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Design and development of a groundnut oil expelling machine

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An expelling machine for extracting oil from groundnut seeds was designed and fabricated for market oriented production. The procedures employed the design stage, construction and testing. The machine components are: the speed reduction gear, expellant unit, drains collector, driving and driven pulleys, and the hopper. The expelling unit consists of a screw expellant shaft with expellant barrel. The groundnut seeds were pre-heated by roasting before extraction of the oil in it. The machine gave a better performance at the speed of 60 revolutions per minute and improvement in the design can be achieved by incorporation a heating chamber along the expeller barrel.

Key words: groundnut, design

Introduction

Groundnut oil extraction in most developing nations such as those of the south Asia and Africa is usually done manually by hand, and like all other manual operations it is drudgery and time consuming. The groundnut, Arachis hypogaea, also known as the peanut or earthnut, is botanically a member of the Papilionaceae, largest and most important member of the Leguminosae (Hans-Jurgen and Frans, 1989; Shankarappa *et al*., 2003). It is a very important oil seed and food crop around the globe for its nutritional and trade values (Shankarappa *et al*., 2003; Olaomi, 2008). Mainly native to warmer climates, groundnuts frequently provide food for humans or livestock, and in the absence of meat, form a valuable dietary protein component (Hammos, 1994). Groundnuts are almost exclusively processed in combination with the

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utilization of the residue for human consumption. In fact often the by-product, a kind of a snack called Kulikuli in Nigeria and some other African countries, is usually the main product and the processing of the groundnut oil only as part of the process. Groundnuts give edible and pleasant tasting oil for direct human consumption and are used as salad oil or for cooking. The oil is also further processed to margarine or Vanaspati in India, soaps, paints and cosmetics. The oil content of groundnut can contain up to 50% oil (although the usual range is 40% to 45%) and 25 % to 30% protein (Hans-Jurgen and Frans, 1989; Hammos, 1994). Oil is extracted from groundnut through either traditional means (mostly dependent on human energy with about 20-30% of the oil extracted) or mechanical means (over 90% of the oil can be extracted) (Olaomi, 2008). Most vegetable oils are recovered by grinding, cooking, expelling and pressing, or by solvent extraction of the raw materials (Gerald, 2009).

The most common method of extracting edible oil from oilseeds is mechanical pressing of oilseeds (Mrema and McNulty, 1985; Bamgboye and Adejumo, 2007). This method ensures extraction of a non-contaminated, protein-rich low fat cake at a relatively low-cost (Bamgboye and Adejumo, 2007). Traditionally, oil is extracted from groundnuts by roasting and crushing to as fine as possible (i.e. first by pounding, followed by crushing between stones or a stone and an iron bar). Afterward, the crushed mass is mixed with water, and the oil is obtained by cooking the mixture, causing the oil to float. The oil is finally skimmed off and dried by heating (Hans-Jurgen and Frans, 1989). The weak points of these processes are the grating or crushing steps. They are time consuming and drudgery, yet crushing is generally not fine enough. Thorough crushing can improve the oil recovery considerably. Traditional processes are very labour intensive and labour saving changes seem apt, at least for any kind of market oriented production-small (or domestic), medium or large scale. The potential for improvements would best be tapped by a simplified reproducible version of the modern technologies: Crushing the seed in a roller mill, heating in a directly fired pan and pressing with a spindle press, a hydraulic press or an engine driven oil expeller.

Materials and methods

Groundnut oil expelling machine is an important device for oil recovery from groundnut seeds by crushing seed in a roller mill, direct firing of barrel and pressing with an engine driven oil expeller. Generally, the barrel behaves like a simple pressure vessel – the cylindrical shell, computed on the assumption that the stress is uniform throughout the wall thickness. Thus, circumferential or hoop stress σ_h and longitudinal stress σ_l is given by:

$$\sigma_h = \frac{f}{tl} = \frac{\Pr l}{tl} = \frac{\Pr}{t} \quad (1)$$

$$\sigma_l = \frac{\pi r^2 P}{2\pi rt} = \frac{\Pr}{2t} \quad (2)$$

f = Hoop force (N), t = Thickness of the cylindrical wall (m), l = Length of the cylindrical wall (m), P = Intensity of the internal pressure $\left(N/m^2\right)$, r = Internal radius of the cylindrical wall (m).

The torque T (in Nm) transmitted by worm action and the angular speed ω (in rad/s) is given by $\omega = \frac{2\pi N_w}{60}$ (3)

$$T = \frac{P}{\omega} = \frac{60P}{2\pi N_w} \quad (4)$$

P = Power transmitted by the worm action (W), N_w = No. of Rev/min of worm action (rev/min).

