Multi-stage and Multi-response analysis of wheat grain separator machine to achieve high quality wheat grain

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Abstract—We know that seed from the field, contains various contaminants like weed seeds, other crop seeds, and inert material such as stems, leaves, broken seed, and dirt. The chief characteristics used in making separations are size, shape, density, surface texture, terminal velocity. The intent of this study is to reduce the human effort and time required for separation of wheat grain from raw material in big trust, flour mill industry, caterers. So we design and fabricate wheat grain separator machine which is helpful for reducing human effort for sorting out wheat grain from raw material. Unique feature of this machine is getting useful wheat grain from spikes (In Marathi KUSHYA) which is unwanted product by passing these raw materials through roller-belt mechanism.

A multistage system consisting of multiple components and stages required to optimize output of the final product. Multistage systems are including a variety of modern manufacturing systems. The present study aims at optimizing input parameter such as stroke and sieve hole diameter accordingly its effect on the output capacity and efficiency of machine. At different stroke, graph between efficiency versus sieve hole diameter and capacity versus sieve hole diameter shows significant improved output at 1 cm stroke and 3.5 mm sieve hole diameter.

Index Terms—Design, fabrication, Wheat Grains, optimization, Multi-staging, Separation, Sieve hole diameter.

I. INTRODUCTION

In India, states such as Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan produces high amount of wheat grain. Wheat grains as it comes from the field, contains various contaminants such as weed seeds, other crop seeds, and inert material like stems, leaves, broken seed, and dirt. These contaminants are requires to remove from raw material. The alternative techniques for wheat grain separation are available such as Air-screen cleaner, specific gravity separator, Pneumatic separator; indent cylinders, indent disks, magnetic separator, electrostatic separator and vibrator separator. The procedures used to meet present quality standards result in a loss of up to 20-30% of the good seed even though many special machines and techniques are used for seed cleaning and handling. Lots of time require for sorting wheat grain product from raw material. The human efforts requires to sorting/cleaning wheat grain is also high. Some of the present seed-cleaning machines make extraordinary separations of small crop and weed seeds; however, the entire seed-cleaning problem is very complex and improvements are still required in methods of cleaning and equipment to reduce the heavy seed losses. In this study we design and fabricate wheat grain separator machine which is capable of cleaning foreign particles from raw material in minimum time and trying to get maximum useful wheat grain products from spikes which is waste material. Machine can be used at flour mill industry, caterers, big trust (e.g. Shegaon and Shirdi trust) and farmer for their business.

Multi-response problem are quite prevalent across various application areas. The multi-response problem consists of roughly three stages namely data collection, model building and optimization i.e. study of various characteristics. We are mainly focused on the optimization of parameters. Two parameters stroke and sieve hole diameter are consider for optimization study.

II. LITERATURE REVIEW

The Characteristics of Multistage Systems:
A multistage system refers to a system consisting of multiple components, stations or stages required to finish the final product. Multistage systems are very common in practice almost all modern manufacturing
processes (e.g., assembly, machining, fabrication, and manufacturing) fit this category.
The performance quality of each task is measured by task outcome variables, which collectively impact on output of machine.
Certain common characteristics make such systems complex, including the following.
1. Multiple stages and hybrid structures with mixed sequential or parallel configurations.
2. Feedback/feed forward loops that arise because outputs from one stage are the inputs to other stages, so the outcomes from one stage are not only influenced by local variations at that stage, but also by the variations propagated from upstream stages, with the final outcome being an accumulation (or stack up) of variations from all stages.
3. Collective and stochastic performance, i.e., the ultimate performance of the overall system depends upon the accumulated performance of individual stages in the system.

Fig. 1 diagram of multistage system
(Source: quality control and improvement for multistage systems: a survey)[1]

Fig. 2 Schematic diagram of machine showing multistages (Microsoft Word 2010)

III. METHOD
A. Model of final assembly:

Fig. 3D final Assembly of Machine on solid-works 2013

B. Working of wheat grain separator machine:
Wheat grain separator machine basically consist of sieve box, main frame, belt and pulley and shaft with cam arrangement and linkages for hanging the box. Sieve box consist of three stages of sieve, first stage is 6 cm from top portion of the machine. Sieve is having 4mm diameter holes. Second stage is 6 cm from the first stage and sieve is having 2mm diameter holes. Third stage of sieve is having 3.5mm diameter holes. Third stage of sieve is at the outlet of machine.
As the motor start the power transmitted from motor to shaft by belt and pulley arrangement. Shaft on the pulley rotates with the power transmitted by the pulley. Rotating motion of the shaft is transmitted to the cam attached to sieve box with linkage. Sieve box have forward and backward motion because cam has offset of 1cm hence the stroke provided is 2cm. sieve box is hanging up with the help of four linkages on main frame.
The Roller and Rubbing belt in semicircle box setup is mounted on the frame. Due to rubbing action between roller and belt we get useful wheat grains from spike which is unwanted product. Because of this we get approximately 50 % to 60% useful wheat grains.

C. Multistage and multi-response study:
Table No. 1 Shows the output of wheat grain at different stroke and sieve hole diameter. The maximum output obtain at sieve hole diameter 4mm and stroke 2 cm. the efficiency is calculated using following equation:

\[
\text{Efficiency} = \frac{\text{Input Impurities} - \text{Output Impurities}}{\text{Input Impurities}}
\]

For stage one in multistage system, the variable are stroke and sieve hole diameter. Then for stage two the sieve hole diameter is changed and stroke is kept constant. Accordingly output is observed which shows in table No. 1 are.

Above graph shows the Efficiency vs various sieve diameter at Stroke of 1 cm shown in fig. 5. At same Stroke the output capacity against sieve hole diameter is shown in fig. 6.

![Fig. 5 Graph of efficiency vs sieve hole diameter (for 1 cm stroke)](image1)

![Fig. 6 Graph of output vs sieve hole diameter (for 1 cm stroke)](image2)

![Fig. 7 Graph of efficiency vs sieve hole diameter (for 1.5 cm stroke)](image3)

![Fig. 8 Graph of output vs sieve hole diameter (for 1.5 cm stroke)](image4)

![Fig. 9 Graph of efficiency vs sieve hole diameter (for 2 cm stroke)](image5)

Above graph shows the Efficiency vs various sieve diameter at Stroke of 1.5 cm shown in Fig. 7. At same Stroke the output capacity against sieve hole diameter is shown in fig. 8.

![Fig. 10 Graph of output vs sieve hole diameter (for 2 cm stroke)](image6)
IV. RESULT

From the above graphs, at stroke of 1 cm and sieve hole diameter of 4mm and 3.5 mm the efficiency of wheat grain separation is 97.29667%.

The output is 6 Kg for 2 minutes run of machine. Capacity of the machine for Cleaning wheat grain is 25-30 kg in 10 min run (approximately).

V. CONCLUSION

Because as per test carried out on machine with six number of trial, it was found that the sand, soil, grass and tiny particles were completely removed as per desired output. But some spikes were found in it. So need to improve the method of sorting and cleaning by incorporating the sieve size of hole diameter 3.5 mm and stroke 1 cm. After applying these changes result found to be excellent and improved; recommended for the future scope of cleaning. It has wide application in NGOs and big spiritual trust. It will be coupled with the wheat flour mill making it semi-automatic.

REFERENCES


