PCOPEN), and (d) feedrate (FEDRAT) and any combinations of these factors upon grain loss performance (PCLOSS), the Statistical Analysis System (SAS) Program was used to compute the analysis of variance and regression analysis for the factorial experimental design. The F-values obtained from this program were used to test the hypothesis that the treatment factors studied affected the performance of the rotary separator.

The analysis of variance of the loss data is presented in Table IV. At the 0.05 level of rejection the effect of FEDRAT and ROTSPD were found to be significant. The data for the tests were evaluated by the SAS Program to give the means for the FEDRAT, ROTSPD, AND PCLOSS, and the plane surface, shown in Figure 28. The equation to describe the plane surface, presented in Figure 28, had a correlation coefficient of 0.643 to fit the data.

To determine if the straw reuse (STWUSE) had a significant effect upon grain loss performance, the SAS Program was used to compute the analysis of variance and the regression analysis. The analysis of variance of the design factors and the STWUSE is presented in Table V. At the 0.05 level of rejection, the effect of STWUSE, FEDRAT, ROTSPD, and CONSCN were found to be significant in the rotary separator performance. From the program, the relationship of the treatment factors may be written in the following form:

$$\begin{aligned} PCLOSS = 43.16 - 1.62*STWUSE + 0.084*FEDRAT \\ + 0.20*ROTSPD - 0.016*CONSCN. \end{aligned}$$

The expression was fitted to the data with a correlation coefficient of 0.88.

