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Research Article

Bottleneck-Based Capacıty Calculatıon in Flour Productıon Facılıtıes

Zehra Gülten YALÇIN[1*], Mustafa DAĞ[1]

[1]*Department of Chemical Engineering, Çankırı Karatekin University, Turkey*

[*]*Corresponding author: zehragulten@karatekin.edu.tr*

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Abstract-In a flour production facility, performing capacity calculations plays a critical role in the efficient management of production processes, meeting customer demands, and controlling costs. In this study, capacity calculation methods, bottleneck analysis, and capacity utilization rates (CUR) were determined for flour production facilities. According to the capacity criterion, the machines in the facility are categorized under three main headings: cleaning unit, breaking unit, and milling unit. To determine capacity, all production lines in the facility were evaluated, and the section that creates the bottleneck was considered the capacity-determining unit. In the facility where flour and bran are produced, the capacity was calculated based on 24-hour operation per day and 300 working days per year. The facility contains 18 roller mills of 100 cm each. The total roller length in the facility was calculated by measuring in both directions. Accordingly, the total roller length is 3,600 cm. The roller speed is taken as 600 rpm, and S = 1.2. Based on these values, the annual wheat breaking capacity was calculated as 90,000 tons/year.

Keywords: Flour Production Facility, Bottleneck Calculation, Annual Total Capacity Calculation.

I. INTRODUCTION

In a flour production facility, the production processes cover the steps from raw wheat to ready-to-consume flour [1]. Below, the main processes in a flour production facility are explained in detail:

Wheat intake and storage: The process begins with the procurement of high-quality wheat [2]. The purchased wheat is classified based on type and quality and then stored. During storage, humidity control and ventilation are carried out to prevent spoilage [3].

Cleaning and preparation: The wheat taken from storage is purified from foreign materials like stones, soil, and straw. The cleaning process is performed in three stages:

- *Pre-cleaning:* Removal of large pieces (stones, straw, metal, etc.)
- *Fine cleaning:* Removal of dust, light foreign materials, and broken grains
- *Washing and drying:* Surface dust and chemical residues are removed from wheat kernels, and moisture content is adjusted [5]

Conditioning (Moistening and resting): They wheat is moistened with water to make it suitable for processing. This process takes between 12 to 24 hours depending on wheat hardness. The aim is to soften the bran and make it easier to separate the endosperm.

Milling (Grinding process): The prepared wheat is milled. Milling is carried out gradually in several stages [6]:

- *Breaking:* Wheat kernels are broken, and the endosperm starts to separate from the bran
- *Separation:* Broken pieces are passed through sieves and classified by size
- *Grinding:* The material is ground again to become finer. At this stage, flour, bran, and semolina are obtained as separate products

Sifting and classification: The milled products are classified into different thicknesses using sieves [7]. Flour, bran, and semolina are separated and prepared for packaging. If necessary, flour is sieved again to different fineness levels.

Fortification (optional): In some facilities, vitamins and minerals (iron, folic acid, etc.) are added to the flour [8]. This process is applied especially in the production of nutritionally enriched flour.

Packaging and storage: The final product is packaged in desired sizes using packaging machines [9]. Packaged flour is stored in a way that protects it from moisture and harmful organisms. Moisture control is maintained during storage, and the FIFO (First In, First Out) method is applied.

Logistics and shipment: Products are prepared for shipment according to customer orders [10]. Before shipment, quality control procedures are completed and approval is obtained.

These processes are optimized to ensure full efficiency in the flour production facility. Capacity calculation is important to see how fast and efficiently each step is performed. The factors determining capacity in the facility are as follows:

- Input capacity (tons/day),
- Mill capacity (wheat processed during milling in tons/hour),
- Output capacity (flour obtained daily in tons/day).

To calculate capacity utilization rate (CUR), the following formula is used to measure how much of the available capacity is utilized:

Example: If theoretical capacity is 80 tons/day, and actual production is 60 tons/day:

Bottleneck Analysis

Each process step is examined, and the slowest or most limiting step is identified. For example, if the mills can process 10 tons/hour but the sifting process has a capacity of 8 tons/hour, the sifting step creates a bottleneck.

Capacity Expansion Planning

If demand is higher or production needs to be increased: Working hours may be extended. This is achieved by adding additional mills and sieving machines to the existing facility. Moreover, technological improvements to increase efficiency can be implemented.

II. MATERIAL AND METHOD

In a facility located in Çankırı that produces flour and bran, capacity is calculated based on 24-hour operation per day and 300 working days per year. There are 18 roller mills, each 100 cm long. The total roller length was calculated by measuring in both directions. Accordingly:

- A (Total roller length) = 18 × 100 × 2 = 3,600 cm
- Roller speed = 600 rpm and S = 1.2

Capacity = [(A / S) × 100 × 300] / 1000 = tons/year wheat breaking

Capacity = [(3600 / 1.2) × 100 × 300] / 1000 = 90,000 tons/year wheat breaking capacity

Capacity Utilization Rate (CUR) = Actual Production / Maximum Capacity

CUR = 90,000 / 98,000 × 100 = 92%

Annual Production Amounts

- Flour: K × 0.74 = Flour → 90,000 × 0.74 = 66,600 tons/year = 66,600,000 kg/year
- Bran: K × 0.26 = Bran → 90,000 × 0.26 = 23,400 tons/year = 23,400,000 kg/year

Required Materials:

