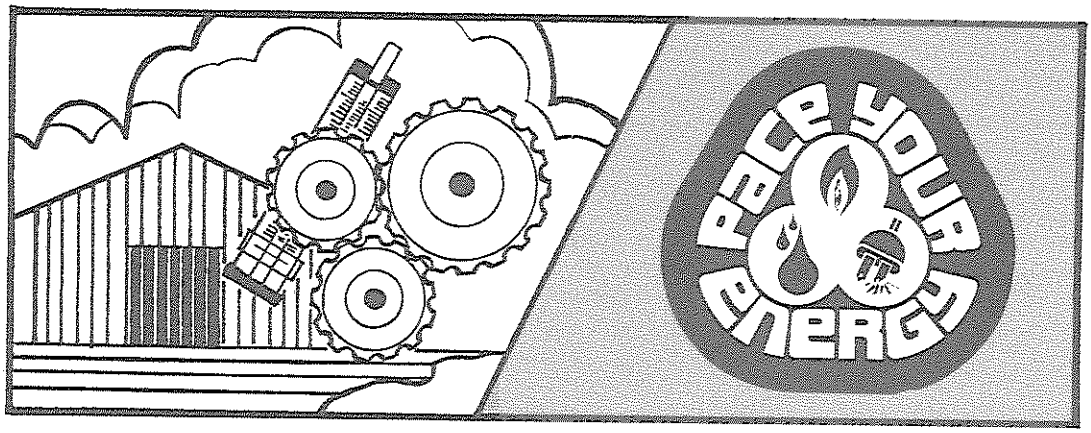
ENERGY IN AGRICULTURE

ESTIMATING FAN SIZES FOR GRAIN DRYING AND STORAGE BINS

Otto J. Loewer, T. C. Bridges, G. M. White,
Robert L. Fehr, and Larry W. Turner



UNIVERSITY of KENTUCKY
COLLEGE of AGRICULTURE
DEPT. of AGRIC. ENGINEERING
COOPERATIVE EXTENSION SERVICE

in
cooperation
with

KENTUCKY
DEPARTMENT
of
ENERGY

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Fans of the same horsepower may not deliver the same amount of air through grain because of the differences in fan design. For example, axial flow fans tend to pump more air through relatively shallow depths of grain than do centrifugal fans. However, the reverse is true in relatively deep grain: the centrifugal fan delivers more air for the same horsepower. To best determine the performance of a particular fan, consult the manufacturer's performance curves that relate static pressure in inches of water to air-flow measured in cubic feet per minute (CFM). The University of Kentucky Agricultural Engineering Department can assist you with that analysis if you submit the input form "Fan Performance on Grain Drying Bins." However, you may estimate the size of fan needed to deliver a certain amount of air at a given depth by returning this completed form to:

Dr. Otto J. Loewer
Agricultural Engineering Department
University of Kentucky
Lexington, Kentucky 40506

1. **NAME**

2. **ADDRESS**

3. **PHONE NUMBER**

4. **TYPE GRAIN IN BIN?**
(Corn, Milo, Wheat or Soybeans)

5. You may wish to estimate fan horsepower requirements for either different depths at a constant airflow rate or for different airflow rates for a constant depth. If you wish to vary the depth of grain enter "DEPTH". If you wish to vary airflow, enter "CFM/BU."

6. Enter the diameter of the grain bin on which the fan will be placed (ft.)

7. If you selected "DEPTH" in Question No. 5, enter the CFM per bushel to be supplied to the grain. A typical value for batch-in-bin systems is 10 CFM/BU, while for layer or low-temperature drying systems, 1 to 3 CFM/NU is commonly used.

   If you selected "CFM/BU" in Question No. 5, enter the bushels to be placed in the grain bin.

8. Enter the lowest depth or CFM/BU value to be considered depending upon your answer to Question 5. For example, if you wish to vary DEPTH, you may want to begin your analysis at a grain depth of 1 ft. If you wish to vary airflow, you may want to begin at 0.1 CFM/BU, the lowest acceptable rate of aeration for farm grain storage.

9. Enter the highest DEPTH or CFM/BU value to be considered depending upon your answer to Question 5. For example, if you wish to vary depth, select the eave height of the grain bin as the stopping point. If you wish to vary airflow, 10 CFM/BU is typical of batch-in-bin systems and 3 CFM/BU is the maximum usually expected when the bin is full. However, you may wish to select values higher than these.

10. Enter how often you wish to estimate horsepower depending upon your answer to Question 5. For example, if you selected DEPTH, you may wish to check the horsepower for each 1 ft. increase in grain depth. If you selected CFM/BU, you may wish to check each 0.1 CFM/BU.

