IMPROVEMENT OF OIL EXTRACTION PROCESS USING ULTRASONIC TECHNIQUE AS A SECOND-GENERATION BIOFUEL SOURCE

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ABSTRACT

The aim of this study was to optimize machine efficiency and the energy content of safflower oil by the ultrasonic technique. The developed machine has an improved effective technique using ultrasonic transmitter system that provide different frequency levels with a regulated power supply. Ultrasonic transmitter system can be described starting from a regulated power supply circuit where a transformer is used to step-down the voltage from 230 to 12 VAC while the voltage is rectified using the full wave bridge rectifier where the rectifier converts the sine waves into a series of positive peaks.

The rectified AC voltage is then smoothed or filtered by a capacitor C1, C2 and C3. Finally, the voltage is passed through a regulator LM7809 to create a fixed 9VDC output with less ripple in the voltage. Circuit of the ultrasonic transmitter runs by using a 9VDC regulated power supply. Design of the ultrasonic generator is essentially built a SA555 stable oscillator. This oscillator generates a frequency from 10 to 70 kHz which is used by the transmitting transducer to generate the ultrasonic wave. The performance of the developed machine was studied under four levels of ultrasonic frequency (20, 30, 40 and 50 kHz) and four different feed rates (125, 145, 160, and 170 kg.h^{-1}) and estimate of its effect on the oil yield, machine efficiency and the energy content of safflower oil.

The extracted oil was subjected to determine properties of them like: the specific gravity, viscosity, heating value, flash point, carbon residue, and sulphur content. The ultrasonic assisted extraction improves the oil yield by 29.33, % and the highest energy content value was achieved 2034 MJ.h^{-1} measured at frequency level of 40 kHz and feed rate of 160 kg.h^{-1}.

This will be useful to the extraction machine to recover higher amount of the oil yield from same amount of the safflower seeds throughout the operational period. Also, the oil extraction machine has been developed with a machine efficiency of 94.60% as well as decreasing energy consumption by 22.94%.

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1.INTRODUCTION

Today different vegetable oils special, the less common and unconventional ones used as a source of biodiesel because it considers as approach for combustion engines and it is essential to exploit new oil resources to meet the increasing in market demands. On the other hand, the global problem of greenhouse gas emissions became bigger and the world give significant concerned to renewable sources.

Recently, the safflower (Carthamus tinctorius L.) is considered as an important oilseed crop, whereas the oil content reached to 92-93 % so it used as a source of oil. Safflower is cultivated in many places in the world because its adaptability to diverse environmental conditions as drought resistance, salt tolerance and no problems to the safflower crop if the temperature reached to 43℃ **Baümler et al., (2006) and Mihaela et al., (2013)**.

The oil percentage in safflower seeds can be 43 ± 3.6% dry basis and be 37% related to hull contents in additional the moisture percentage be approximately 6.9%. Additionally, it was noticed that the variation in moisture percentage in seed lead to a little difference in seed size, volume, thickness, sphericity and weight, the increase in these physical properties be linearly with moisture % rise recorded by **Baümler et al., (2006)**.

The oil can be harvested from oilseeds by mechanical or solvent methods. The oil extracts mechanically via forced out of liquid meaning separate liquid from a liquid-solid substrate, the mechanical method is the most familiar and oldest method in the world according to **Pradhan et al., (2011) and Savoire et al., (2013)**.

The mechanical method prefers compared to solve one because different reasons as it is simpler, safer, more economy and its product is also a chemical-free product in additional this way take up only a few minutes from starting the process operation confirmed by **Pradhan al., (2011)**.This is in agreement with **Chapuis et al., (2014)** opinion, who reported that the screw press method is preferred because its high oil production (oil recovery of up to 90–95%), flexible and its high capacity which can be reached to 45 kg per hour so be good proposal for biofuel production under small-scale.

With similar trend, **Chemat et al., (2017a) and Jacotet-Navarro et al., (2016)** noted that the using green processes, extract oil from plants without an organic solvent, have many advantages compared to the chemical method as it is more attractive, need less time and energy, its product is pure, easier heat and mass transfer and Last but not least fast in extraction rate.

Recently most countries use chemical or physical methods in order to increase the crude oil production (Enhanced Oil Recovery). The physical way can be done hydro fracturing or electromagnetic and wave treatment. According to, **Dyblenko et al., (2000) and Kuznetsov et al., (2001),** the ultrasonic oil production technique is a most promising wave method, whereas, the ultrasound effect on the well which lead to improve the production is based on two aspects (1) improve the flow of oil through seeds (2) the oil viscosity reduction which make oil movement easier.

