THE DESIGN OF OGI SIEVING MACHINE

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ABSTRACT

In an attempt to ease the processing of Ogi (ground soaked corn in slurry form) a major staple food in Nigeria, especially among infants and thereby increase the rate of its consumption, the manual process of sieving Ogi has been studied and a new technological method has been developed to improve the sieving process of ogi. The mechanization of the ogi sieving process involves the design of a simple machine which operates based on the principle of suction pressure to achieve solid-liquid separation of the Ogi mixture. The Ogi sieving machine has been designed and assembled in three stages to improve performance of the equipment. Performance tests carried out on the machine designed show that the machine has a sieving flow rate of 11. 1x 10^{-5} m^3/s as compared with manual sieving flow rate of 3.02 x 10^{-5} m^3/s.

Keywords: Ogi Sieving, Machine Design, Suction Pressure.

1. INTRODUCTION

Ogi, an acid fermented cereal, produced from maize, millet and sorghum which can be categorized as corn is a staple food of several communities in Nigeria. The conceptualization of a mechanized process of sieving Ogi (the Ogi sieving machine) was brought into reality in three stages of fabrication works done by Ndukwe (1998) and a group of others.

The processing of Ogi has long suffered the neglect of scientists and technologists in its improvement, nevertheless, the importance of ogi as a valuable source of nutrients especially amongst infants cannot be overstated. Over the years, it has been discovered that the manual process of sieving ogi is time consuming, boring, could be unhygienic and not properly done in some cases. Hence the objective of designing an Ogi sieving machine is to make the sieving process faster, less boring and to improve the filtrate quality in terms of smoothness and cleanness.

The first stage of the design of the Ogi sieving machine entailed the general specification, kinematics or skeletal arrangement of the equipment as described by Allen et. al. (1982). A centrifugal pump (vacuum cleaner) of 1KW rating was used to provide the required pressure drop at this initial stage and a sieving capacity of 8.09 x10^{-3} m^3/s obtained at the first stage.

The second stage of the design involved the design and fabrication of an appropriate suction unit for the sieving machine thereby replacing the vacuum cleaner used in the first stage of design with the newly designed centrifugal blower. The capacity of the sieving machine reduced to 2.8 x 10^{-5} m^3/s at the second stages of design due to the reduced efficiency of the newly designed pump.

Works at the third stage carried out by Adeleke and Gbolagade (2000) therefore concentrated on the improvement of the blowers efficiency and choosing appropriate materials for the machine units.

Steel and other anti-corrosive alloys were used to replace other materials in the machine parts, while the size of the whole machine was also reduced to increase the pressure drop in the equipment at the third and final stages of design.

The machine evaluation at the completion of the third stage of design shows that the mechanical process of sieving Ogi is faster than the manual process with the production of a well sieved Ogi filtrate. However works are still going on to improve the efficiency of the machine.

2 PARTS AND OPERATION OF MACHINE

The ogi sieving machine at the third stage of design is made up of the following six units.

(i) The slurry container
(ii) The mixing unit
(iii) The sieving unit
(iv) The reservoir
(v) The suction pump
(vi) The tripod stand

Shown in Fig. 1 is the exploded isometric view of the units of the ogi sieving machine. The slurry container is a cylinder of diameter 24 cm and height 11.6cm which serves as the receiving unit for the slurry ogi and water mixture to be sieved. At the commencement of the sieving operation, the ogi and water mixture flows from the slurry container into an outlet below leading into a valve which is linked to a conduit 18cm long and 24cm in diameter and finally ends up in the mixing unit.

The mixing unit which is a cylinder of diameter 24cm and height 24.3cm serves as compartment where water from an external source flows through a sprinkler (20mm diameter) and mixes with the ogi for ease of sieving as it enters into the sieving unit. The introduction of water is to continuously wash the slurry ogi mixture in the sieving unit thereby preventing quick clogging of the sieving membrane.

The sieving process takes place in the sieving unit with the aid of the suction pump. (shown in Fig. 2) which when switched on creates suction pressure needed for the sieving operation. The sieved ogi filtrate is deposited in the ogi reservoir while the filtrate cake remains as residue on the surface of the sieving membrane. There is the possibility of dismantling the sieving unit and removing the filtrate cake while the filtered ogi is allowed to settle down in the ogi reservoir which has a volume of 0.0124 m^3.