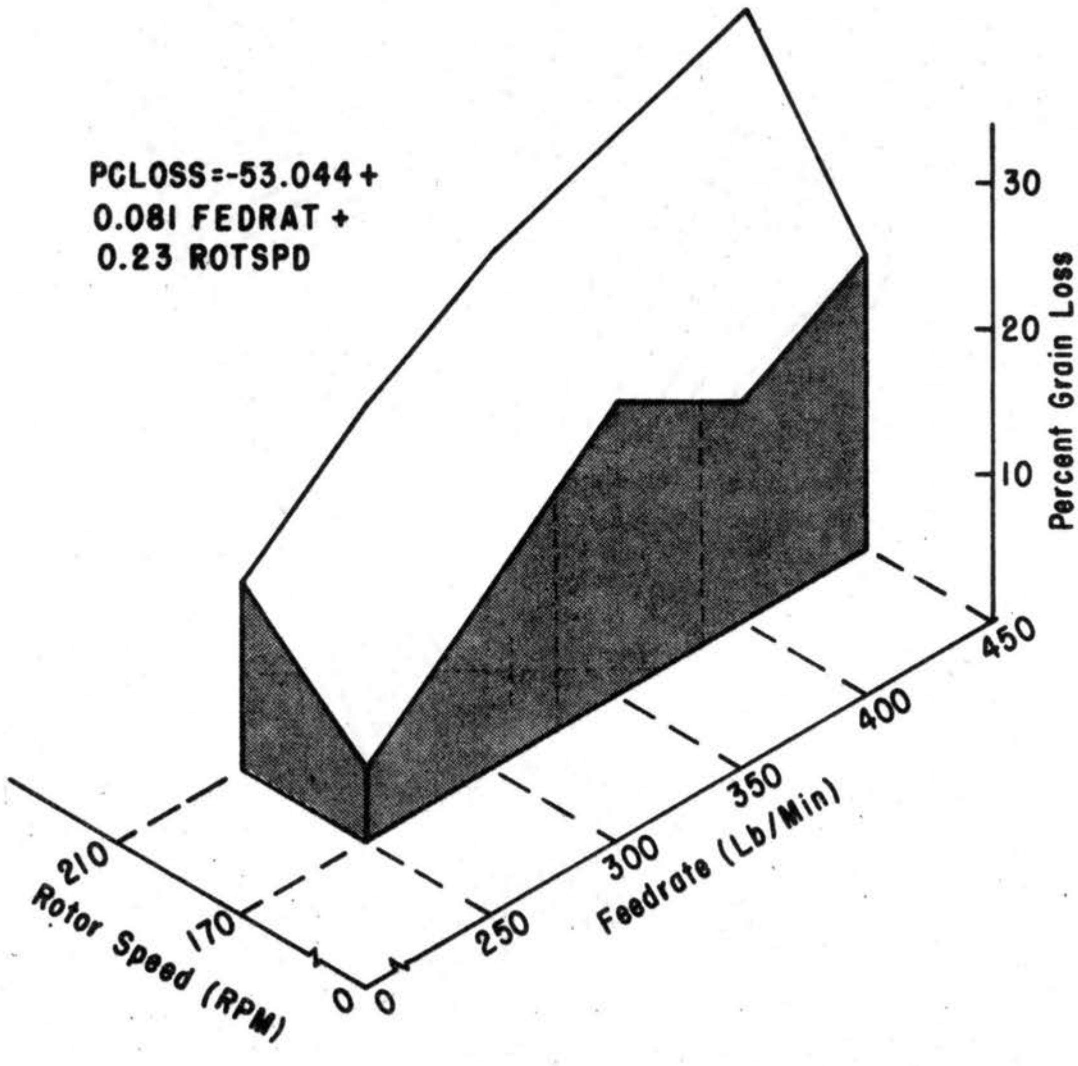

Figure 28. Per Cent Grain Loss Versus Feedrate and Rotor Speed

TABLE IV

ANALYSIS OF VARIANCE OF DESIGN FACTORS

SOURCE	df	ss	ms	f
TOTAL	79	10379.05	----	----
FEDRAT	4	2899.00	724.75	9.77*
ROTSPD	1	1697.40	1697.40	22.9*
CONSCN	1	277.14	277.14	3.73
PCOPEN	1	185.14	185.14	2.49
C.T.	32	2356.15	73.62	0.99
RESIDUAL ERROR	40	2964.22	74.11	----

C.T. = Combinations of Between Treatment Factors: FEDRAT, ROTSPD, CONSCN, and PCOPEN.

* Significant at the 5 per cent level of significance.

TABLE V

ANALYSIS OF VARIANCE OF DESIGN FACTORS AND STRAW REUSE

SOURCE	df	ss	ms	f
TOTAL	79	10379.05	----	----
STWUSE	1	1010.29	1010.29	16.58*
FEDRAT	4	3345.79	836.44	13.61*
ROTSPD	1	1196.03	1196.03	19.46*
CONSCN	1	293.80	293.80	4.78*
PCOPEN	1	71.35	71.35	1.16
C.T.	33	1126.74	34.14	0.55
RESIDUAL ERROR	38	2335.05	61.45	----

C.T. = Combinations of Between Treatment Factors: FEDRAT, ROTSPD, CONSCN, and PCOPEN.

* Significant at the 5 per cent level of significance.

Separation Process

The separation process was studied by high speed movies with the Wollensak Fastax movie camera. The camera lens aperture and focal distance was set by using the recommended operation procedure. The Fastax was set for 1000 frames per second and loaded with Kodak TRI-X Reversal Type 7278 film. The high speed movies were taken of the separator moving the material over the wire cloth concave bottom screen at 170 RPM for the discharge rotor.

From an inspection of the high speed motion pictures, it was possible to study the separation of the grain from the mat of straw. As the clearance between the tip of the tine and the concave screen decreased, the mat of straw in front of the tine was compressed, while the straw behind the tine was stretched. The compressed straw was pushed along over the concave screen until it was picked up by the next rotor. The straw behind the tine was suspended aerodynamically. This suspension of the straw provided an ideal situation for the grain to be separated from the straw before the next tine started to compress the straw and move it along over the concave screen. A segment of the separation process is shown in Figure 29.

Figure 29. Segment of the Separation Process

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

A rotary separator test stand containing six rotors and a concave screen was designed, constructed, and tested. A belt conveyor provided a means of supplying an 18 second charge of straw and grain to the rotary separator. The charge of material was run through the separator and a catch tray was used to collect the grain and chaff that fell through the concave screen.

