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DEVELOPMENT AND EVALUATION OF A SQUARE WIRE MESH TYPE OF POTATO GRADER

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ABSTRACT: Grading is an important operation for preparing potatoes for seed and commercial purposes. An improved square wire mesh type of potato grader, has been designed and developed. Major systems of the grader are the main frame, grading mechanism and power transmission system. Grading unit consists mainly of three numbers of grading sieves having 52, 32 and 20 mm size square openings made out of 8 SWG MS wire. Conveyor belt system (take in conveyor) has been provided for uniform feeding of potatoes to the grading mechanism. The grader can grade the potatoes in four size grades *e.g.* < 20 mm, 20-32, 32 -52 and > 52 mm. The output capacity of this grader is 5-6 t/h and its would reduce the cost of grading by 68.18%.

KEY WORDS: Wire mesh type, size grading, power transmission, output capacity.

INTRODUCTION

Grading, that is separating of potatoes more or less accurately on the basis of their size, is of considerable commercial importance for potato growers. Grading can be done based on physical dimension of potatoes as well as their weight. The former method of grading is preferred over the later (Roy *et al.*, 2005). The purpose of grading potatoes is to aid in standardization and to facilitate marketing. Grading is important for successful marketing. Mechanized grading is not only to replace the manual work by mechanical grading but also to adapt systems, which may help growers and market dealers to determine their prices in an accurate and accepted way to the consumer. Manual sorting of potatoes into different size grades is very slow and labour intensive. It requires 20 man-hours per tonne of produce as reported by (Shyam and Singh, 1979). Manual grading is carried out by trained operators who consider a number of grading factors and separate potatoes according to their physical quality. Manual grading operation is affected due to the low availability of labourers during peak season. The main drawback with manual sorting is that uniformity within the different grades is not maintained as the sizing mainly depends upon the visual judgment of the persons engaged in the grading process. Human operations are less consistent, less efficient and more time consuming. Thus mechanizing the grading operation is desirable for both reducing the cost and time required for the operation and ensuring uniformity in the grades. Mechanical planting of potatoes, which is gradually picking up in the country, has further necessitated the grading of seed potatoes accurately. Potatoes are sized according to their axial dimensions, average diameter etc. Potato-grading machines designed to work on small-scale farms in the developing world must satisfy both technical and economic requirements, as well as considering social factors for successful technology adoption. Machines must not only be suitable for use in harsh physical conditions, but they must also be profitable to the farmer. Such machines must be able to grade a wide range of tuber sizes and shapes efficiently and cost-effectively in the short and

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long term (Butler *et al.,* 2005). Throughputs of the graders vary widely according to the number and ability of the operators, as well as according to the machines and auxiliary equipment employed. No one grading machines has all the advantages, so choice of a grader requires careful consideration of the most important needs for the conditions in which it is to be used (Culpin, 1981).

A number of potato graders viz. wire belt type, conical rotary type, oscillating sieves type, rubber rollers type, differential belt speed expanding pitch type, expanding and fixed pitch rubber spool type, etc. [(Grover and Pathak, 1972), (Atwal *et al.,* 1992)., (Shyam *et al*., 1990), (Atwal *et al.,* 2001), (Singh, 1980), (Verma and Kalkat, 1975), (Verma and Kalkat, 1992) respectively] have been developed at Central Potato Research Institute, Shimla and at Agricultural Universities for size grading of potatoes. High initial and/or maintenance cost, complicated design, inconvenience caused during operation due to excessive vibrations and noise, sieve clogging, bruising of tubers, in proportionate dimensions and poor grading efficiency, low output capacity and non-existence of any provision for transportability to other destinations, were the major hindrances and drawbacks in commercial exploitation of these graders/ sizers. Amongst these developments, only expanding pitch rubber spool and oscillating sieves potato graders, were commercially exploited to some extent but are not in regular demand and production now-a-days (Singh *et al.,* 1992). Taking into account the above facts, the study was carried out with the following objectives-

1) To develop a square wire mesh type potato grader which can be used for grading freshly harvested tubers after curing them in heaps for 15 to 20 days.
2) To test and field evaluate the potato grader.

MATERIALS AND METHODS

Development criteria

Following points were considered while designing the potato grader.

1) Machine should be simple with lesser number of parts, which should be easily replaceable.
2) It should provide four grades.
3) Minimum labour as well as power for operation should be required.
4) No or minimum product injuries by way of bruising, skinning or cutting.
5) Suitability for sizing potato tubers of different varieties.
6) High output capacity per hour.
7) Use of locally available raw material for fabrication.
8) Convenient bagging arrangement for the sized tubers.
9) Ease of transportability.

Keeping in view the defects in the existing potato graders, an improved square wire mesh type potato grader, was designed and developed. The grader was made of locally available materials to keep the cost low. Efforts were made to keep the mechanism and operation of the machine as simple as possible. The materials used for the fabrication of different parts of the machine were M.S. angle iron, M.S. flat, M.S. rod, M.S. sheet, M.S. shaft, rubber sheet, wood, ball-bearings, V-belt, V-pulley, and miscellaneous small items. All the joints were made by welding to make the machine strong, rigid, and to reduce the vibration at the time of operation. The paper deals with the fabrication, mode of operation and performance evaluation of the machine.

