International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 03 | March - 2023 Impact Factor: 7.185 ISSN: 2582-3930

DESIGN AND FABRICATION OF A HIGH-YIELD EDIBLE OIL EXPELLER SCREW SHAFT

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ABSTRACT:

This project focuses on the design, construction, and performance testing of a mechanical oil expeller press for extracting oil from various raw materials including coconut, mustard seed, sesame, and groundnuts. The expeller was also subject to structural analysis using simulation software to ensure its safety and efficiency. Unlike chemical and centrifuge processes, which rely on solvents or high-speed spinning to extract oil, the mechanical expeller press uses a screw to apply pressure to the raw material, forcing the oil out. The screw shaft was designed using the ASME shaft design code and manufactured using locally available mild steel. The machine was powered by a 1 hp electric motor, and the screw rotated at a speed of 140 rpm. Raw materials were fed into the machine through a hopper and compressed inside the barrel for oil extraction. The cake, or residual material, was discharged outside the machine using a choke mechanism. The pressure on the screw was analyzed using simulation software and found to be within safe limits, ensuring the machine's durability and reliability. Overall, this project provides a viable solution for small-scale oil extraction using a mechanical expeller press that is safe, efficient, and cost-effective.

KEYWORDS: Seeds, Oil Expeller Shaft Design, Oil Extraction, Fabrication, Efficiency.

1.Introduction:

The extraction of oil from various sources involves specific processes to ensure the oil extracted is of high quality and purity. Mechanical and chemical extraction are the two main methods of extracting oil. The mechanical extraction method involves the use of an oil expeller or screw press to exert sufficient pressure on the seed to extract the oil. This method is relatively inexpensive and suitable for low production. However, it has a low oil recovery rate when processing untreated seeds. The extracted oil can be used for both food and industrial purposes.

The solvent extraction method is another efficient method of extracting oil, but it is not suitable for small-scale production due to its high cost of equipment and plant. Furthermore, the commercially available solvent used in this method can react with air to yield an explosive mixture.

In this research, the focus is on the screw press extraction method, which involves confining the seed in a barrel and exerting sufficient force to rupture the cells and force the oil out. The extracted oil is used as a food or industrial product. The residue of the material from which oil has been expressed is known as the cake. The worm shaft is a crucial component of the screw press, which supplies the pressure required to extract oil from the raw materials. Failure of the screw press can result in extra costs and major overhaul of the press. Therefore, it is essential to analyze the stress and bending of the screw blades to increase the life of the screw press and ensure efficient oil extraction.

In conclusion, the extraction of oil from various sources involves specific processes to ensure the extracted oil is of high quality and purity. Mechanical and chemical extraction are the two main methods of extracting oil. The focus of this research is on the screw press extraction method, and stress and displacement analysis of the installed worm shaft to increase the life of the screw press and ensure efficient oil extraction.

2. Material and Method:

The construction of the oil expeller utilized locally available materials such as mild steel. The design of the oil expeller was established first, and the stress calculations were validated before proceeding to construction. To facilitate the passage of oil and generate pressure inside the barrel, rectangular bars were installed around the oil extraction barrel. A choke mechanism was incorporated into the screw at the outlet of the extraction barrel, and it was calibrated to regulate the output of waste and adjust pressure levels accordingly. A reducing gear was also integrated to decrease the motor's rpm and increase the energy in the screw shaft..

Fig 1 : Design of tapered screw shaft in Solid Edge

3. Design Structural Analysis and Construction

3.1 Design

3.1.1 Design Criteria

i. Achieving maximum oil extraction efficiency is one of the main goals of the oil expeller design. This can be achieved by optimizing the pressure, temperature, and speed of the machine to ensure that the maximum amount of oil is extracted from the raw materials.

ii. The extraction loss refers to the amount of oil that is left in the cake after the pressing process is completed. Minimizing extraction loss is important for increasing the overall efficiency of the process, as well as ensuring that the maximum amount of oil is extracted.

iii. The quality of the oil produced is also an important factor. By using the right combination of pressure, temperature, and speed, it is possible to produce oil with better flavor, color, and nutritional value.

iv. Availability of construction materials is another important consideration in the design of an oil expeller. It is important to use materials that are readily available and affordable in the local market to keep the cost of construction low.

v. To ensure maximum pressing of the worm shaft, it is important to carefully design and manufacture the screw and barrel. The design should ensure that the pressure is evenly distributed along the length of the screw and that the raw materials are compressed uniformly to achieve maximum oil extraction efficiency.

3.1.2 Findings

To Increase Pressure:

Decreasing the distance between the screw flights in the direction of the axial movement can help increase the pressure.

Oil Release Mechanism:

As pressure increases inside the barrel, the oil is gradually released from the raw material.

The released oil flows out of the press through slots on the periphery of the barrel.

Meanwhile, the remaining press cake continues to move in the direction of the shaft towards a discharge gate located at the other end of the machine.