A test program was designed to evaluate the effect of three design factors on the performance and efficiency of the rotary separator. The factors were: two rotor speed combinations of 170 and 210 RPM, two concave screen areas of 4980 and 5220 square inches, and two screen materials with approximately 60 and 80 per cent openings. The comparisons were made on the basis of grain loss curves obtained by varying the M.O.G. feedrate from 250 to 450 LB/MIN in 50 LB/MIN increments and statistical analysis.

Conclusions

The following conclusions were made on the interpretation of the experimental results:

1. The rotary separator successfully accelerated and stretched the mat threshed material to allow the grain to be separated from the straw in laboratory tests.
2. The most significant design factors affecting the separator grain loss performance were the rotor speed and the concave screen area; while the per cent screen openings within the range tested had little effect.
3. The interaction between combinations of the three design factors had little effect on grain loss performance.
4. The M.O.G. feedrate and the number of times the straw was reused had a significant effect on the grain loss performance.
5. The six separator rotors were able to separate 98 per cent of the total grain from the mat of straw.
6. The rotary separator operating at 170 RPM with the wire cloth concave bottom screen had the best grain loss performance in comparison to the other 15 test conditions.

Suggestions for Further Study

1. Construct a test stand consisting of the rotary separator plus a threshing cylinder to provide an improved straw consistency for laboratory studies.
2. Investigate the rotary separator performance with: a concave bottom screen with various degrees of wrap, rotor speed with various step-up increments, rotors with various number of rows of tines, and rotors with different tine configurations.

3. Construct a rotary separator to mount in a combine-harvester and evaluate the separator under field conditions.

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APPENDIX

GRAIN LOSS PERFORMANCE DATA AND THE CONVERSION OF RAW DATA TO REPORTED DATA

EXAMPLE:

Adjusting for separator width:

$$\frac{34\ \text{LB}}{24\ \text{IN}} = \frac{X}{53\ \text{IN}}$$

$$X = 75\ \text{LB}$$

Adjusting for time:

$$\frac{75\ \text{LB}}{18\ \text{SEC}} = \frac{Y}{60\ \text{SEC}}$$

$$Y = 250\ \text{LB}$$

TEST: 1

REP: 1

SCREEN: PLANE BOTTOM --FLATTENED EXPANDED METAL

ROTOR SPEED (RPM)		170	170	170	170	170	210	210	210	210	210
FEEDRATE (Lb/Min)		250	300	350	400	450	250	300	350	400	450
STRAW WT. (Lb)		34	41	48	55	62	34	41	48	55	62
GRAIN WT. (Lb)		17	20.5	24	27.5	31	17	20.5	24	27.5	31
RUN NUMBER		2	5	1	4	9	3	8	6	7	10
STRAW REUSE		4	7	3	6	11	5	10	8	9	12
M.O.G. + GRAIN (Lb)											
ROTOR	1	4.8	6.3	3.5	4.0	7.1	4.8	5.7	5.2	6.2	7.8
	2	4.3	5.6	4.0	5.8	6.3	4.7	4.1	5.3	6.2	5.9
	3	2.7	3.8	3.1	5.0	5.3	3.2	3.1	3.8	5.0	4.5
	4	2.5	3.2	3.2	4.4	4.8	2.5	2.9	3.5	4.4	3.9
	5	1.5	1.8	2.5	2.7	3.3	1.2	1.8	2.2	2.5	2.5
	6	1.8	2.0	3.2	3.0	3.8	1.3	1.9	2.1	2.5	3.0
GRAIN (Lb)											
ROTOR	1	4.2	4.8	2.7	2.9	5.0	4.6	4.0	3.7	5.3	5.1
	2	3.8	4.6	3.3	4.9	5.4	4.1	3.5	4.5	4.1	4.8
	3	2.4	3.4	2.5	4.4	4.6	2.7	2.7	3.2	4.3	3.6
	4	2.1	2.9	2.6	3.5	4.3	2.2	2.5	3.1	3.9	3.2
	5	1.2	1.6	2.0	2.4	2.7	0.9	1.5	1.8	2.0	2.0
	6	2.4	1.6	2.6	2.4	3.1	0.9	1.4	1.7	2.0	2.1
TOTAL (Lb)		16.1	18.9	15.7	20.5	25.1	15.4	15.6	18.0	21.6	20.8
% LOSS		5.2	7.8	34.5	25.4	19.0	9.4	23.9	25.0	21.4	32.9