The pulley was designed by considering the power to be transmitted between the electric motor and the screw expellant shaft. The ratio of the pulley for the electric motor to that of the expellant shaft was 1:2 and the allowable diameter of the pulleys were calculated as given by Olaomi (2008) as:

$$N_1D_1=N_2D_2 \quad (5)$$

N_1 = Speed of the driving motor (rev/min), N_2 = Speed of the expellant shaft, D_1 = Diameter of driving pulley (m), D_2 = Diameter of driven pulley (m)

The belt speed V (m/s^2) and its total length L (m) were calculated as given by Khurmi and Gupta (2004) respectively as:-

$$V = \pi N_1 D_1 \quad (6)$$

$$L = 2C + \frac{\pi}{2}\left(D_1 + D_2\right) - \frac{D_2 - D_1}{4C} \quad (7)$$

C = Center diameter (m)

For the center diameter,

$$C = \left(\frac{D_2 + D_1}{2}\right) + D_1 \quad (8)$$

The shaft, made from wrought iron carried combined load of bending moment and torque is given as:

$$\tau_{\max} = \frac{16}{\pi d^3}\sqrt{\left(M^2 + T^2\right)} \quad (9)$$

τ_{max} = Maximum shear stress (N/m), T = Torque (Nm), M = Bending moment of shaft (Nm), d = Shaft diameter of the machine (m).

Principles of operation of the oil expelling machine

The machine component parts include speed reduction gear, drain collector, driver and driven pulleys, and the hopper. The expeller is driven by a 3hp electric motor via a reduction gear. The expelling unit consists of a screw expellant shaft, shown in Fig. 1 below. The heating of groundnut seeds is achieved by generated heat, which heats the surrounding of seeds passage.

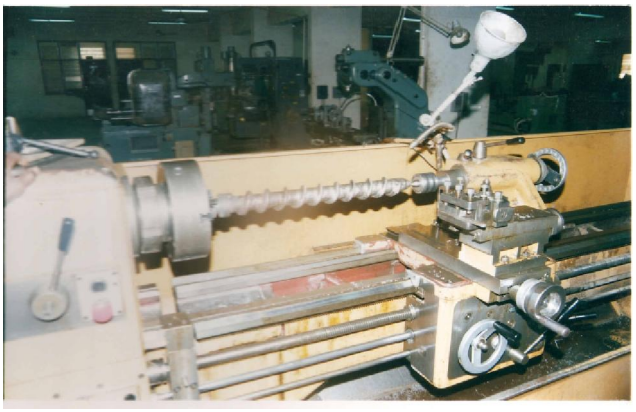

Fig. 1 Lathe machining of Screw Expellant Shaft.

Results and discussion

Oil is a valuable product with universal demand, and the possible income from oil extraction is therefore often enough to justify the relatively high cost of setting up and running a small scale oil milling business as stated by Hans and Frans (1989). The cell walls of oil seeds encapsulating the oil are characterized by cellulosic and non-cellulosic materials like hemicelluloses, pectin etc. They in general protect the constituents of the cell. In the extraction process the cell wall is ruptured by grinding in order to release oil. Incomplete rupture due to process constraints results in reduced yield (Hammos, 1994).

The result suggested that the performance of the machine is highly depended on the speed of the electric motor and the quantity of material passing through the machine with expelling operation probably better at around 60 revolutions per minute. Preliminary test carried out on the machine without heating of the groundnut gave no oil yield and only paste was observed passing

through the cake outlets. This was similar result of Olaomi (2008). This implies that for oil to be extracted from groundnut heating is necessary. However, when the groundnut was roasted before extracting oil from it, oil was produced because of the breaking of oil bearing cells during heating. The fabricated groundnut oil expelling machine and its schematic diagram is shown in Fig. 2 below.

A groundnut oil expeller was developed. Preliminary evaluation of the machine gave a better performance at the speed of 60 revolutions per minute. Without heating of the groundnut no oil yield was observed with only paste observed through the cake outlet. When the groundnut seeds were roasted before extraction of oil, reasonable oil was extracted. However, improvement in the design by incorporation a heating chamber along the Expeller barrel is expected to greatly improve the performance efficiency of the machine as also stated by Gerald (2009).

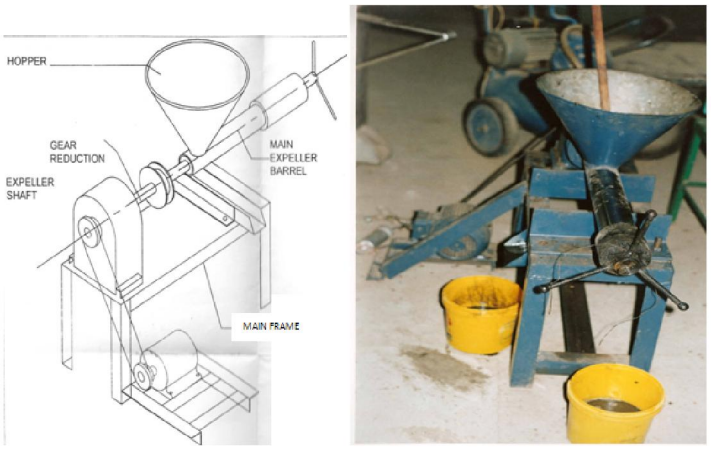

Fig. 2. Groundnut Oil Expelling Machine and the Schematic Diagram.

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