The tripod stand prevents the ogi sieving machine from touching the ground thereby preventing the rusting of the filtrate unit.

3. DESIGN ANALYSIS

3.1 Power Required for Sieving Operation

The pressure generated in the sieving unit of the ogi sieving machine is calculated based on the design principle that the sieving unit is not full of ogi mixture during the sieving operation. Atmospheric pressure therefore is active on the surface of the ogi mixture while sieving process is going on. Hence the pressure (P_o) generated due to the ogi mixture at a height (h) above the sieve cloth and wire gauze under atmospheric pressure (P_{atm}) is determined from the Eqn. (1) (Douglas et. al. 1979).

$$P_o = \rho g h + P_{atm} \qquad (1)$$

where:

ρ = density of ogi mixture

Hence the power (P_{min}) required to carry out the sieving operation is determined using Eqn. (2)

$$P_{min} = P_o Q \qquad ...(2)$$

Where Q is the normal flow rate of ogi slurry in the sieving unit with the use of suction pump. Shown in Table 1 is the result obtained from the experiment conducted to find the flow rate of the Ogi mixture with the use of the suction pump.

3.2 Maximum Deflection of Sieving Gauze

The maximum deflection of the wire gauze which supports the sieving cloth under the weight of the ogi mixture thereby preventing it from sagging must be determined so that it can withstand the continual pressure of the ogi mixture during sieving operation. The maximum deflection (W_r) is obtained from Eqns. (3) and (4).

$$W_r = P_r\ (r_4)/ 64\ D_o \qquad ...(3)$$

where

$$D_o = Et^3/12(1-v^2) \qquad ...(4)$$

r = radius of sieving gauze
D_o = flexural rigidity
E = modulus of elasticity of sieve gauze
t = thickness of sieve gauze
v = poison ration