TEST: 2

REP: 1

SCREEN: PLANE BOTTOM - WIRE CLOTH

ROTOR SPEED (RPM)		170	170	170	170	170	210	210	210	210	210
FEEDRATE (Lb/Min)		250	300	350	400	450	250	300	350	400	450
STRAW WT. (Lb)		34	41	48	55	62	34	41	48	55	62
GRAIN WT. (Lb)		17	20.5	24	27.5	31	17	20.5	24	27.5	31
RUN NUMBER		9	8	3	7	4	6	10	1	5	2
STRAW REUSE		11	10	5	9	6	8	12	3	7	4
M.O.G. + GRAIN (Lb)											
ROTOR	1	7.6	7.0	6.7	6.2	5.5	5.9	6.0	3.5	6.5	4.5
	2	4.0	4.8	5.5	5.9	5.6	3.7	4.4	4.7	5.2	4.4
	3	2.5	3.1	4.3	4.5	5.1	2.7	2.7	3.7	4.2	3.3
	4	2.1	2.1	3.5	3.8	4.8	2.2	2.4	3.0	3.6	2.9
	5	1.7	1.7	2.5	3.4	4.0	1.5	1.9	2.5	3.1	2.4
	6	1.7	1.8	3.7	3.5	4.2	1.9	2.4	2.5	3.8	2.7
GRAIN (Lb)											
ROTOR	1	5.7	5.2	5.2	4.5	4.0	4.4	5.3	2.6	4.8	3.4
	2	3.2	4.0	4.5	5.0	4.7	2.9	3.9	3.8	4.4	3.5
	3	2.0	2.5	3.6	3.9	4.4	2.3	2.3	3.0	3.6	2.5
	4	1.7	1.7	2.9	3.2	4.2	1.7	2.1	2.4	3.1	2.3
	5	1.4	1.4	2.1	2.8	3.4	1.1	1.5	2.0	2.6	1.9
	6	1.5	1.4	3.1	2.9	3.6	1.4	1.9	2.0	3.1	2.1
TOTAL (Lb)		15.5	16.2	21.4	22.3	24.3	13.8	17.0	15.8	21.6	15.7
% LOSS		8.8	20.9	10.8	18.9	21.6	18.8	17.0	34.1	21.4	49.3

TEST: 3

REP: 1

SCREEN: CONCAVE BOTTOM - WIRE CLOTH

ROTOR SPEED (RPM)		170	170	170	170	170	210	210	210	210	210
FEEDRATE (Lb/Min)		250	300	350	400	450	250	300	350	400	450
STRAW WT. (Lb)		34	41	48	55	62	34	41	48	55	62
GRAIN WT. (Lb)		17	20.5	24	27.5	31	17	20.5	24	27.5	31
RUN NUMBER		4	2	5	10	8	6	1	7	3	9
STRAW REUSE		6	4	7	12	10	8	3	9	5	11
M.O.G. + GRAIN (Lb)											
ROTOR	1	6.2	4.4	5.1	8.3	7.3	6.9	4.5	6.0	5.2	7.5
	2	4.9	4.7	5.2	5.1	6.6	4.6	3.8	5.7	4.7	8.1
	3	2.6	3.3	2.9	3.5	4.3	2.2	2.6	3.0	3.2	4.3
	4	2.8	2.9	4.6	4.5	5.8	2.7	2.1	3.6	3.0	5.3
	5	1.9	2.5	3.4	3.1	3.6	1.9	2.0	2.5	2.5	3.4
	6	1.6	2.2	2.6	3.0	3.4	1.4	2.0	2.2	2.3	2.8
GRAIN (Lb)											
ROTOR	1	5.2	3.6	4.1	6.8	6.0	5.8	3.8	4.8	4.1	6.2
	2	4.1	4.1	4.5	4.4	5.7	3.9	3.3	4.9	3.8	6.9
	3	2.2	3.0	2.6	3.1	3.7	2.1	2.2	2.7	2.8	4.0
	4	2.3	2.5	4.0	3.8	4.9	2.3	1.6	3.0	2.5	4.5
	5	1.5	2.1	2.9	2.6	3.1	1.5	1.5	2.0	2.0	2.7
	6	1.0	1.6	2.0	2.2	2.5	0.9	1.3	1.5	1.7	1.9
TOTAL (Lb)		16.3	16.9	20.1	22.9	25.9	16.5	13.7	18.9	16.9	26.2
% LOSS		4.1	17.5	16.2	16.7	16.4	2.9	33.1	21.2	38.5	15.4