If you chose to vary depth, a sample analysis is shown below with a listing of terms following the analysis.

```
CORN,MILO,WHEAT,SOYBEANS OR STOP?
?CORN-1

INCREMENT DEPTH OR CFM/BU?
?DEPTH-2
```

3 DIAMETER	4 CFM/BU	5 START	6 DEPTH STOP	7 INCREMENT
?24	10	1	4	1

	3 DIAMETER 24.	4 10.0 CFM/BU			8 PF 1.50
9 DEPTH	BUSHELS 10	SP 11	CFM 12		HP 13
1.00	362.	0.08	3619.		1.0
2.00	724.	0.40	7238.		2.2
3.00	1086.	1.07	10857.		3.7
4.00	1448.	2.26	14476.		10.3

1. CORN–Type of grain considered (Question 4).
2. DEPTH–Indicates that "Depth" was to be varied for a constant CFM/BU value (Question 5).
3. DIAMETER–Diameter of grain bin, ft. (Question 6).
4. CFM/BU–The cubic feet of air per minute delivered to each bushel of grain in the bin (Question 7).
5. START–The lowest value of grain depth for which the analysis was made, ft. (Question 8).
6. STOP–The highest value of grain depth for which the analysis was made, ft. (Question 9).
7. INCREMENT–The grain depth (ft.) between each analysis (Question 10).
8. PF–The "packing factor" multiplier; that is, clean loosely filled grain has a value of 1.0. This serves as a safety factor in fan design.
9. DEPTH–The depth of grain in the bin for a particular analysis, ft.

10. BUSHELS–The bushels of grain in the bin for a given depth.
11. SP–The static pressure, in inches of water, generated by the resistance of the grain to the airflow.
12. CFM–The total airflow in cubic feet per minute that must be delivered by the fan.
13. HP–The estimate of the horsepower requirement of the fan to deliver the necessary CFM for the given static pressure, assuming a 50% fan efficiency.

If you chose to vary air flow (CFM/BU), a sample analysis is shown below, with a listing of terms following the analysis.

```
CORN,MILO,WHEAT,SOYBEANS OR STOP?
?CORN —1

INCREMENT DEPTH OR CFM/BU?
?CFM/BU —2
```

3 DIAMETER	4 BUSHELS	5 START	6 CFM/BU STOP	7 INCREMENT
?24	1448	1	10	2

3 DIAMETER 24,	8 DEPTH 4.00	4 1448. BUSHELS	9 PF 1.50

10 CFM/BU	SF 11	CFM 12	HP 13
1.00	0.10	1448.	0.4
3.00	0.39	4344.	1.3
5.00	0.80	7240.	2.2
7.00	1.28	10136.	4.1
9.00	1.91	13032.	7.9
11.00	2.64	15928.	13.2

1. CORN–Type of grain considered (Question 4).
2. CFM/BU–Indicates that airflow (CFM/BU) was to be varied for a constant depth of grain (Question 5).
3. DIAMETER–Diameter of grain bin, ft. (Question 6).
4. BUSHELS–Bushels of grain in the bin (Question 7).
5. START–The lowest value of CFM per bushel for which the analysis was made (Question 8).
6. STOP–The highest value of CFM per bushel for which the analysis was made (Question 9).
7. INCREMENT–The CFM per bu value between each analysis (Question 10).
8. DEPTH–The depth of grain in the bin (ft) determined from the number of bushels in the bin and the bin diameter.
9. PF–The "packing factor" multiplier; that is, clean loosely filled grain has a value of 1.0. This serves as a safety factor in fan design.
10. CFM/BU–The quantity of air delivered per bushels of grain for a given analysis.
11. SP–The static pressure in inches of water generated by the resistance of the grain to the airflow.
12. CFM–The total air flow in cubic feet per minute that must be delivered by the fan.
13. HP–The estimate of the horsepower requirement of the fan to deliver the necessary CFM for the given static pressure, assuming a 50% fan efficiency.

ESTIMATING DRYING TIME:

The CFM per bushel term is one of several factors required to estimate drying time. Typical values for layer or low-temperature drying systems are 1 to 3 CFM/bu when the bin is full. A typical value for batch-in-bin systems is 10 CFM per bushel when the grain is approximately 4 ft. deep. You may estimate drying time using one of the available programs listed below (No. 6, 7, 8).

ESTIMATING ENERGY USAGE:

An estimate of energy usage may be found with the following equation:

$$\text{Energy used in KW-hr} \approx \left(\begin{matrix}\text{hours of fan} \\ \text{operation}\end{matrix}\right) \text{X} \left(\begin{matrix}\text{horsepower value} \\ \text{given in program}\end{matrix}\right)$$

assuming 1 hp-hr = 1000 watts allowing for a motor efficiency of 75%.

The hours of operation may be estimated using the drying programs that are available.

AVAILABLE PROGRAMS:

1. BNDZN: Computer analysis of economics, energy consumption and engineering design of a grain storage system.
2. CHASE: Computer model that evaluates and compares costs of selected methods of harvesting, handling, drying and storage of corn for an individual farmstead. Energy consumption is also estimated.
3. CACHE: Computer model for economic analysis of farm drying and processing systems.
4. SQUASH: Computer simulation of the harvesting-delivery-drying system used to determine bottlenecks in the system.

*5. ESTIMATING FAN SIZES FOR GRAIN DRYING SYSTEMS
*6. GRAIN DRYING PERFORMANCE EVALUATION
*7. DRYERATION PERFORMANCE EVALUATION
*8. NATURAL AIR-LOW TEMPERATURE DRYING PERFORMANCE EVALUATION
*9. FAN PERFORMANCE ON GRAIN DRYING BINS

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*These programs were developed by:

Dr. Thomas L. Thompson, Professor
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University of Nebraska
Lincoln, Nebraska

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