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Development of an Oil Extraction Machine for Cashew Nut Shell

Thierry Godjo
Department of Mechanical Engineering, University Institute of Technology of Lokossa, B.P. 133 LOKOSSA, Benin
Laboratory for Applied Energy and Mechanics (LEMA), EPAC, Abomey-Calavi, Benin.

Abstract:

An Oil Extraction Machine was developed for extracting oil from Cashew Nut Shell. The extracting unit consists of an auger with decreasing pitches. Two different samples of cashew nut shell were used: old cashew nut shells that have been decorticated more than two months and new shells that have been decorticated less than two months. After the performance test, the machine was tested at different auger speeds. Results showed that the designed machine was able to extract oil from Cashew Nut Shell with a good performance: Extraction efficiency of over 80% was obtained and the machine has extraction rate of 38.66 kg/hr. of oil and throughput capacity of 100.33 kg/hr.

Keywords — **Cashew Nut Shell, Design, Oil Extraction Machine, Performance evaluation, Benin.**

I. INTRODUCTION

In Benin as in some African countries, today cashew tree (*Anacardium occidentale*) is grown as a cash crop. The cashew nut shells (CNS) are rich in oil (about 36 wt. %) (1). In terms of climactic conditions, the most favourable area is between Gamia in the north and Abomey in the south. Apart from the very noticeable increase in activity at the end of the nineties, due to the rapid rise in prices paid to growers, this crop, which is Benin's biggest export after cotton, remains comparatively little known (2). The cashew value chain represents an enormous economic, social and environmental opportunity for Benin. The cashew sector has gained in importance in recent years, especially since the late 1990s. Cashew plantations have gone from covering an estimated surface area of 10,000 ha at the time to over 190,000 ha nationwide today, with more than 75% of plantations being under 10 years old (3). Similarly, exports of cashew products rose from 116,398 tonnes in 2008 to 170,101 tonnes in 2014 (4). The local, regional and national economies have used the substantial revenues obtained thanks to the sector's health cashews account for 8% of national export revenues and 24.87% of agricultural export revenues to stabilise the trade balance. The sector's basic characteristic is that income from cashew products is derived chiefly from exports of raw nuts with no added value, making processing the weakest link in the cashew value chain. There have been some success stories, and the potential for developing the cashew sector in Benin is truly favourable, but a great many difficulties remain to be overcome before national production is competitive and becomes a source of greater revenues for the various stakeholders. Those difficulties include the fact that the cashew processing sector is very stunted, accounting for less than an estimated 5% of national production. The oil extracted from cashew nut shells, Cashew nut shell liquid (CNSL) is a natural resin with a yellowish sheen found in the honeycomb structure of the cashew nutshell, and is a by-product of processing cashew nuts. It is a raw material of multiple uses in developing drugs, antioxidants, fungicides and biomaterials (5). It is used in tropical folk medicine and for anti-termite treatment of timber (6). About 90% of the CNSL imported by the USA, the UK and Japan was used as friction dust for drumbreak linings and clutch facings in motor cars. It is expensive compared with asbestos but the superior friction modifying properties make it economic. Since disc brakes replaced break shoes in motor cars, the use of CNSL has decreased (5). Still then, a huge variety of other products can be made from CNSL.

In order to promote small-scale extraction of CNSL, a research has been carried out on the development of an oil extraction machine for cashew nut shell.

II. MATERIALS AND METHODS

A. Description of the Cashew Nut Shell Oil Extraction Machine

The main components of the Cashew Nut Shell Oil Extraction Machine are frame, cylinder, auger, hopper, cake outlet, auger pulley, shafts, Reducer, Motor as shown in Figure 1. Various components of the machine were designed using standard formula. The frame was constructed from 45 x 80 x 45 mm channel and 45 x 45 mm angle bar to give rigidity and stability that will withstand load and vibration. The cake outlet is located at the end of the expelling housing where the conditioned seeds are compressed and the oil content forced out through the oil outlet slots on the housing. The machine is powered by an electric motor via pulley arrangement connected to the main shaft that turns the screw conveyor. The hopper into which the cashew nut shell is fed is located at the top of the cylinder.

B. Operation of the Cashew Nut Shell Oil Extraction Machine

The principle of operation involves the rotation of a helically flighted shaft in a cylinder. An electric motor was used to power the machine. The oil cashew nut shells are fed from the hopper to the screw conveyor which rotates in an expeller housing. When the electric motor is switch on, the main shaft and the auger, which moves and packs the cashew nut shells being heated along the passage to the far side, will start to rotate. The compression is achieved by decreasing pitch of the auger, designed to act as a screw press. The conditioned shells are compressed and the oil content forced out through the slots on the housing. The heating of the shells along the passage, and high pressure generated at expeller housing due to drastic reduction in volume, ensured expelling of the oil content.

C. Evaluation Procedure

Cashew Nut Shell Liquid (CNSL) collected from two cashew nuts processing plants (Kake-5 Industry and Nad & Co Industry), was used for evaluation of the machine. Evaluation of the machine was carried out with using two different samples of cashew nut shell (Old cashew nut shells that have been decorticated more than two months and new shells that have been decorticated less than two months) and at different speeds. Samples were then weighed to determine the weight before loading into the expelling machine. Statistical analysis was carried out using Descriptive Analysis, ANOVA.