TEST: 4

REP: 1

SCREEN: CONCAVE BOTTOM - FLATTENED EXPANDED METAL

ROTOR SPEED (RPM)		170	170	170	170	170	210	210	210	210	210
FEEDRATE (Lb/Min)		250	300	350	400	450	250	300	350	400	450
STRAW WT. (Lb)		34	41	48	55	62	34	41	48	55	62
GRAIN WT. (Lb)		17	20.5	24	27.5	31	17	20.5	24	27.5	31
RUN NUMBER		8	7	3	10	6	2	9	4	5	1
STRAW REUSE		10	9	5	12	8	4	11	6	7	3
M.O.G. + GRAIN (Lb)											
ROTOR	1	7.7	8.0	5.5	7.5	7.1	5.7	6.0	6.6	5.7	3.5
	2	4.5	5.2	4.8	6.0	6.9	3.6	4.2	5.4	5.7	5.1
	3	3.0	3.4	3.7	4.8	5.8	2.6	3.2	4.0	4.4	4.6
	4	2.4	2.7	3.0	3.7	5.1	2.1	2.6	2.9	3.5	3.7
	5	1.8	2.2	2.7	3.2	4.0	1.7	2.2	2.4	2.8	3.2
	6	1.8	2.2	2.7	3.1	3.7	1.7	2.4	2.4	2.8	3.3
GRAIN (Lb)											
ROTOR	1	6.4	6.8	4.6	6.2	5.9	4.7	4.7	5.8	4.7	2.7
	2	3.7	4.4	4.2	5.2	6.0	2.8	3.4	4.9	4.9	4.5
	3	2.4	2.8	3.2	4.1	5.1	2.2	2.6	3.6	3.7	4.0
	4	1.8	2.2	2.6	3.1	4.4	1.7	2.1	2.5	2.9	3.2
	5	1.4	1.7	2.3	2.7	3.3	1.3	1.7	2.0	2.3	2.6
	6	1.0	1.4	2.1	2.2	2.8	1.2	1.6	1.8	2.0	2.5
TOTAL (Lb)		16.7	19.3	19.0	23.5	27.5	13.9	16.1	20.6	20.5	19.5
% LOSS		1.7	5.8	20.8	14.5	11.2	18.2	21.4	14.1	25.4	37.0