- Wheat: Assuming a 5% loss in wheat: 90,000 / 0.95 = 94,737 tons/year wheat required

Sacks:

- 50% of the flour in 50 kg sacks → (66,600 × 0.5 × 1000) / 50 = 666,000 sacks/year
- 40% in 10 kg sacks → (66,600 × 0.4 × 1000) / 10 = 2,664,000 sacks/year
- 10% in 5 kg sacks → (66,600 × 0.1 × 1000) / 5 = 1,332,000 sacks/year
- Bran in 35 kg sacks → (23,400 × 1000) / 35 = 668,571 sacks/year
- Total polyethylene sack requirement = 5,330,571 sacks/year

Sieves: 1 m² sieve per 50 tons of wheat → 94,737 / 50 = 1,895 m²/year

Sack thread: 1 kg thread per 100 sacks → 5,330,571 / 100 = 53,306 kg/year sack thread

III. CONCLUSION

The capacity analysis conducted in this study demonstrates that the total annual wheat crushing capacity of the examined flour production facility is 90,000 tons per year, based on a 24-hour/day operation over 300 working days. This calculation was derived by identifying the bottleneck process—milling—and by considering roller dimensions, operational speeds, and the machine configuration. By including a 5% processing loss (shrinkage, dust, spillage, etc.), the total wheat input requirement rises to approximately 94,737 tons annually. This adjustment is crucial for accurate procurement planning and sustainable raw material sourcing. The calculated capacity utilization rate (CUR) is 92%, indicating that the plant operates near its full theoretical capacity. This high utilization suggests efficient production planning and minimal idle capacity, but it also implies limited flexibility in the event of increased demand or equipment downtime. In terms of output, the facility annually produces 66,600 tons of flour and 23,400 tons of bran, aligning with a typical flour-bran ratio of 74:26 in commercial wheat milling. These values are essential not only for production tracking but also for downstream logistics, inventory management, and customer order forecasting. From a supply chain and operational perspective, the annual requirement for polyethylene sacks (over 5.3 million units) and sewing thread (53.3 tons) provides actionable insights for purchasing and budgeting departments. Additionally, the annual need for sieves—estimated at 1,895 m^2—points to maintenance planning and replacement scheduling of critical processing components. The results also highlight potential areas for capacity expansion. If product demand continues to grow, upgrading the bottleneck units (such as adding additional sifting capacity) or implementing advanced automation could further improve throughput without compromising quality. Ultimately, this detailed capacity model can serve as a replicable framework for similar flour production facilities seeking to assess, optimize, and expand their operations based on data-driven decision-making.

REFERENCES

[1] Sarkar, A., & Fu, B. X. (2022). Impact of quality improvement and milling innovations on durum wheat and end products. Foods, 11(12), 1796. https://doi.org/10.3390/foods11121796

[2] Mudgil, D., & Mudgil, S. B. (Eds.). (2024). Unit operations in food processing. Scientific Publishers.

[3] Befikadu, D. (2014). Etiyopya geleneksel depolama yapılarında depolanan tahılın kalitesini etkileyen faktörler ve iyileştirme fırsatları. Uluslararası Bilim Dergisi: Temel ve Uygulamalı Araştırma, 18(1), 235–257.

[4] Ziegler, V., Paraginski, R. T., & Ferreira, C. D. (2021). Grain storage systems and effects of moisture, temperature and time on grain quality: A review. Journal of Stored Products Research, 91, 101770. https://doi.org/10.1016/j.jspr.2021.101770

[5] Prabhasankar, P., & Haridas Rao, P. (2001). Effect of different milling methods on chemical composition of whole wheat flour. European Food Research and Technology, 213, 465–469. https://doi.org/10.1007/s002170100394

[6] Sabillón, L., Stratton, J., Rose, D., & Bianchini, A. (2021). Microbiological survey of equipment and wheat-milled fractions of a milling operation. Cereal Chemistry, 98(1), 44–51. https://doi.org/10.1002/cche.10367

[7] Fazel-Niari, Z., Afkari-Sayyah, A. H., Abbaspour-Gilandeh, Y., Herrera-Miranda, I., Hernández-Hernández, J. L., & Hernández-Hernández, M. (2022). Quality assessment of components of wheat seed using different classifications models. Applied Sciences, 12(9), 4133. https://doi.org/10.3390/app12094133

[8] Faye, M. H., Diémé, M. M. A., NKhoma, P. M., Diouf, A., Panagides, D., Badiane, A., ... & Dossou, N. I. (2025). Assessing the fortification quality of refined vegetable oil with vitamin A, wheat flour with iron, and salt with iodine: Findings from a market assessment in Senegal, West Africa. Current Developments in Nutrition, 107440. https://doi.org/10.1016/j.cdn.2025.107440

[9] Thomas, M. S., Berglund, Z. R., Low, M., Bryan, I. M., Soewardjono, R., & Feng, Y. (2022). Evaluation of flour safety messages on commercially available packages: An eye-tracking study. Foods, 11(19), 2997. https://doi.org/10.3390/foods11192997

[10] Karjalainen, A., Leppänen, M., Ruokolainen, J., Hyttinen, M., Miettinen, M., Säämänen, A., & Pasanen, P. (2022). Controlling flour dust exposure by an intervention focused on working methods in Finnish bakeries: A case study in two bakeries. International Journal of Occupational Safety and Ergonomics, 28(3), 1948–1957. https://doi.org/10.1080/10803548.2020.1858329