Description of the machine: The fabricated grader **(Fig. 1)** consists of the following main

parts. Specifications of the main components are listed in the Table 1:

1) Main frame
2) Grading mechanism
3) Power transmission system

Main frame: Main frame was developed keeping in view the static and dynamic loads during operation and transportation.

Table 1: Salient features of square wire mesh type of potato grader

Sl. No.	Item	Specifications
1	Type	Engine operated
2	Overall length (mm)	6380 mm
3	Overall width (mm)	3150 mm
4	Overall height (mm)	1830 mm
5	Size of the grading sieves	20, 32 and 52 mm size square openings
6	Power requirement	A 3 to 5 hp diesel engine
7	Power transmission	Through chain drive, belt & pulley arrangement
8	Method of feeding	Generally manual feeding with baskets/gunny bags
9	Bagging system	Bag holders provided
10	Transportability	Four Nos. of solid rubber lined transport wheels provided
	Performance evaluation of the prototype grader	
11	Output capacity	5-6 t/hr
12	Nos. of labourers needed to work with this machine	5 to 8
13	Suitability for freshly harvested tubers	Can be used for freshly harvested tubers after curing them in heaps for 15 to 20 days
14	Nos. of grades obtained & range	Three grades (A) First grade with tuber diameter exceeding 52 mm. (B) Second grade with tuber diameter between 32 and 52 mm. (C) Third grade with tuber diameter between 20 and 32 mm. D) Fourth grade with tuber diameter below 20 mm
15	Tuber damage	Almost negligible

The main frame of the grader resembles the shape of a rectangular box and is fabricated mainly out of MS channels, MS angles, MS square pipe and MS flat, which are readily available and are the most commonly used materials in the fabrication of farm machinery. Design of the grader is flexible so as to fit all other working components units rigidly. Main frame was mounted with two axles along with two pairs of solid rubber lined transportation wheels of diameter 300 mm

Fig. 1. Square wire mesh type of potato grader

each provided at front and rear sides of the frame. For easy transportation of the grader to the desired destination, location/ positioning of these wheels with axles can be easily changed as per the requirement. In order to combat the mechanical fatigue failure, machine elements were designed with appropriate factor of safety. A telescopic bar handle fabricated mainly out of angle iron welded together in the form of a square pipes, having provision for hitching with a tractor has also been provided in the front. Two pairs of adjustable supports were fitted below the front and rear corners of the frame for stability of the grader and for changing its inclination during operations as well as for parking.

Grading mechanism: The system consists of metal meshes, through which tubers smaller than the mesh size pass. Grading is done with the help of three endless net belts with different size meshes. Grading mechanism of this grader mainly consists of a GI wire that has been given the shape of a square. All the wires have been so bent with the help of specially designed and fabricated dies that when held together with the help of GI sheet clamps, they get the shape of squares at regular intervals throughout the width of the grading belt. For getting different grades of tubers, square wire meshes of different sizes have been provided. Grading unit consists mainly of three numbers of grading sieves having 52, 32 and 20 mm size square openings made out of 8 SWG MS wire. Both ends of the all the three wire belts have been clamped together with the help of GI sheet clamps thus making them endless screens. Whereas the wire belts having 52 and 32 mm size opening moves along the length of the grader, the other wire belt having 20 mm size opening moves perpendicular to it. These grading sieves were properly aligned so as to keep a check on their sideways movement. Proper care has been taken to disallow any loosening of the wires of the grading belts during operation. Twelve numbers of wooden drive and driven rollers have been fitted with bearings (number 6205) and brackets at appropriate locations in the grading belts for proper movement and tightness of these grading belts during operation.

Whereas wire belt having 32 mm size opening will move along the length of the grader and will firstly receive the tuber material to be graded, the other wire belt having 20 mm size opening shall move perpendicular to it and has been provided beneath this wire belt (having 32mm size sieve opening). If the produce is small enough, it will pass through the screen (having 32mm size sieve opening). Larger produce will progress on to the next screen (having 52mm size opening) to repeat the process. This screen/ wire belt having 52 mm size opening is also provided in line with it and moves along the length of the grader. The Screen Sizer 'sizes' potatoes, as the produce passes over a series of mesh screens. Sizing is aided by shakers on the screens that agitate the produce, thereby aligning the smallest dimension with the mesh. Under each belt, agitators have been provided that shake the net, to ensure that the product is correctly graded. Belt and agitator speeds can be set independently of each another.