TEST: 5

REP: 2

SCREEN: CONCAVE BOTTOM - FLATTENED EXPANDED METAL

ROTOR SPEED (RPM)		170	170	170	170	170	210	210	210	210	210
FEEDRATE (Lb/Min)		250	300	350	400	450	250	300	350	400	450
STRAW WT. (Lb)		34	41	48	55	62	34	41	48	55	62
GRAIN WT. (Lb)		17	20.5	24	27.5	31	17	20.5	24	27.5	31
RUN NUMBER		4	7	3	6	8	10	5	2	1	9
STRAW REUSE		6	9	5	8	10	12	7	4	3	11
M.O.G. + GRAIN (Lb)											
ROTOR	1	7.1	7.4	7.2	8.4	6.7	7.6	6.0	6.4	3.3	8.1
	2	4.4	5.2	5.7	6.5	5.7	4.5	4.8	4.2	4.6	6.2
	3	2.9	3.7	4.2	5.1	4.8	3.2	3.6	3.3	4.0	5.1
	4	2.0	2.7	3.4	4.0	4.3	2.4	2.7	2.7	3.2	4.0
	5	1.7	2.3	2.5	3.0	3.8	1.9	2.2	2.2	2.5	3.4
	6	1.8	2.3	2.5	2.7	4.1	2.2	2.1	2.2	2.3	3.6
GRAIN (Lb)											
ROTOR	1	5.9	6.0	5.9	6.9	5.5	6.3	4.6	5.0	2.5	6.7
	2	3.6	4.2	4.7	5.3	4.6	3.6	3.9	3.2	3.7	5.2
	3	2.2	2.9	3.4	4.2	3.7	2.5	2.8	2.6	3.2	4.1
	4	1.5	2.1	2.7	3.2	3.5	1.8	2.1	2.0	2.5	3.2
	5	1.3	1.6	1.9	2.3	3.0	1.5	1.8	1.7	1.9	2.6
	6	1.2	1.5	1.6	1.9	2.9	1.3	1.2	1.5	1.7	2.5
TOTAL (Lb)		15.7	18.3	20.2	23.8	23.2	17.0	16.4	16.0	15.5	24.3
% LOSS		7.6	10.7	15.8	13.4	25.1	0.0	20.0	33.3	43.6	21.6

TEST: 6

REP: 2

SCREEN: PLANE BOTTOM - FLATTENED EXPANDED METAL

ROTOR SPEED (RPM)		170	170	170	170	170	210	210	210	210	210
FEEDRATE (Lb/Min)		250	300	350	400	450	250	300	350	400	450
STRAW WT. (Lb)		34	41	48	55	62	34	41	48	55	62
GRAIN WT. (Lb)		17	20.5	24	27.5	31	17	20.5	24	27.5	31
RUN NUMBER		8	3	2	9	7	1	5	10	4	6
STRAW REUSE		10	5	4	11	9	3	7	12	6	8
M.O.G. + GRAIN (Lb)											
ROTOR	1	7.0	5.9	6.2	6.6	7.3	3.3	6.7	8.0	6.7	7.2
	2	3.6	4.6	4.4	4.6	5.6	2.7	4.1	4.1	5.2	6.5
	3	3.1	2.9	3.4	5.0	4.7	2.1	2.7	4.2	3.8	4.7
	4	2.5	2.4	3.2	4.3	5.0	2.1	2.6	3.7	3.2	3.5
	5	1.9	2.4	2.8	3.8	4.4	1.7	2.2	2.8	3.0	3.1
	6	1.7	2.1	2.2	3.3	3.7	1.6	2.0	2.4	2.6	2.7
GRAIN (Lb)											
ROTOR	1	5.6	4.6	4.6	5.3	5.9	2.0	5.2	6.5	5.4	5.9
	2	2.9	3.5	3.3	3.7	4.6	1.9	3.3	3.4	4.3	5.4
	3	2.4	2.2	2.4	4.1	3.7	1.4	2.1	3.4	3.0	3.8
	4	1.9	1.8	2.4	3.5	4.1	1.5	2.0	2.9	2.5	2.7
	5	1.4	1.8	2.1	3.1	3.6	1.2	1.6	2.2	2.4	2.4
	6	1.1	1.5	1.5	2.4	2.7	1.0	1.2	1.6	1.9	2.0
TOTAL (Lb)		15.3	15.4	16.3	22.1	24.6	9.0	15.4	20.0	19.5	22.2
% LOSS		10.0	24.8	32.0	19.6	20.6	47.0	24.8	16.6	29.0	28.3

