A MACHINE FOR SORTING NUTMEGS

C.K. Sankat and C.V. Narayan
Department of Mechanical Engineering
University of the West Indies
St. Augustine, Republic of Trinidad & Tobago.

Summary

A machine for sorting nutmeg seeds is described. Seeds are fed from a hopper and are passed between a pair of counter-rotating, inclinded cylindrical rollers. When the seed diameter is equal to the clearance between the rollers, seeds can no longer be supported by the rollers, and are separated out.

1. INTRODUCTION

Nutmegs (*myristica fragrans)*, a leading export crop of Grenada are processed by many tedious, manual methods. Sankat and Narayan [1] reviewed the present methods employed in Grenada for the processing of this crop. The principal processing operations are drying of the freshly harvested seeds to 8 - 9% moisture content, cracking of the seeds and separation of the nutmegs (the product of commerce) from the shell, and finally grading of the nutmegs. Nutmegs are graded by size, the usual grades in decreasing sizes being 60, 65, 80, 110 and 130. These grades represent the numbers of nutmegs/pound i.e. 60 nutmegs/pound, etc. This manual sorting operation is presently undertaken by experienced workers.

A system for the mechanical cracking of nutmeg seeds has also been proposed [2]. In this system, sorting of seeds into various size ranges is a pre-requisite to mechanical cracking.

This paper describes the essential functional features of a machine which was designed and fabricated to sort nutmeg seeds into desirable seed sizes.

2. MACHINE DESIGN

2.1 *Design Objectives*

Nutmeg seeds are variable in size, with shapes that are generally round or oval. Seed sizes [3] can vary in diameter from 14mm to 40mm, and correspondingly kernel diameters can vary from 11mm to 36mm. To mechanically crack dried nutmeg seeds, it was suggested [2] that seeds of common sizes be sorted into five ranges based upon their diameters. The size ranges suggested were:—

16.0 — 18.5mm,	18.5 — 21.3mm,	21.3 — 24.4mm
24.4 — 27.8mm and	27.8 — 31.5mm.	

The design objective was therefore to develop an experimental machine, that could continuously sort nutmeg seeds into 4 or 5 ranges.

2.2 *Principle of Operation*

From a number of alternatives, a design was chosen to reflect simplicity in operation and consequently ease in fabrication. The principal features of the machine are shown in Figure 1.

Essentially, nutmeg seeds are allowed to move by gravity and in a single file, in the gap created between a pair of similar, divergent cylinders, that are inclined to the horizontal. The seeds which are supported on the surfaces of the rotating cylinders, orient themselves in a stable position i.e with their major axes directly above, and in line with the centre line of the gap created between the rollers. The frictional forces on the seed in contact with the counter-rotating cylinders, produce a bouyant effect on the seeds. Seeds therefore move down the inclined divergent cylinders until they reach a location where they can no longer be supported on the roller surface. At this point, the diameter of the seed is equal to the clearance between the cylinders. Such seeds fall into collection chutes which are compartmentalised so as to collect seeds of a particular size range only.

2.3 *Functional Features*

The machine consisted essentially of three units, viz:—

(i) A feeding mechanism
(ii) A pair of divergent, cylindrical rolls
(iii) A frame for supporting the above.

Nutmegs were discharged by gravity directly into the cavity created by the rollers from a wooden hopper. This hopper of 47cm in height was positioned directly above the rollers, and had a cross sectional area of 160cm^2 at the base, while at the top it was 1260cm^2. To ensure a steady flow of seeds to the rollers, a small agitator was welded to one of the rollers. This cam shaped device, 12mm in height, rotated through a slot in the hopper's side, thus agitating the seeds within. To accelerate the nutmegs along the rollers, a positively oriented spiral was formed on the roller surface directly beneath the hopper by wrapping wire of 3mm in diameter. This wire was welded into position, with a pitch of 5cm.

The pair of cylindrical rollers were fabricated from galvanized piping of 10cm in outside diameter. Rollers of 120cm in length were chosen so as to keep the angle of divergence between the rollers small, as well as to increase the sensitivity of the sorting process. Shafts of 25mm in diameter were welded to the ends of the rollers, and were supported on the frame through self aligning bearings. For ease in fabrication and assembly, Dexion framing was used, and constructed so as to provide a 6° slope of the rollers. The rollers were driven by a variable speed motor through V-belts and pulleys.