4.0 Design, structural Analysis and construction

4.1 Pressure lifted by screw thread

$A_p = \pi D_m n h$

Here,

A_p = Pressing Area

h = screw depth at maximum pressure or at discharging end

D_m =Mean Thread Diameter

$A_p = \pi D_m n h$

$=\pi$*(0.22)*12*0.85

$A_p = 7.049 N/m^2$

4.2 Load Lifted by Screw

$$W_e = \frac{\frac{D_m}{2}\tan\theta + \frac{\mu}{\cos\alpha}}{1 - \mu\tan\theta\cos\alpha}$$

Here,

D_m=Mean Thread Diameter

μ =Coefficient of Friction

α =Tapering Agle

θ =Tapering Angle

$$W_e = \frac{\frac{0.22}{2}\tan 3 + \frac{15}{\cos 15}}{1 - 15\tan 3\cos 15}$$

$$W_e = \frac{15.639}{0.2406}$$

$$W_e = 65.16 KN$$

4.3 Diameter of the Screw Shaft

$$D^3 = \frac{16\sqrt{(k_b * M_b)^2 + (k_t * M_t)^2}}{\pi * S_s}$$

D = Shaft Diameter

M_b = Bending Load

M_t = Torsional Load

$k_t = Combined\ Shock\ and\ Fatigue\ Factor$

$Applied\ to\ Bending\ Moment$

$k_b = Combined\ Shock\ and\ Fatigue\ Factor$

$applied\ to\ Torsional\ Moment$

S_s=Allowable Shear Stress in Shaft

The Value of k_b&k_t for Rotating Shaft if applied to minor shock

k_b=1.5~2

k_t = 1.0~1.5

f_s =Factor of Safety

= 1.15 (Maximum factor of safety for mild steel)

Load = 60

τ = 60*9.81=588.6N

$$M_b = \frac{\pi}{16} * 19.5^3 * 588.6 = \frac{\pi}{16} D^3(\tau)$$

= 856947.0378

$$D^3 = \frac{16\sqrt{(k_b * M_b)^2 + (k_t * M_t)^2}}{\pi * S_s}$$

$$19.5^3 = \frac{16\sqrt{(1.5 * 856947.0378)^2 + (1.5 * 588.6)^2}}{\pi S_s}$$

$$19.5^3 * \pi * S_s = 20566733.57$$

$$S_s = \frac{20566733.57}{23294.51683}$$

$$S_s = 882.9002002$$

$$\text{Permissible shear stress } (\tau) = \frac{0.5 * S_s}{f_s}$$

$$\tau = \frac{0.5 * 882.9002002}{1.15}$$

$$\tau = 383.8696 N/Mpa$$

5. OPERTIONS ON SHAFT:

5.1 Drilling:

Drilling is the process of creating holes in a solid material using a rotating cutting tool. The process starts with creating an indentation on the surface of the material, which then serves as a guide for the drill bit. Drilling can be used to create through-holes or blind holes.

5.2 Taper turning:

Taper turning is a machining operation that involves gradually reducing the diameter of a cylindrical workpiece from one end to another. This creates a conical shape and can be either internal or external. Taper turning is often used in creating fittings or components that need to fit together precisely.

5.3 Step turning:

Step turning is a machining process that creates a stepped feature on the surface of a cylindrical workpiece. This involves turning two surfaces with different diameters separated by a flat surface, which creates the appearance of a step. Step turning is often

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 03 | March - 2023 Impact Factor: 7.185 ISSN: 2582-3930

used in creating shafts or components that require a shoulder to stop against another component.

5.4 Thread cutting:

Thread cutting is a process in which a helical ridge of uniform section is created on the surface of a cylindrical workpiece. This is done by taking successive cuts with a threading tool bit that matches the required thread form. Thread cutting is often used in creating fasteners, screws, and bolts.

5.5 Grooving:

Grooving is a turning operation that creates a narrow cut, or groove, in the surface of a cylindrical workpiece. The width of the groove is determined by the width of the cutting tool, and multiple passes may be necessary to machine wider grooves. Grooving can be done on the external or internal surface of a workpiece and is often used in creating O-ring grooves, snap ring grooves, and other similar features.

