

Flow Sheet Analysis

Effective mill management hinges on developing and interpreting a detailed flow sheet.

Whether called a milling flow diagram or flow sheet, this document is an invaluable instrument to manage any mill successfully. For starters, the

flow sheet easily could be considered as the single most important tool used by the miller and the mill engineer or even by the production and the quality team to communicate closely with each other.

The flow sheet is a two-dimensional road map of the milling process that not only helps chart out the direction of where the stock is going but also, more importantly at times, where it is coming from.

But the flow sheet tells the trained miller and milling engineer so much more. The information on a complete flow sheet includes everything from equipment allocation to screening material and roll corrugations or fluting.

The length of a flow diagram helps determine the flexibility the miller has in making changes to the flour extraction

rate and quality of the flour produced to meet specific needs of different customers.

While designing a flow sheet can be a complex task, trying to analyze a flow sheet often becomes just as complex. However, analyzing a flow sheet becomes easier by breaking it down into a few manageable steps.

Management



Mark Fowler

Recognizing the Systems

For example, any milling flow sheet can be broken down into five basic subsystems:

1. The break system.
2. Sizings and residue or collection system.
3. Purification system.
4. Reduction system.
5. The low-grade system.

The Break System

The break system opens up the wheat kernel and removes the endosperm from the bran in large pieces making it suitable for purification or midds reduction while

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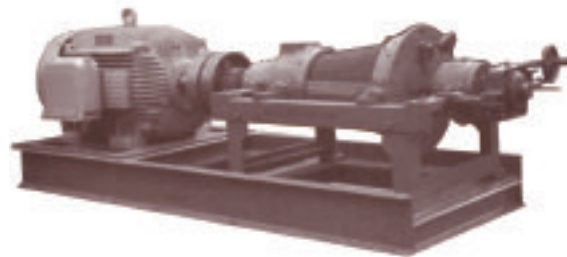
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trying to minimize bran breakage.

The break system is the most important aspect of all the systems used in milling. It has the greatest impact on the mill's flour extraction rate and, more importantly, the balance and distribution of stock throughout the remaining process.

The break system can be divided into the primary break and the secondary break.

- The primary break opens the wheat kernel and separates the bulk of the endosperm from the bran.

- The secondary break scrapes the remaining endosperm from the bran as cleanly as possible. Most bran and shorts dusters or finishers would be part of the secondary break system.

Sizing and Residue Collection

The sizing and residue or collection passages sometimes are challenging to identify, because they can serve several systems.

Similar to the break system, the sizing passages can be defined as primary col-



At the Hal Ross Mill, Kansas State University (KSU), Manhattan. International Grains Program Associate Director Mark Fowler (foreground) demonstrates to milling course participants how to measure break release.

lection passages, while residue passages can be considered secondary collection passages.

Both the sizing and residue passages use rolls and sifters to detach endosperm from fine bran particles to feed into the midds reduction system.

The sizing rolls reduce and size the endosperm gently to feed the primary midds

reduction passages to increase low-ash flour production.

The residue system handles rejected stocks from the previous systems and recovers material to be returned to the secondary midds reduction system to maximize flour production and extraction rates.

For the collection passages, the objective is to detach compound particles and distribute endosperm and fine bran for continued reduction. Flour production is not the primary concern.

Purification System

The purification system includes the processes that separate particles based on endosperm content. In most cases, the purification system is well-defined, since it's composed primarily of the purifiers that separate clean endosperm and fine bran before delivering this material to the appropriate passages for further processing.