3. DISCUSSION

To achieve the sorting scheme previously described, the angle of divergence of the rollers i.e. the angle contained by the centre line of the rollers was small and equal to 0.56°. This was achieved by setting a 16mm clearance between the rollers directly beneath the leading edge of the hopper. At the end of the rollers, the clearance was set at 27.8mm. By setting the dividing sheets between the discharge chutes such that roller clearances of 18.5mm, 21.3mm, and 24.4 mm are directly above, the sorting scheme proposed was achieved, with any seeds greater than 27.8mm removed at the end of the rollers.

The machine showed consistent sorting at roller speed up to 115 r.p.m. and inclination angles of 12 — 15° to the horizontal. These higher angles were achieved by tilting the machine frame, and were desirable so as to increase the sorting rate. Under these conditions the sorting rate was 0.5kg/min. At speeds greater than 115 r.p.m., higher sorting rates could be achieved, but sorting accuracy reduced as nutmegs tended to be lifted and thrown by the rollers. Similarly, at higher angles of inclination, seeds tumbled uncontrollably between the rollers.

The feeding device performed satisfactorily with the addition of the agitator. Nutmegs were fed continuously between the rollers.

4. CONCLUSION

The principal features of a machine, designed specifically for sorting nutmeg seeds before the cracking operation, have been described. It is felt that a similar machine can be used for grading nutmegs, in the downstream operation.

The machine performed satisfactorily and has the advantage of simplicity in design, and could be fabricated locally. It has the disadvantage of a slow sorting rate. The machine can be driven by a 200W motor through a speed reducer.

5. ACKNOWLEDGEMENTS

The authors would like to thank the Mechanical Engineering Technicians and Mr. S. Alfred for their contributions to this study.

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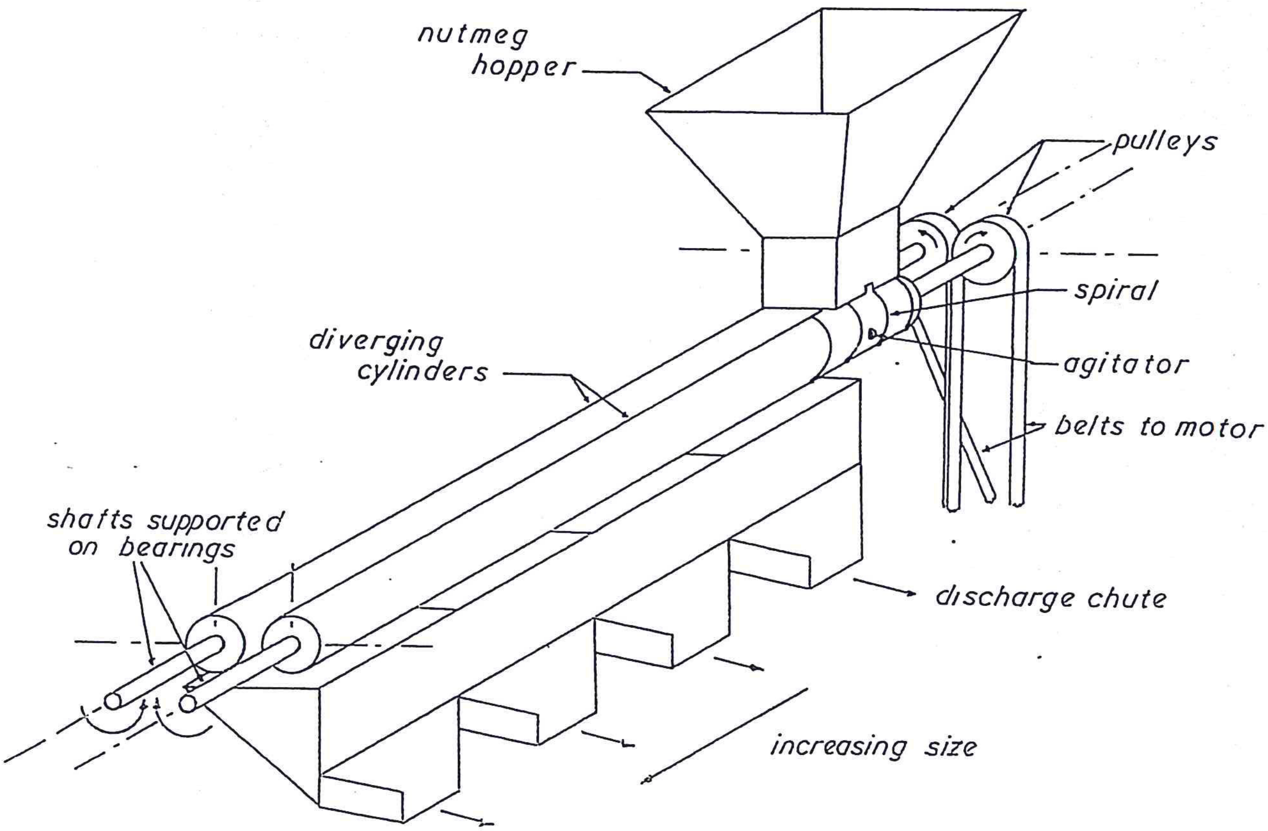

