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EFFECT OF SCOURER SCREEN PATTERNS ON THE WHEAT HUSK REMOVAL EFFICIENCY

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Abstract:
The scourer machines remove wheat husk contaminated with pesticides and other impurities that adversely affect product quality and shelf life. For this purpose, at least one scourer machine is used in each industrial grain flour factory, depending on the capacity. The efficiency of these machines is highly dependent on the surface texture and scourer screen patterns. In this study, the efficiency of the wheat scourer machines with various wall patterns and meshes was investigated experimentally. The investigation employed six distinct types of scourer screens. Type-4 has produced the best results in fractured grain rate, whereas Type-2 has produced the best in ash content. It was revealed that wheat's scouring efficiency and physical and chemical properties vary depending on the scourer screen pattern.

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1. INTRODUCTION

Flour with a high ash level is considered less pure and is reported to contain more significant amounts of fine bran and bran-associated endosperm [1-3]. Therefore, ash is seen as one of the indicators of wheat flour quality. On the other hand, whole wheat grain contains about 1.17%-2.96% mineral compounds [4,5]. Ash is formed due to mineral compounds such as phosphorus, potassium, calcium, magnesium, iron, zinc, and copper [6]. While the main elements of ash are phosphorus (~45%), potassium (~38%), magnesium (~13%), and calcium (~3%), other elements are included in about 1% [3]. Apart from that, it is reported that the mineral and ash content is caused by the genotype, wheat class, and cultivar, as well as the growing year and location [7,8].

Minerals are unevenly distributed in the kernel [9]. It is reported that the aleurone layer and pericarp contain approximately 68%, the starch endosperm 20%, and the embryo 12% of minerals [10]. The ash content is generally measured by burning the samples at about 550 °C for soft wheat flours and 575-590 °C for tricky wheat flours during 5-7 hours [11].

Many impurities can be found in wheat mixed during the growing, harvesting, transportation, and storage stages. In addition, unhealthy and diseased grains damaged due to the cultivation and storage of wheat under unsuitable conditions may be found. Foreign substances, namely grass, seeds, and diseased grains, can decrease product quality [12,13]. These foreign substances can also help microorganism reproduction and microscopic contamination, and some foreign substances may damage the processing machines. For this reason, the foreign materials in the wheat should be separated, and the dirt on the grains should be cleaned with various methods and techniques [14]. Usage areas of scourer machines are the food industry, flour and semolina mills, wheat, oats, rye, corn cleaning plants, and grain storage silos.

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Tasks of scourer machines are as follows:

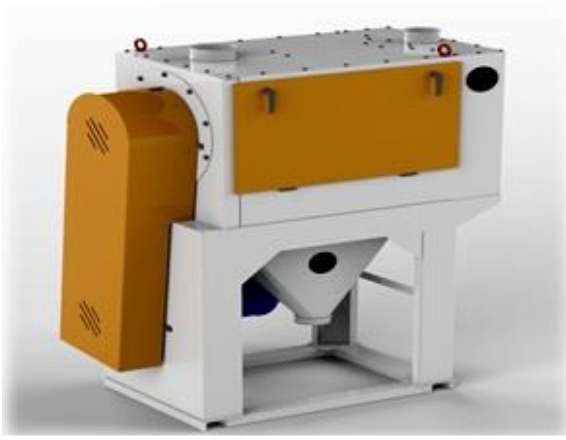
- To remove the skin of the grain (pericarp) and beard parts. In rye, the germ part is also separated from the grain, being less in wheat;
- The impact resulted from separating dust and dirt attached to the grain, especially collected in the abdominal cleft;
- The working principle of scourer machines is to combine impact, friction, and aspiration to effectively remove dirt, heavy/light substances, and wheat husk simultaneously [15]. The inner surface consists of rough or grooved, rotating or fixed, horizontal, or vertically placed cylindrical jacket rotating approximately 300 rpm in a metallic or wooden pallet. In addition, it has aspirator parts to remove the light material released at the end of the impact process from the environment;
- The grains are pressed and rubbed vigorously on the sieve with the help of a horizontal rotor. At the same time, the grain being rubbed is caused by the intense friction effect of the following processes results in following:
  - Grains are pressed against each other and rubbed;
  - Grains are squeezed and rubbed with the wings attached to the rotor;
  - Grains are rubbed with an abrasive sieve.