D. Machine Performance Evaluation

Throughput capacity

It quantifies the machine's capability in terms of quantity of CNS it can process per unit time. It can be quantified using the (7) relationship as stated in following equation.

$$Throughput\ capacity\ (\frac{kg}{hr}) = \frac{Mass\ of\ seeds\ processed}{Time\ taken\ for\ extracting}$$

Extraction rate

The extraction rate (8) quantifies the percentage of weight of oil that the machine is capable of expelling compared to total weight of Cashew Nut Shell (CNS).

$$\textbf{Ectraction rate}\ (\%) = \frac{\textbf{Weight of oil extract}}{\textbf{Total Weight of CNS}}$$

Extraction efficiency

It depicts the level of effectiveness of the developed machine comparing the volume of oil extracted to the volume of extractable oil in the processed cashew nut shell. It can be quantified using the (9) relationship as in 3.

$$\textbf{Extraction efficiency}\ (\%) = \frac{\textbf{Mass of Oil extract}}{\textbf{Extractable Oil}}\ \textbf{x 100\%}$$

The oil content of CNS ranges between 45-50% (1). The average was assumed for purpose of computation.

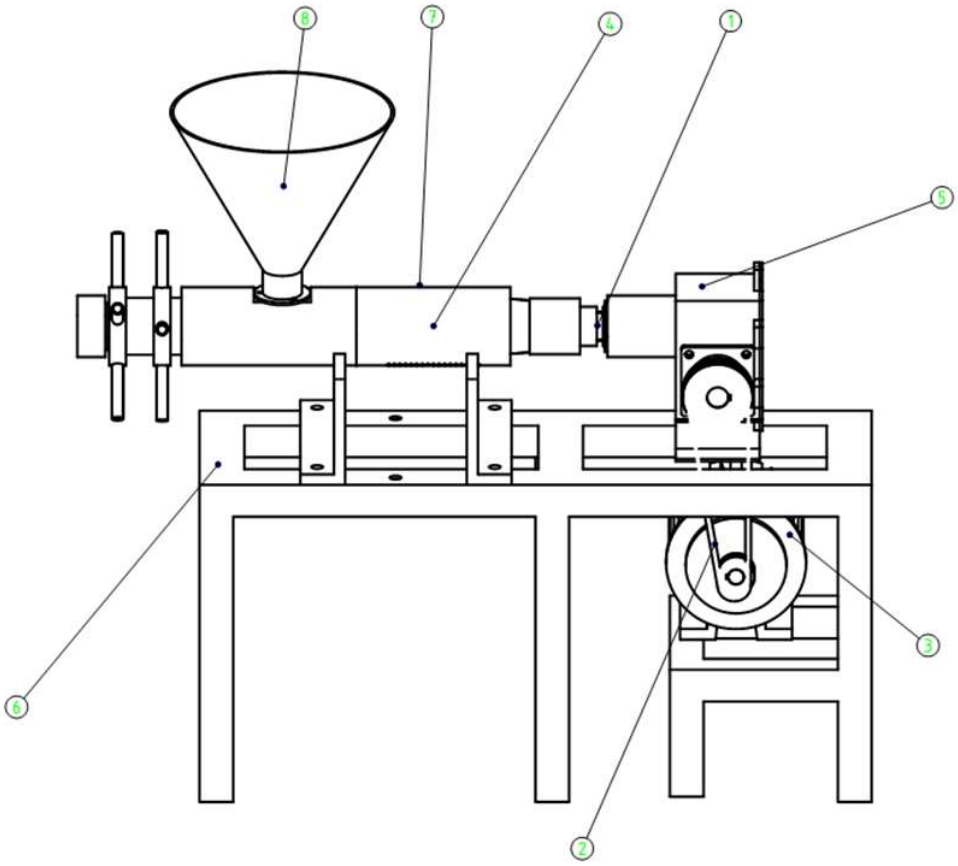

Fig. 1 Cashew Nut Shell Oil Extraction Machine

Legend: 1. Machine shaft, 2. Motor belt, 3. Motor, 4. Auger, 5. Reducer, 6. Frame, 7. Cylinder, 8. Hopper

III. RESULTS

TABLE I
DESCRIPTIVE STATISTICS OF TECHNICAL PERFORMANCES OF DESIGNED MACHINE

	New Cashew Nut Shell				Old Cashew Nut Shell			
	Speed	N	Mean	StDev	Speed	N	Mean	StDev
Throughput	30	3	100,33	0,577	30	3	95,667	0,577
	40	3	97,000	1,000	40	3	92,33	2,08
	50	3	96,333	1,528	50	3	90,333	0,577
Extraction Rate	30	3	38,667	0,577	30	3	37,333	0,577
	40	3	37,667	0,577	40	3	35,333	0,577
	50	3	35,667	1,155	50	3	34,667	0,577
Extraction Efficiency	30	3	80,556	1,203	30	3	77,778	1,203
	40	3	78,472	1,203	40	3	73,611	1,203
	50	3	74,31	2,41	50	3	72,222	1,203

The summary of the results of the performance of the developed oil extraction machine with cashew nut shell samples at different speeds is presented in Table 1.

For both samples, Throughput, Extraction Rate and Extraction Efficiency were observed to decrease with an increase in speed. The performances obtained from new CNS better than those obtained from old CNS.

The results suggest that the performance of the machine is highly depended on machine speed. Analyses of variance indicated significant differences at 5% level of significant in oil yield and efficiency due to speed and throughput.

These results show that the speed at 30 rpm is best suited to obtain the best machine performance. In fact, more the speed increases more the torque decreases. Thus, in charge the machine needs more couple.

IV. CONCLUSIONS

An Oil Extraction Machine for Cashew Nut Shell with a capacity of 100, 33 ± 0,577 kg/hr. was developed. Evaluation of the machine on Cashew Nut Shell gave an expelling efficiency of 80% at the speed of 30 rpm. However, the power requirement of the machine is 4 kW and is designed to expel oil from Cashew Nut Shell and can be adapted to expel oil from most oil seed varieties. Presently, the targeted users of the developed prototype machine are the cottage industries.

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