At the same time, purifiers also classify and deliver fine and coarse endosperm to the midds reduction system ▶

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Table 1 : Global calculations for flow sheet allocations

$$\text{Roll surface} = \frac{\text{mm roll length}}{100 \text{ kg wheat processed in 24 hrs.}}$$

$$\text{Sifter surface} = \frac{\text{m}^2 \text{ sift area}}{100 \text{ kg wheat processed in 24 hrs.}}$$

$$\text{Purifier surface} = \frac{\text{mm sieve width}}{100 \text{ kg wheat processed in 24 hrs.}}$$

Table 2 : Calculations for flow sheet allocations in the U.S.

$$\text{Roll surface} = \frac{\text{inches roll length}}{\text{cwt. flour produced in 24 hrs.}}$$

$$\text{Sifter surface} = \frac{\text{ft.}^2 \text{ sift area}}{\text{cwt. flour produced in 24 hrs.}}$$

$$\text{Purifier surface} = \frac{\text{inches sieve width}}{\text{cwt. flour produced in 24 hrs.}}$$

to optimize grinding efficiencies. However, the purification system is part of the flow sheet, whether or not purifiers are in the mill.

Purifying the ground product can be achieved by using rolls and sifters, as commonly is the case with soft wheat milling. Moderate compressive force can reduce the particle size of the endosperm while flattening the bran and, thus, purifying the stock. This is the point where the purification system and the sizing and residue systems can become intertwined.

Midds Reduction System

The midds reduction system has the single purpose of making flour. Purified middlings, separated and classified in the other systems, are fed to the smooth or finely corrugated rolls and crushed to create as much flour as possible with the least amount of breakage in the remaining bran and germ particles

that may be present.

Maximum production of low-ash-content flour on the primary midds rolls is the main objective. High-intensity-impact mills may be used on clean stock to increase flour production. Flake disrupters or low-intensity-impact mills can be used to improve sifting efficiency.

Low-grade System

The final passages of the mill flow make up the low-grade system. The low-grade system recovers low-quality flour from the rejected stock in the midds reduction and residue systems. Low-grade flour requires high-efficiency sifters, because this material tends to be sticky and difficult to sift. Using centrifugal and vibratory sifters is common on the tail-end, low-grade flour passages.

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Calculating the Allocations

What is meant by the length of a flow sheet? The length of a mill flow is determined by the linear inches or millimeters of roll length in the total process flow. Sifter and purifier capacity is sized to support the grinding capacity of the mill.

The calculations for roll length, sifter surface, and purifier width are listed in **Tables 1** and **2** (see Page 52).

In the United States (see **Table 2**), these dimensions are expressed compared to the hundredweight (cwt.) production rate or flour produced per 24 hours.

The rest of the world compares these dimensions to the quantity of 100 kilograms (kg) per 24 hours delivered to first break (see **Table 1**).

For example, roll length in the United States is reported as inches/cwt. of flour produced/24 hours, while the rest of the world reports roll length as millimeters (mm)/100 kg of wheat to first break/24 hours.

Longer flows may have up to 12-15 mm/100kg/24 hours or (0.28-0.35 inches/cwt./24 hours in the United States).

Shorter flow diagrams may have only

“In order to judge the load on the mill, roll length, purifier width, and sifter surface dimensions are indicated on complete flow sheets.”

half that allocation. In order to judge the load on the mill, roll length, purifier width, and sifter surface dimensions are indicated on complete flow sheets.

A flow sheet can be further analyzed by calculating surface allocations by system.

For example:

- Break roll length of 0.105 inch/cwt./24 hours.
- A sizing roll length of 0.05 inch/cwt./24 hours.
- Midds reduction, residue, and low-grade roll length 0.125 inch/cwt./24 hours.

For most modern flour mills, the maximum roll length is normally less than 12.5mm/100kg/24 hours (0.37 inch/cwt./24 hours in the United States).

Flow Sheet Management

There also is the ancillary equipment that needs to be considered, which includes bran and shorts finishers, centrifugal or vibratory sifters, pin mills, flake disrupters, etc. This equipment all can be included in one of the systems defined and the capacity calculated accordingly.

The analysis of the flow sheet is a vital part of effective mill management. Knowing and understanding the constraints and limitations due to the length of the milling diagram is critical when working through the challenges of new crop wheat or when considering changes in flour specifications for customers. Longer flows require more capital expense to install.

However, as the price of wheat continues to increase, the investment in a longer flow may pay dividends in the form of higher flour extraction and improved flour quality.

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