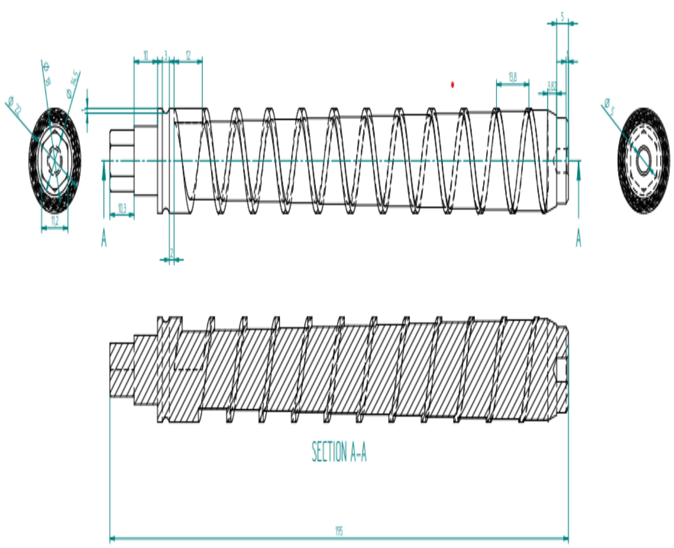

Fig 2 : Sectional Diagram of tapered screw shaft

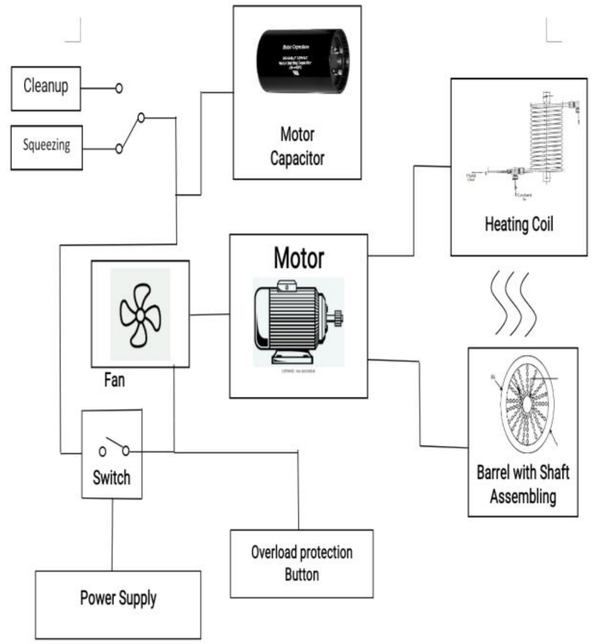

Fig 3: Block diagram of oil extraction machine

6. <u>G – codes & M – codes to Manufacture the modified shaft on CNC machine :</u>

O0238;

G00 T0 X0.0 Z -400;

T0808;

G00 Z0.0;

M00;

G00 Z10.0;

N1 G00 T0 X0.0 Z -400.0;

T0101;

G97 S800 M03;

G00 X67.0 Z10.0;

G00 Z0.0;

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G01 X24.0 F0.2 M07;
G00 Z1.0;
G00 X54.0;
G01 Z7.0 F3.0;
G01 X62.5 Z -3.0 F0.2;
G00 X65.0;
G00 Z10.0 M09;
M97 M05;
N2 G00 TO X0.0 Z -400.0;
T0404;
G97 S800 M03;
G00 X29.0 Z10.0;
G00 Z1.0;
M07;
G71 U0.5 R0.5;
G71 P30 Q40 U0.0 F0.15;
N30 G01 X37.5;
G01 Z0.0;
G01 X35.0 Z -2.5;
G01 Z-22.0;
N40 G01 X29.0;
G00 Z10.0 M0.9;
G97 M05;
N3 G00 T0 X0.0 Z -400.0;
T0606;
G97 S300 M04;
G00 X33.0 Z10.0;
G00 Z3.0;
MO7;
G76 P020060 Q25 R0
G76 X37.0 Z =23.0 Q20 P1200;
G00 Z10.0 M09;
G97 M05;
G00 T0 X0.0 Z -400.0;
M30;
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6.1 Merits of Modified shaft

1. More oil can be obtained

2. Crushing strength of the screw shaft is high.

3. The space between the shaft and barrel is less so that less vibration has occurred.

4. The space between the screw shaft and barrel is less so that the crushing load of seed is high.

6.2 Demerits of Modified shaft

1. Time consumption is high compared to old shafts.

2. As time consumption is high, power consumption is also high.

7. Conclusion, Result and Recommendations:

Sl.No	Type of Seed	Oil extracted from old shaft with 500gm of seeds.	Oil extracted from modified shaft with 500gm of seeds.
1.	Ground nut	212 grams	257.5grams
2.	Mustard	217.5grams	261.2grams
3.	Sesame	207.8grams	251.5grams
4.	Coconut	198.3grams	233.7grams

Based on the given information, it has been observed that the extracted oil varies with respect to the feed of raw materials and increases almost proportionally with time. The constructed expeller was tested for four different raw materials, namely coconut, groundnut, sesame, and mustard seed, and the oil extraction efficiency varied for each material. The machine's performance was evaluated based on oil expected ratio, oil extracted efficiency, material discharge efficiency (MDE), and machine capacity (MCP).

The stress analysis was performed to determine the perfect clearance between the screw and barrel of the machine, and the safe functioning of the screw was verified by applying pressure on the thread. To enhance the machine's efficiency, it is recommended to cut an inner groove on the bars for easier extraction of oil from smaller seeds such as mustard and sesame. It is important to note that this machine is suitable only for small-scale production and may incur undesirable costs in case of screw failure due to excessive stress and bending deformation. Any failure of parts can also pose a safety hazard, and vibration can cause damage and noise. Therefore, it is recommended to use materials other than steel for constructing the screw, as steel may not be readily available.

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