AUTOMATIC BOOM HEIGHT CONTROL AND DESIGN PARAMETERS FOR HYDRAULIC DRIVES ON POTATO HARVESTERS

G.S. Saqib* and J.S. Townsend**

Summary

An electrohydraulic automatic boom height control was designed and fabricated. The system was mounted on a Lockwood Mark 76 potato harvester and was tested for correct function of the automatic height control operating both independently from and simultaneously with manual control of the boom height. Design data for a variable speed hydraulic drive system on the harvester were collected while running the boom elevator and side elevator at different speeds for several simulated yields of potatoes. The maximum input power required for running a conveyor at a speed of 3 km/h under a potato yield of 37 t/ha was 2.43 kw. The required running torque was 108 N.m with a starting torque of 203 N.m The corresponding hydraulic oil pressures were 3.04 MPa for running and 5.78 MPa for starting. Maximum oil flow for each motor was 36 L/min.

1. INTRODUCTION

The greatest source of loss to potato growers has been found to be mechanical damage to tubers. The harvester is a major source of the potato damage (Townsend [1]). The boom elevator on the potato harvesters elevates and delivers the potatoes into a bulk transport vehicle. The height of fall of the potatoes is generally too great to handle the potatoes without damage. The operator of the present potato harvesters spends from 50 to 75 percent of his time operating the boom while he is digging (Johnson et al. [2]). This often leaves too little time to attend to the operation of the machine. As a result more potatoes than necessary could be damaged because of improper machine operation. An automatic boom height control can help maintain proper drop heights during loading of the truck and thus reduce potato damage.

A considerable reduction in mechanical damage to potatoes can be achieved by coordinating various conveyor speeds on the harvester with the forward speed and potato yield (Peterson et al [3]). Speed adjustment of the conveyors can be achieved using a variable speed-hydraulic drive system. Design data for hydraulic drives would help interested farmers and manufacturers to incorporate this system on the potato harvesters.

The objectives of this research were to

(i) Design, fabricate and test a low cost electro-hydraulic boom height control, and to

(ii) Obtain actual design data for the variable speed hydraulic drive system.

2. MATERIALS AND METHODS

2.1. Automatic boom height control

The automatic boom height control system designed for this study was a combination of mechanical, electronic and hydraulic components. A mechanical height sensor attached to the discharging end of the outer boom determined the height of the free fall of the tubers. When the sensor touched the bottom of the truck box or the top of the potato pile, the microswitch on the sensor actuated the electronic circuit which in turn operated the electrohydraulic valve.

*Agricultural Engineering Department, University of Ife, Ile-Ife, Nigeria.

**Agricultural Engineering Department, University of Manitoba, Winnipeg, Canada.

With the miscroswitch closed, current passed to the double-solenoid hydraulic valve. The valve directed hydraulic oil to a lift cylinder which lifted the boom. Lifting continued for an adjustable time interval. After the adjusted time interval the circuit switched the solenoid valve to the down position. The boom continued to cycle up and down through a distance which depended on the setting of the time delay and the flow of oil rate from the tractor hydraulic supply.

The electrohydraulic valve was a tandem centre, 3 — position double solenoid valve. The final electronic circuit is illustrated in Fig. 1. The electronic circuit control box was located near the operator's station on the tractor so that it could be reached for adjustments.

A variable speed rotating eccentric was built and used as a sinusoidal input to the height sensors. The sinusoidal input model represented the potato pile. The operation of the boom was observed for correct function of the automatic height control both independently from and simulatenously with manual control of the boom height.