Fig. 1: Exploded Isometric View of the Ogi Sieving Machine

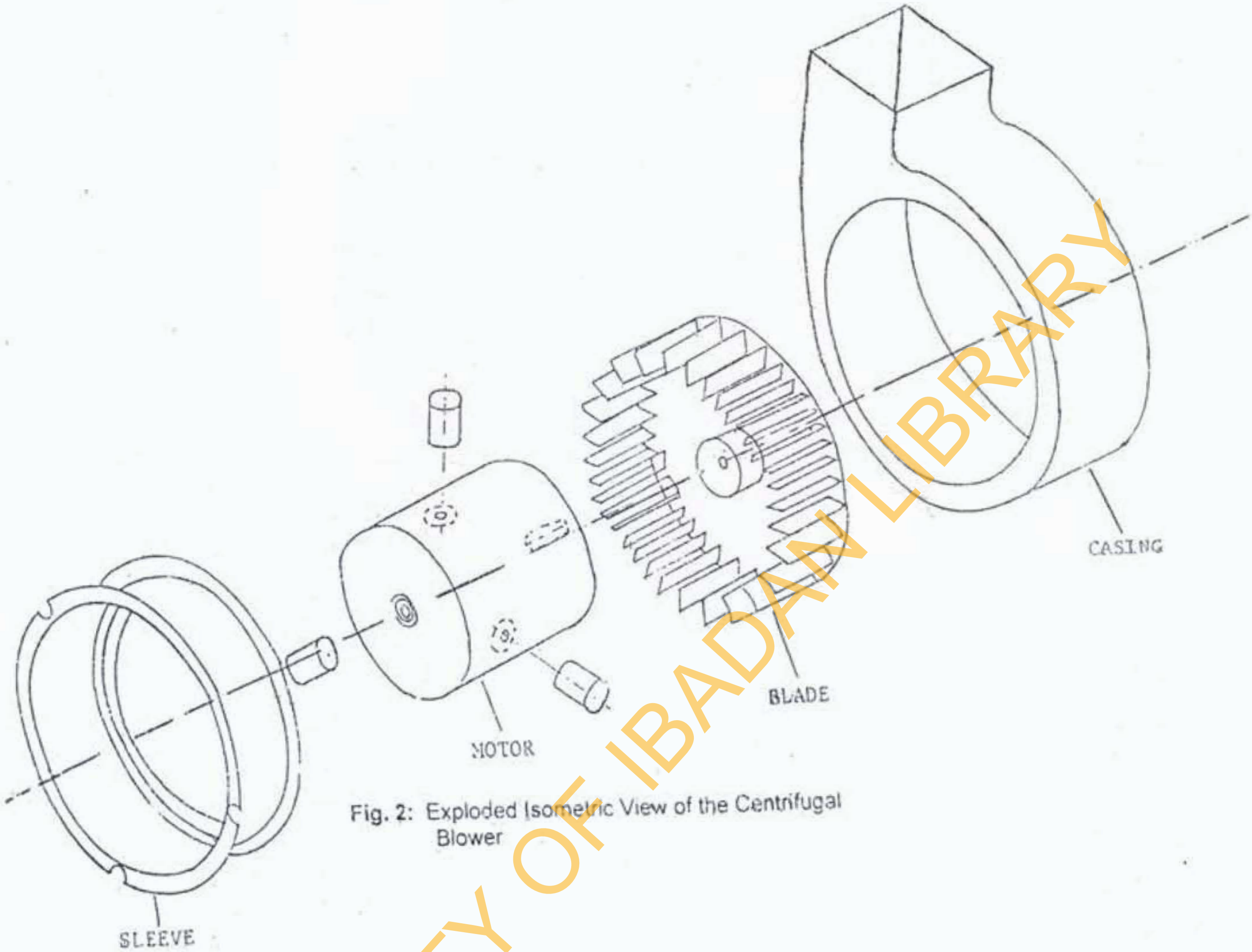

Fig. 2: Exploded Isometric View of the Centrifugal Blower

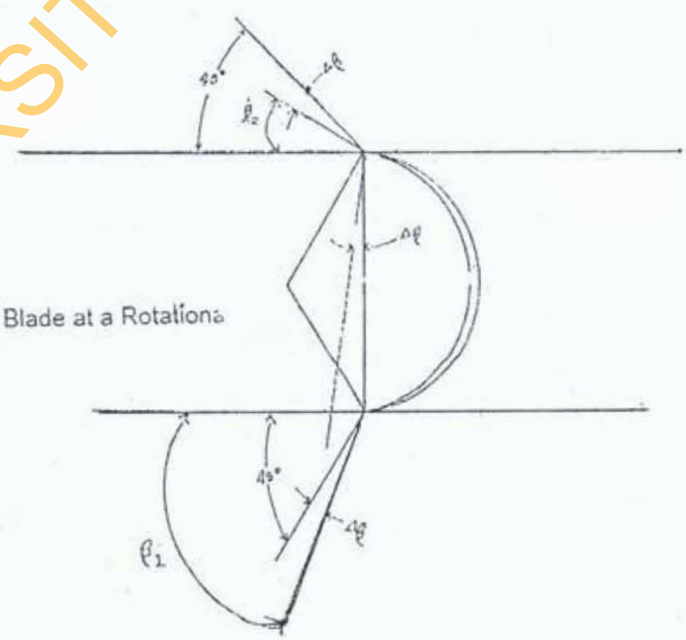

Fig. 3: Geometry of Impeller Blade at a Rotational Angle (Δβ)

The calculated deflection of the wire gauze is within the limit for maximum allowable elongation of the gauze material (galvanized steel) and therefore can withstand the suction pressure built inside the machine as well as the weight of the ogi mixture during sieving operation.

3.3 Design of Impeller Blades and Casing

The circular arc geometry is chosen for the impeller blades as profile. The advantages of its ease of construction and analysis are placed above the short-coming of average efficiency at this initial stage of design. Inner and outer sleeve diameters (d_1 and d_2 respectively) are chosen for the impeller and the values for the blade number (z), and the blade rotational angle ($\nabla\beta$) are both obtained from design tables for centrifugal blowers (Eck, 1972) based on the ration d_1/d_2. The blade inlet and outlet angles ($\beta 1$ and $\beta 2$ respectively) for the impeller are then obtained by considering are geometry of the blade. Fig. 3 shows a magnified portion of a blade arc geometry arranged along the circle base profile of the blower.

In the design of the blower casing profile the volute shape with parallel walls is employed, and the casing profile is described by the equation of a logarithmic spiral given in Eqns. (5) and (6).

$$Ln\,(r/r_o) = \phi \tan(\alpha_o) \quad \ldots(5)$$

where:

$$\tan(\alpha_o) = v_{of2}/v_{ow2} \quad \ldots(6)$$

In Fig. 4 which shows the contact point (o) between the base circle and the spiral casing profile.