Grain scourers are generally driven by a belt-pulley system and can be used with different air ducts and dredgers. It is commonly used in flour mills, cleaning, Transfer, and B1 lines. Even if all kinds of foreign matter found with wheat in the cleaning unit are entirely separated, the crust is one of the most important quality criteria in grinding. This is because the crust causes an increase in the amount of ash and a decrease in quality [16]. In this respect, the more the shell can be peeled off, the less crumbling will decrease in grinding, and the quality will increase as the ash content of the flour decreases.

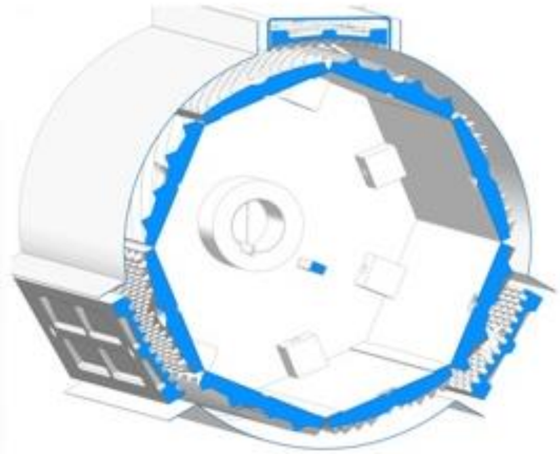
Today, there are many types of scourer machines on the market, and it is seen that the scourer wall surfaces in each of them have different patterns [17-19]. However, no study in the literature related to pattern type affecting the scourer's performance has been found. In addition, there is no information about how effective the peeler is when used at different stages in mill facilities. Therefore, in this study, the stage at which the scourer should be used in the mill facilities and the type of wall pattern used in real mill plants were experimentally investigated.

2. MATERIALS AND METHOD

In this study, the scouring performance of a scourer machine for different types of scouring screens was measured. Fig. 1 and 2 shows the generals structure of a grain scourer. and scourer screens, respectively. The six distinct types of scourer screens employed in this study is given in Fig. 2, which of all have different mesh or surface types.



(a)



(b)

Fig. 1. a) Structure of grain scourer and b) Drum

The wheat grain consists of several layers with different chemical compositions. It is reported that the chemical composition of a wheat grain contains different percentages of ash-producing minerals [20]. In order to determine the peeling efficiency, two different types of tests, physical and chemical, were carried out [21]. In the experiments, the wheat breaking rate of the hulling machine and the amount of peeling were measured. For this purpose, the wheat samples taken from the machine's entrance were mixed, spread on the table, and divided into four equal parts. The sampling batch was obtained by taking two cross-sections and repeating the mixing, spreading, and dividing into four parts. The sample batch was visually differentiated into solid wheat and cracked wheat on a white background. Broken wheat was divided into two categories as; long grain and short grain broken. The natural fracture rate was determined by weighing the sample pile and the fractures separately on a precision scale.