2.2 Variable speed hydraulic drives

Design data were collected for two separate variable speed hydraulic motors driving the conveyors on the potato harvester. The side elevator and the rear cross conveyors were driven by one motor. Another hydraulic motor (Boom motor) drove the boom elevator. Both these motors ran in parallel and directly or indirectly drove the head shafts of the conveyors. The motors were supplied with hydraulic oil from the tractor hydraulic system. The specifications for the hydraulic motors of the drive system are given in Table 1.

A Flo-tech hydraulic tester was used to determine the oil flow and pressure for different loadings on the elevators. Sandbags were used to simulate net conveyor loads that would be expected for potato yield of zero to 44t/ha. The required starting torques for each simulated yield were also determined.

3. RESULTS AND DISCUSSION

3.1. Automatic boom height control

The automatic boom height control was mounted on a potato harvester. The system was first checked for correct function independent from the manual boom control. An input simulation model was built to represent the potato pile and was placed under the discharging end of the boom.

It was discovered that the time delays were not set correctly for the first tests. It was quickly determined that no delay was needed in either the lifting circuit or in the lowering circuit. There were some vibration problems associated with the sensors and the microswitches. Redesign of the sensor mounting overcame these problems. The available oil flow for downward travel of the boom was excessive. Flow control valves to the outer boom lift cylinders overcame this problem.

The above modifications gave satisfactory operation in the fully automatic mode. Safety considerations and field practice considerations made it imperative to provide a manual control over-ride. The manual over-ride control did not work satisfactorily. The problem was traced to the internal hydraulic system of the tractor used as the power unit.

3.2 Hydraulic drive design data

The results of power and torque measurements for the side and boom elevators are listed in Table 2 and 3, respectively. The maximum power required was for the boom elevator motor at the maximum simulated yield of 37t/ha. The power was 1.13 kW at an oil flow of 22 L/min and an oil pressure of 3.04MPa. The maximum power for the side elevator motor was 0.89 kW at an oil flow of 20L/min and an oil pressure of 2.75MPa when the simulate yield was 44/ha.

There is the possibility of running the conveyors at the same speed as the average field speed of 3 km/h. A linear relationship was determined for the data of Table 3 with increasing conveyor speed. For an assumed maximum yield of 37t/ha the required power would be 2.43 kW at an oil flow of 36L/min.

4. CONCLUSIONS

(i) The automatic boom height control performed satisfactorily when operated independently from the manual control. The manual over-ride control did not work satisfactorily because of some internal problems in the hydraulic system of the tractor used as a power unit.

(ii) For conveyor speeds equal to the average field speed of 3 km/h the boom elevator motor would require 2.43 kW at an oil flow of 36 L/min for a potato yield of 37t/ha.

(iii) At the maximum yield simulated in this study, starting torques were 203 N.m for the boom elevator and 108 N.m for the side elevator motor. The required maximum oil pressure would be 5.78MPa.

ACKNOWLEDGEMENTS

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Table 1. Specifications for the Hydraulic Motors

Specification	Boom Elevator Motor	Side Elevator Motor
Model	Charlyn M—206	Charlyn M—204
Displacement, L/rev	0.244	0.169
Maximum flow capacity, L/min	56.8	56.8
Maximum speed at maximum flow, rev/min	233	336
Maximum pressure, MPa	6.89	8.27
Maximum torque, N.m	120	166

Table 2. Hydraulic Requirements for a Hydraulic Motor to Drive the Side Elevator on a Potato Harvester

Conveyor Loading (Simulated Yield) (t/ha)	Starting Torque (N.m)	Conveyor Speed (km/h)	Motor Speed (rev/min)	Oil Flow (L/min)	Oil Pressure (Mpa)	Hydraulic Power (kW)	Running Torque (N.m)*
0	(68)	1.75	85	15	0.88	0.22	22
		2.25	110	20	1.77	0.58	45
11	(75)	1.75	85	15	1.08	0.26	27
		2.25	110	20	1.77	0.58	45
17	(77)	1.75	85	15	1.18	0.29	29
		2.25	110	20	1:86	0.60	47
22	(81)	1.75	85	15	1.27	0.31	31
		2.25	110	20	1.96	0.64	50
33	(95)	1.75	85	15	1.47	0.36	36
		2.25	110	20	2.26	0.73	58
44	(108)	1.75	85	15	1.86	0.46	46
		2.25	110	20	2.75	0.89	70

*Ninety percent efficiency assumed.