- r = radius of curvature of spiral profile of casing
- r_o = radius of curvature of spiral profile at base circle
- α = air flow angle
- ϕ = angle measured along casing profile
- v_{of2} = airflow velocity at impeller outlet at point (o)
- v_{ow2} = impeller outlet whirl velocity at point (0)

In order to plot the outline of the casing, eqns. (5) and (6) are used (knowing the values of r_o, ϕ and α_o r is obtained). Eqn. (7) is used to plot the final outline of profile from $\phi = 5^0$ at intervals of 5^0 to the point $\phi = 290^0$ where the outlet arm connects and completes this casing profile.

$$R = r/\cos\alpha \quad \ldots(7)$$

3.4 Head Developed by Centrifugal Blower

The one-dimensional streamline theory is used in the determination of the actual head developed in the centrifugal blower. The theoretical head (H_{th}) is given by Eulers equation as:

$$H_{th} = (1/g)\,[U_2 V_{w2} - U_1 V_{w1}] \quad \ldots(8)$$

while the actual head is given as SF (H_{th}) ...(9)

where
- SF = slip factor
- V_{w1} = Velocity of whirl at inlet of impeller (value = 0 for design considered)
- V_{w2} = Velocity of whirl at outlet of impeller
- U_1 = tangential velocity at impeller's inlet
- U_2 = tangential velocity at impeller's outlet
- g = acceleration due to gravity

The values of U_2 and V_{w2} are calculated geometrically from the velocity diagram (Fig. 5) which is based on the calculated values of β_2 obtained in section 3.3. From Fig. 5.

- V_1 - absolute velocity of air at inlet to blade
- V_2 - absolute velocity of air at outlet to blade
- V_{r1}, V_{r2} - relative velocities at inlet and outlet to blade respectively
- V_f - air flow velocity

The slip factor (SF) which is adequate for this impeller design is based on the Stanitz relaxation method which is given as:

$$SF = 1 - [\{(0.63\pi)/Z\}\{1(V_f/U_2)\cot\beta_2\}] \quad \ldots(10)$$

where Z is the number of blades in the impeller, β_2 is the blade outlet angle and v_f is velocity of airflow.

4. MACHINE PERFORMANCE

Performance tests of the ogi sieving machine were carried out under two conditions namely:

(a) when suction pump was connected to machine
(b) when suction pump was not connected to machine (manual sieving)