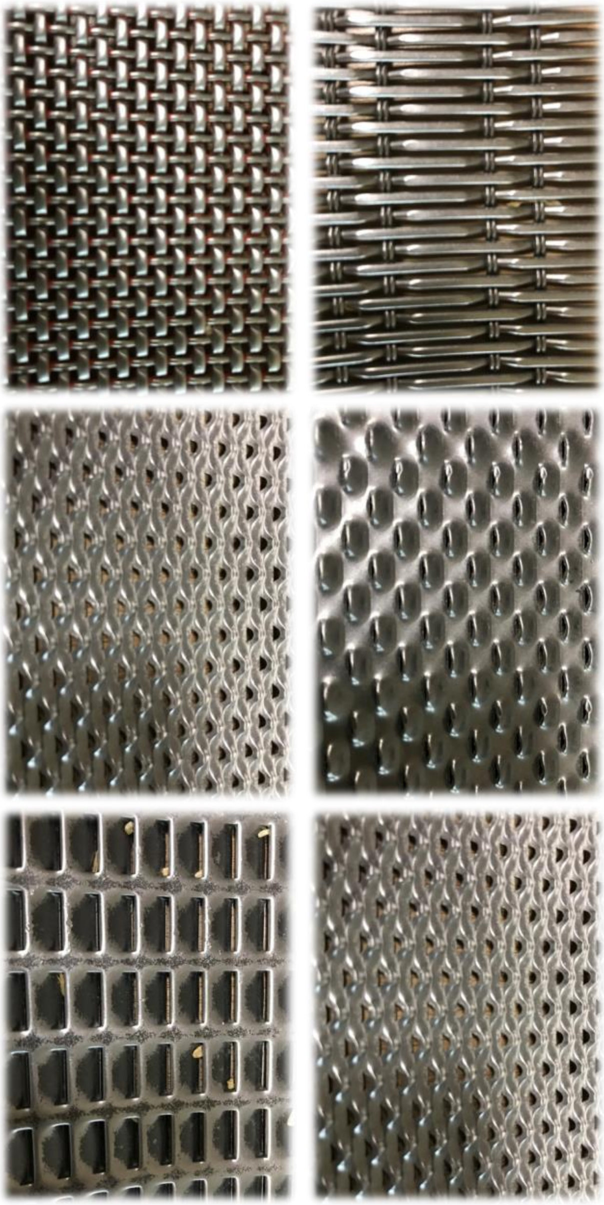


Fig. 2. Surface textures of scourer screens used for drum

Similarly, samples were taken at the machine's exit, and the sample pile was visually separated as solid wheat and cracked wheat on a white background. Broken wheat was also divided into two as long and short grain. The fracture rate at the exit was determined by weighing the sample pile and the fractures separately on a precision scale.

To determine the amount of peeling, the inside of the machine was cleaned first, and the remaining crusts from the previous processes were removed. Then, a bypass line was integrated into the machine, and wheat husk was collected for 15 minutes. The obtained shells were separated by sieving in a 1000-micron sieve in laboratory. The samples remaining above 1000 microns were separated with the help of gentle airflow. By weighing the separated shards, the number of shards at the exit was obtained by proportioning the weight to the capacity and time. The mass increase in the total amount of bark collected was evaluated as the peeling efficiency of the machine. Next, the fracture rate was evaluated by dividing the origin fracture by weight. This evaluation was obtained by dividing the amount of cracks at the machine's exit by the number of cracks in the natural state of wheat. Therefore, if the fracture rate reaches 1.00, it shows that the machine separates the husk of the wheat without breaking it.

The scourer machine can be used at different stages of the production process in mill facilities. In this respect, in the experimental study, flour samples were taken at four different stations, namely before dry wheat, before the scourer, after the scourer, and after the air recycling aspirator, and thus the ash amount, breakage rate, and shells taken values were measured. The specified measurements were repeated for six different wall patterns shown in Fig. 2.

3. RESULTS AND DISCUSSIONS

In this study, physical and chemical tests were carried out to determine the performance of different types of scourer screens used in the peeler. Samples were made in the same wheat mix at the same facility.

3.1 Physical test

The tests presented in this section were conducted at a fully operational facility. Plant capacity and operating performance will affect the specified physical and chemical test results. In case the plant does not operate at full capacity, regardless of the scourer screen types used, the grains may be broken without peeling in the peeler.

Fig. 3 shows the total amount of crust obtained using different scourer screens. As seen in the Fig. 3, the amount of shell collected in 15 minutes is the highest in Type-3 and the lowest in Type-5. As it is known, husks that cannot be separated from wheat cause colour changes in flour and increased ash in the final product. In other words, the peel that cannot be peeled turns to ash. The slight differences in Fig. 3 show a daily crustal difference of around 2 kg/day in a medium-sized facility, even between the closest species. Due to the very low density of the shells, it can be said that there is a massive difference in volume. It occupies about 7-8 litres of density in the flour, which is highly important. This is also very important. In addition, a good cleaning of the shell causes the flour to come out more easily afterward. When the wheat is broken and the shell is separated, some wheat is lost along with the shell, reducing the factory's efficiency.