TEST: 7

REP: 2

SCREEN: CONCAVE BOTTOM - WIRE CLOTH

ROTOR SPEED (RPM)		170	170	170	170	170	210	210	210	210	210
FEEDRATE (Lb/Min)		250	300	350	400	450	250	300	350	400	450
STRAW WT. (Lb)		34	41	48	55	62	34	41	48	55	62
GRAIN WT. (Lb)		17	20.5	24	27.5	31	17	20.5	24	27.5	31
RUN NUMBER		8	3	9	5	7	6	10	4	2	1
STRAW REUSE		10	5	11	7	9	8	12	6	4	3
M.O.G. + GRAIN (Lb)											
ROTOR	1	10.3	10.9	8.8	10.3	7.6	11.7	10.0	10.0	8.6	6.6
	2	5.1	5.8	5.5	6.8	5.8	4.5	4.8	6.1	5.2	6.4
	3	3.5	4.0	4.7	5.2	5.1	2.9	3.2	3.8	3.9	4.5
	4	2.4	2.7	3.7	3.9	4.7	2.1	2.6	2.8	3.2	3.3
	5	1.7	2.0	2.8	3.4	4.0	1.6	2.0	2.1	2.7	2.6
	6	1.8	1.9	2.7	3.0	4.1	1.7	2.2	2.0	2.7	2.6
GRAIN (Lb)											
ROTOR	1	8.3	8.9	6.8	7.8	6.0	9.3	8.0	8.0	6.4	5.1
	2	3.9	4.4	4.1	5.3	4.5	3.4	3.5	4.6	4.0	4.9
	3	2.5	3.0	3.5	4.0	4.0	2.1	2.3	2.7	2.9	3.4
	4	1.6	1.9	2.9	2.8	3.6	1.4	1.8	2.0	2.5	2.3
	5	1.1	1.4	2.1	2.4	3.2	0.9	1.4	1.4	2.0	1.9
	6	0.9	1.1	1.7	2.0	2.9	1.0	1.3	1.2	1.8	1.6
TOTAL (Lb)		18.3	20.7	21.1	24.3	24.2	18.1	18.3	19.9	19.6	19.2
% LOSS		0.0	0.0	12.0	11.6	21.9	0.0	10.7	17	28.7	38.0

TEST: 8

REP: 2

SCREEN: PLANE BOTTOM - WIRE CLOTH

ROTOR SPEED (RPM)	170	170	170	170	170	210	210	210	210	210
FEEDRATE (Lb/Min)	250	300	350	400	450	250	300	350	400	450
STRAW WT. (Lb)	34	41	48	55	62	34	41	48	55	62
GRAIN WT. (Lb)	17	20.5	24	27.5	31	17	20.5	24	27.5	31
RUN NUMBER	5	8	6	3	10	4	7	1	9	2
STRAW REUSE	7	10	8	5	12	6	9	3	11	4
M.O.G. + GRAIN (Lb)										
ROTOR 1	8.8	10.0	8.3	10.9	8.6	9.0	9.0	5.4	8.2	8.0
2	5.4	4.9	5.5	7.5	6.3	4.9	6.2	5.1	6.1	6.3
3	3.3	2.8	3.6	5.4	4.8	2.9	3.5	3.1	4.5	4.0
4	2.3	2.4	3.2	4.2	4.2	2.3	2.9	2.4	4.2	3.8
5	1.3	1.5	2.5	2.5	3.4	1.5	1.6	2.6	2.6	2.7
6	1.7	2.2	3.9	3.9	4.3	2.0	2.3	2.4	2.9	4.0
GRAIN (Lb)										
ROTOR 1	6.7	8.2	6.3	8.9	6.7	6.7	7.1	4.3	6.4	5.4
2	4.2	3.9	4.2	5.9	5.1	3.6	4.9	4.1	4.9	4.6
3	2.4	2.0	2.7	3.9	3.8	2.1	2.6	2.2	3.5	2.8
4	1.7	1.9	2.5	3.0	3.4	1.6	2.1	1.7	3.3	2.8
5	0.9	1.0	1.9	1.8	2.6	1.1	1.1	1.1	1.9	1.9
6	1.1	1.4	2.9	2.5	3.1	0.9	1.5	1.6	2.1	2.9
TOTAL (Lb)	17.0	18.4	20.5	26.0	24.7	16.0	19.3	15.0	22.1	20.4
% LOSS	00.0	10.2	14.5	5.4	20.3	5.8	5.8	37.5	19.6	34.1

VITA

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