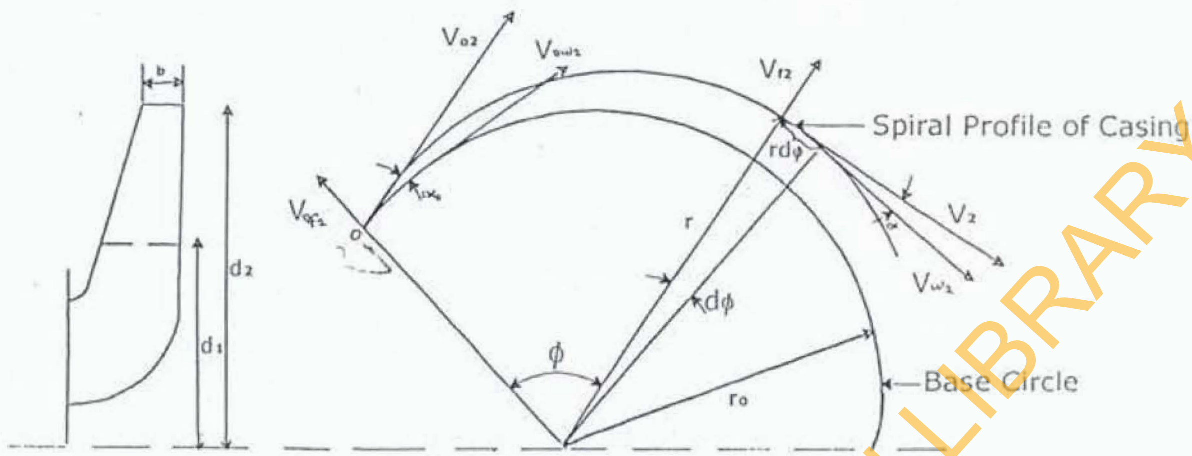

Fig. 4: Blower Spiral Profile with Parallel Side Walls

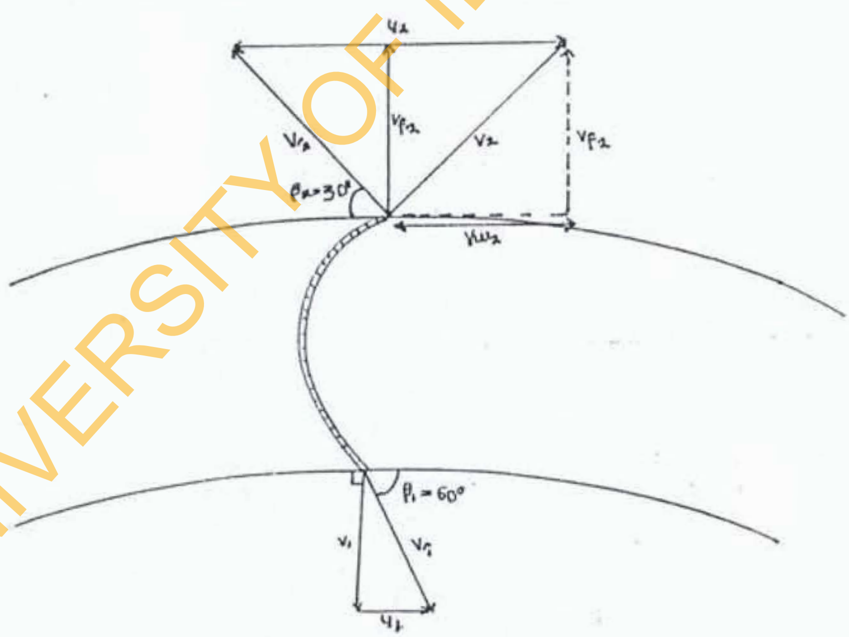

Fig. 5: Air Flow Velocity Diagram for Impeller Blade with Arc Geometry

The performance test procedure for the first condition (with the use of the pump) is as described in section 2.2. while for the second condition, the ogi mixture and sprinkled water were simply allowed to pass through the sieve cloth under natural gravitational force. Both tests as described were conducted four times each and the sieving flow rates were determined by taking the time it takes different volumes of ogi mixture to pass through the sieve unit. Presented in Table (1) are the results of the performance tests for the two experimental conditions.

The results presented in Table 1 show that the average flow rate of ogi using the designed machine (11.1×10^{-5} m^{-3}/s) is 368% faster than the flow rate of ogi (3.02×10^{-5} m^{-3}/s) using the manual sieving process.

Table 1: Performance Results of the Ogi Sieving Machine

Type of Sieving	Volume (m^3)	Time (s)	Flow Rate (m^3/s)
Manual Sieving	4.52×10^{-3}	149	3.03×10^{-5}
	4.34×10^{-3}	145	2.99×10^{-5}
	4.52×10^{-3}	146	3.10×10^{-5}
	4.34×10^{-3}	146	2.90×10^{-5}
			Average = 3.02×10^{-5} m^{-3}/S
Pump Assisted Sieving	9.52×10^{-3}	82	11.6×10^{-5}
	9.34×10^{-3}	85	11.0×10^{-5}
	9.52×10^{-3}	87	10.9×10^{-5}
	9.34×10^{-3}	84	11.0×10^{-5}
			Average = 11.1×10^{-5} m^{-3}/s

CONCLUSION

Over the years, the manual process of sieving ogi (ground soaked corn in slurry form) has always been slow, tedious, boring, time consuming and in some cases unhygienic. The possibility of mechanizing the sieving process of ogi using a process similar to that of solid-liquid separation (Svarovsky, 1977), has been surveyed and three design stages of the ogi sieving machine presented.

Results have shown that by the mechanization of the ogi sieving process, there is about 368% improvement over the manual process of sieving Ogi. A pressure of 106.34KN/m² which acts on the sieving surface is generated in the sieving unit of the machine while the volute centrifugal pump with parallel walls used as the suction unit of the ogi sieving machine has a developed actual head of 11.54m. Also, results obtained so far show that the pressure drop produced by the suction pump could be further increased thereby improving the performance of the ogi sieving machine.

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