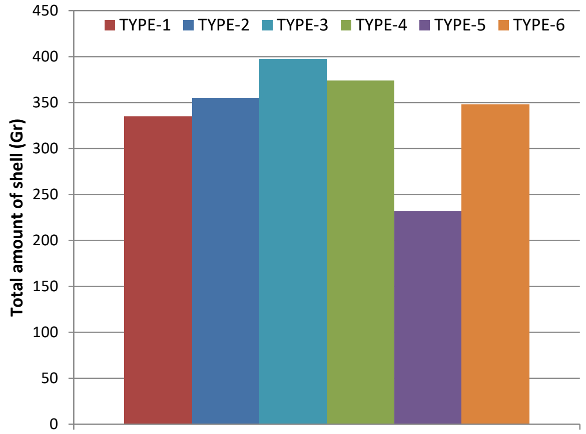


Fig. 3. Total amount of shell mass

Fig. 4 presents the fracture percentage in the shell obtained using different scourer screens. This chart should be evaluated together with Fig. 5. Because both graphs give information about peeling characteristics. Fig. 4 shows how much wheat is separated into small pieces as the hull is separated. In this section, the wheat that was broken but did not reach the roller and could not be caught elsewhere is considered lost. As seen in Fig. 4, Type-1 causes the most wheat fractures, while Type-3 and Type-6 are the types that cause minor fractures comparatively.

Fig. 5 presents the percentage of cracked wheat obtained when different scourer screens are used. In a flour production facility, it is desired to break the wheat in the roller, not during the peeling, because it is not possible to obtain flour from wheat that is not broken in the roller mill. In this respect, the amount of crushed wheat before the roller mill is desired to be kept at a minimum. As shown in Fig. 5, type-1 cracks wheat the most, and type-4 breaks it the least. It is impossible to use cracked wheat because it cannot absorb water. In addition, because the wheat is broken, the floury layer appears. This way, the wheat broken before reaching the roller machine must be separated by expending energy in the trieur machine. This situation leads to both a decrease in factory efficiency and energy efficiency. In addition, this situation increases the need for trieur machines in large-scale facilities and may cause an increase in the space requirement of the factory by complicating the flow process.

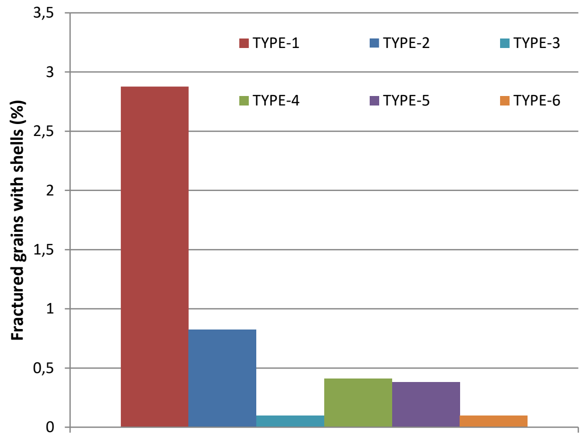


Fig. 4. Percentage of fractured grains with shells

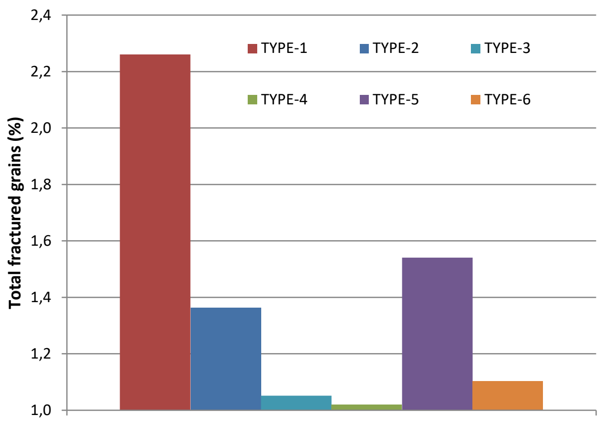


Fig. 5. Total percentage of fractured grains

3.2. Chemical test

Chemical tests were performed on samples taken from different stations of the flour production facility. While testing different types of scourer screens, care was taken to take samples while processing the same wheat mixture. Samples were taken from four different stations, and ash rates were determined by burning for 8-9 hours as specified in the relevant standard [22]. The peeler and the radial comb machine work together, helping to determine the peeler's effectiveness better. In this respect, the ash ratio was also evaluated after this station.