Inclined chutes made out of GI/MS sheet (20 gauges) were also provided to receive the four grades of potatoes falling through the wire belts. The graded potatoes roll down to the bag holding attachments fitted at the outlet of each chute. These bag-holding attachments have locking levers for easy holding of gunny bags in position. There is provision to hold four gunny bags simultaneously for two chutes (for 32-52 mm and for >52 mm size grades) where as the another chute (for 20 -32 mm size grade)

has the provision for holding two bags at a time. Except for the smaller size chute (< 20 mm size grade), wooden flaps have been provided in all other chutes, to divert the flow of potatoes to the desired bags, thus maintaining the continuity of operation. Proper inclinations to these chutes were given so that potatoes roll down smoothly to the gunny bags. Potatoes having less than 20 mm size roll down directly in the basket kept below the outlet of the chute. Rod and hook type of bag holder for grade size 20-32 mm, has been made folding type, so as to optimize upon the width of the grader and also for easy transportation of the grader to the work site. Height of the bag holders has been so kept as to suit the average length of a gunny bag.

Conveyor belt system (take in conveyor): Conveyor belt system (take in conveyor) has been provided for uniform feeding of potatoes to the grading mechanism. The design of the take in conveyor was made keeping in view the functions to perform, fabrication facilities and skill, simplicity of the design, social acceptability, knowhow of the end users, trend of the local industry. Take in conveyor consisted of driving shaft, driving drum, rubber belt, frame of the conveyor and power transmission system etc. Rubber belt (750mm wide and of 4 ply rating) with retainers (angle iron of size 25x25x3.15mm) constitutes the tuber feeding system. Height of this conveyor belt system is adjustable up to 308 mm. A pair of telescopic arms made out of 25 mm diameter MS bar and pipe was attached to the lower side of the conveyor mechanism for changing the inclination of the belt for efficient conveying of the potatoes.

Power transmission system: A power transmission system was developed to transmit the required power from prime mover to the gear box or other parts of the grader. Chain, sprockets and belt and pulley, shafts etc have been used in the power transmission system to give drive to grading and conveyor belt mechanisms.

One of the wooden rollers provided in the wire belt having 52 mm size square opening, receives power from the power transmission system of the prototype, through an arrangement of chain and two numbers of sprockets and rotates the grading belt. Rest of the wooden rollers act as driven rollers and keep rotating as the grading belt moves. Power is further transmitted to other grading belts (having 32 mm and 20 mm size square openings), with the help of chain and sprockets arrangement. MS shaft (25 mm size) that receives the power rotates the grading sieve (20 mm size square opening) with the help of bevel gear arrangement. Bevel gear arrangement provided in the system helps to transmit power at right angles. Wire belt vibrators consisting mainly of PVC rollers, MS flat and rod, also get power from the shafts of the respective wire belt units through an arrangement of chain and sprockets. Idler sprockets wherever necessary, have been provided to tighten the chains for its smooth movement. All the chains have been covered with MS sheet covers to protect them from the dust and for the safety of the persons working on the grader.

Rubber sheets have also been fixed on the GI sheet / wooden pieces, provided on the sides of the wire belts to prevent any bruising to the tubers moving on these belts. Grader wire belts can be tightened whenever required as the wooden rollers fitted with bearings and brackets have been made adjustable.

RESULTS AND DISCUSSIONS

The engine operated square wire mesh type potato prototype grader (**Fig. 1**) was

evaluated at the farms of the Central Potato Research Station, Jalandhar. Feeding to the grader was carried out manually with the help of baskets.

Performance of the grader: For its performance evaluation, the ungraded potatoes were fed to the lower end of the conveyor belt system. Five to eight persons are needed to carry out the operation. They are required for feeding and for fixing of empty bags and removal of filled bags. These potatoes were carried up by the conveyor belt system and then dropped on the inclined chute for further feeding to the grading endless net belts. For potato grading machines, loading is specified in terms of the width of the grader surface. The throughput capacity of the grader was calculated as the hourly rate of graded tuber mass received from all the delivery chutes of the grader. With this potato grader, the potato tubers could be graded in to four different size grades viz.

(i) Grade A (Large): First grade with tuber diameter exceeding 52 mm.

(ii) Grade B (Medium): Second grade with tuber diameter between 32 and 52 mm.

(iii) Grade C (Small): Third grade with tuber diameter between 20 and32 mm and

(iv) Grade D (Very small): Fourth grade with tuber diameter less than 20mm

The output capacity of this grader is about 5-6 t/hr. (**Table1**). Five to eight labourers are needed to work with this machine. They are used for operation, feeding, shifting of the filled up bags and for attaching empty bags with bag holders. The graded potatoes were collected directly in bags which provide some cushion to the tubers. This grader is suitable for grading even the freshly harvested tubers, which have been cured in the heaps for about 15-20 days after harvesting. The damage to the tubers was almost negligible. It is because of the fact that the fully cured potatoes were used for testing. The capacity of the grader depends to a great extent on the sorting accuracy. When the feed rate is greater, the accuracy of grader suffers significantly. The quality of separation of harvest in to different sizes depends upon the adjustments of the various components of the potato grader. Prototype grader can be easily transported to the worksite. Two axles along with two pairs of solid rubber lined wheels of diameter 300 mm each, have been provided at front and rear sides of the frame for this purpose. The present potato grader has been designed and fabricated to keep its cost low. The grader reduced the cost of grading by 68.18%.

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