Table 3. Hydraulic Requirements for a Hydraulic Motor to Drive the Boom Elevator on a Potato Harvester

Conveyor Loading (Simulated Yield) (t/ha)	Starting Torque (N.m)	Conveyor Speed (km/h)	Motor Speed (rev/min)	Oil Flow (L/min)	Oil Pressure (MPa)	Hydraulic Power (KW)	Running Torque (N.m)*
0	(163)	1.36	66	16	0.98	0.27	35
		1.85	90	22	1.96	0.73	70
9	(170)	1.36	66	16	1.18	0.32	42
		1.85	90	22	1.96	0.73	70
14	(176)	1.36	66	16	1.27	0.35	45
		1.85	90	22	2.21	0.83	79
18	(179)	1.36	66	16	1.47	0.40	52
		1.85	90	22	2.35	0.88	84
26	(190)	1.36	66	16	1.67	0.45	59
		1.85	90	22	2.70	1.01	96
37	(203)	1.36	66	16	1.96	0.53	69
		1.85	90	22	3.04	1.13	108

*Ninety percent efficiency assumed.

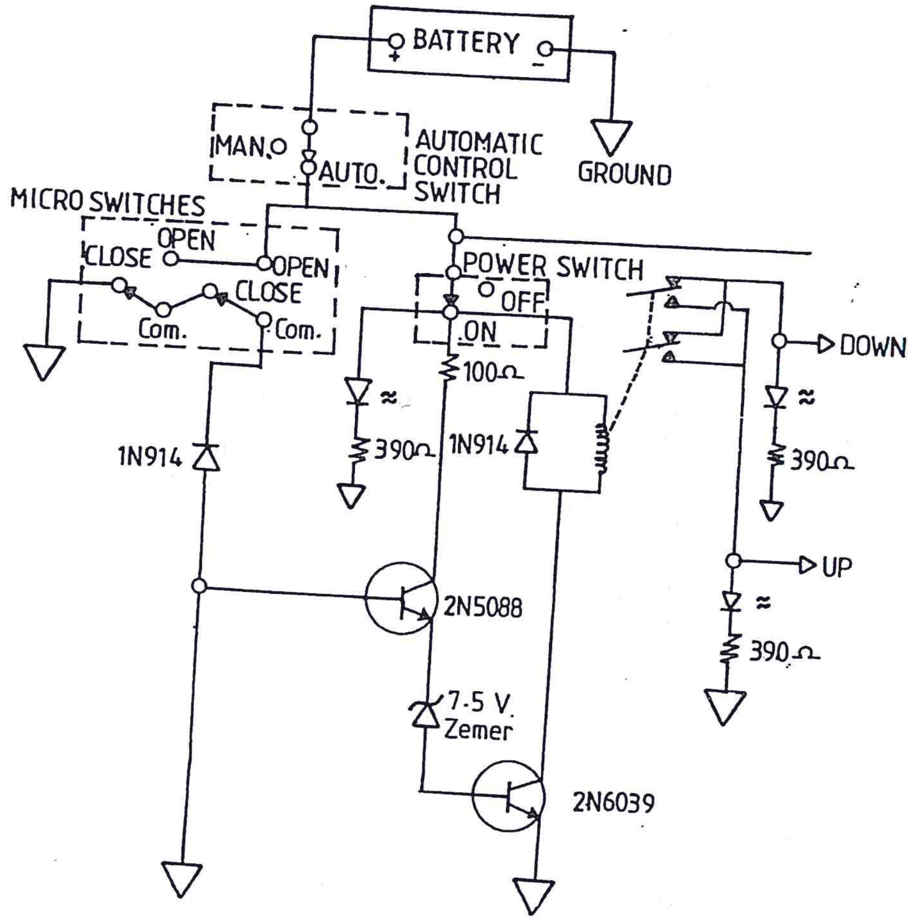

Fig. 1 Final Electronic Circuit for Automatic Boom Height Control

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2. MORRIS, J.E. and GEWARTOWSKI, J.W. "A 1W 6Ghz IMPATT Amplifier For Short Haul Radio Applications", Proceedings of the IEEE International Conference on Communication, Washington D.C., 1973, Vol. 1 pp. 8-27.
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