The most influential factor in the ash amount is that some layers cause more ash formation in the layered structure of wheat. For example, the aleuron layer has the most significant influence on ash formation. In this respect, both the peeling efficiency and ash amount in the flour are affected since the aleuron layer is not separated from the crust during the peeling process. However, the reduction in the ash amount compared to the previous station indicates that the bark of the wheat has been successfully separated.

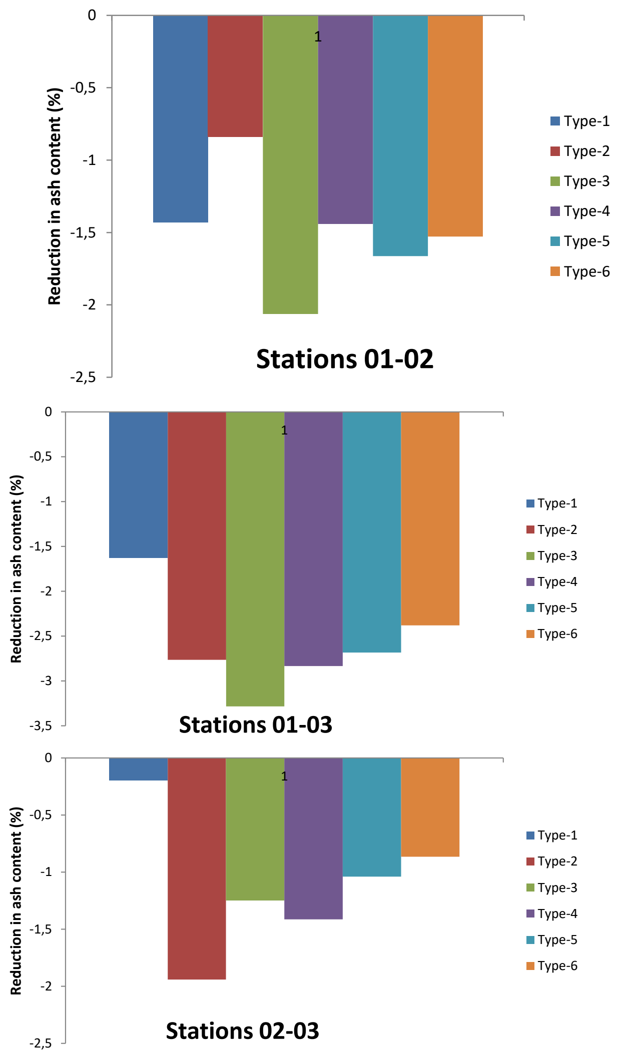


Fig. 6. Reduction in ash content at different stations a) Stations 01-02, b) Stations 01-03, c) Stations 02-03

In Fig. 6, when different types of scourer screens are used, the reduction rates in the amount of ash while passing through different stations are presented. As shown in Fig. 6a, the decrease in ash ratio is mainly obtained in Type-3, according to the measurements taken from stations 01 and 02. Among the specified measurements, the measurement that best shows the efficiency of the machine is the measurements taken from stations 01 and 03 (Fig. 6b). As can be seen in this figure, the highest decrease in ash content is obtained in Type-3, followed by Type 2 and 4 (Fig. 6c).

4. CONCLUSION

In this study, the effect of scourer type on total fractured grain and final ash content has been experimentally investigated. The main findings and conclusions are as follows.

The scourer screen type affects the efficiency of scouring, the total fractured grain, and overall product quality. The best results, in the view of fractured grain rate, have been obtained by Type-4, and in the view of ash content, have been obtained by Type-2. Therefore, whichever criterion is essential for the facility production portfolio, one of these two types should be preferred.

Choosing a low-efficiency type will result in an increased load on other cleaning machines or an increase in the facility's need for cleaning machines (number/capacity, etc.). However, results may differ in plants of different capacities. For example, although not reported in this work, it was found that the crack rate increased during low-capacity operation for all types and the least crack rate occurred when the scourer machine was operating at full capacity.

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