Another recent studies **Zhang et al., (2013) and Wang and Suman (2015)** noted that the ultrasonic technique is easy to create sound wave immediately in oil reservoir in order to improve the oil production. Also, using ultrasonic technique in oil production has many advantages as its no pollution to environment, low cost, strong adaptability and easy to operate. Therefore, the ultrasonic oil production technique is preferred way compared to conventional chemical method because it is appropriate and easier.

Thomas et al., (2015) and Tiwari (2015) found that ultrasonic assisted extraction (UAE) was applied uses high frequency (20–50 kHz) sound waves to make mini pores at plant cell wall as well causes high strength thermal and mechanical effects, leading to breaks plant wall. With similar trend, **Xu et al., (2018)** reported that the mechanical vibration effect which can be generated by ultrasound could amends the inhomogeneous heating of by microwave pretreatment.

The operating parameters effect on process performance, machine capacity and oil yield. Fundamentally the screw rotation speed and the diminution between the cage and screw. The speed increasing lead to rise in temperature and decrease in pressure. On other hand increasing the material throughput increase the recovery of oil on other words seed throughput is symmetric to screw speed. Thence optimize the parameters have taken place to improve the pressure and capacity as proposed by **savoire et al., (2013)**.

The present work focuses on extract safflower oil form seeds and improve it by using ultrasonic technique and providing experimental parameters in order to used it as a second-generation biofuel source

2.MATERIAL AND METHODS

The experiments were carried out to improve and evaluate the performance of the extraction machine to be suitable for extracting safflower oil which can be used in many different applications particularly as a biofuel. This development relates generally to processing safflower seeds by using ultrasonic waves and regards more particularly to a technique of using ultrasonic vibrations to develop the performance of largely extraction machine with the aim of increasing oil yield and ratio low losses as well a high extraction efficiency by using ultrasonic transmitter-assisted extraction.

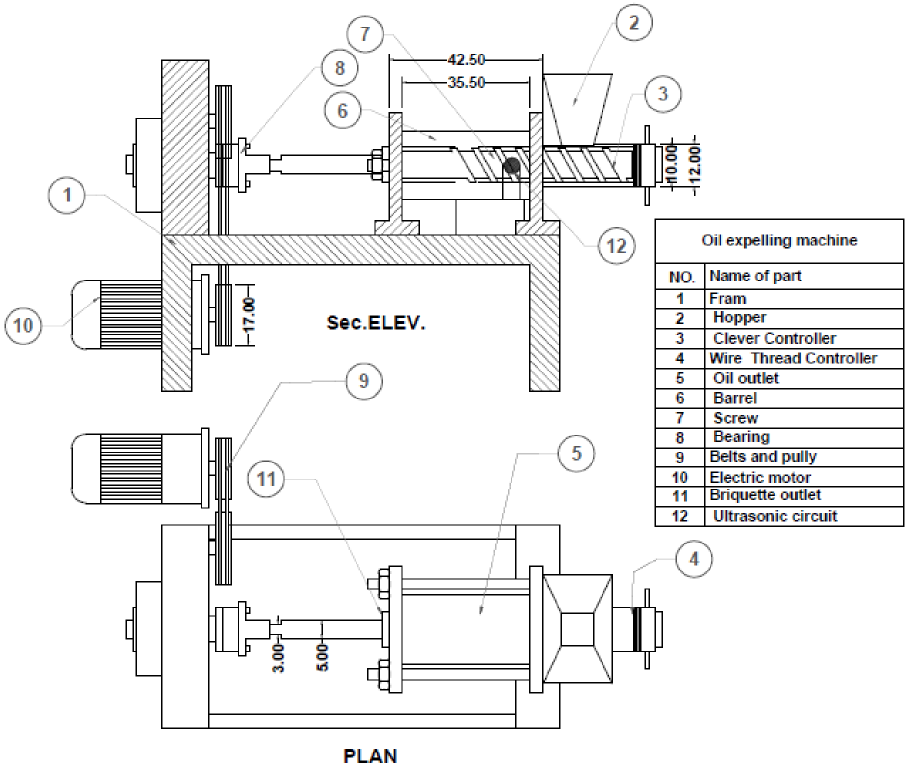
A series of experiments were performed and different parameters were studied on a pilot-scale screw press. For each experiment the machine productivity, extraction efficiency and the specific energy consumption were measured with respect to ultrasonic frequency and feed rate.

The used safflower seeds

For this study, dried safflower (Carthamus tinctorius L.) seeds were used from Research Institute of Oil Crops, Agriculture Research Centre, Egypt. Seeds were harvested manually during July–August and stored in jute bags at temperatures between 15 and 25◦C. After transport the seeds were cleaned manually to remove impurities and then stored at room temperature at a range of 18–22 ◦C, reaching a moisture content of 8.3% and oil content of about 37%. The moisture content of seeds was not altered.

Description and operation of developed machine

The screw press machine was developed using ultrasonic transmitter system to improve oil yield and extraction efficiency. The machine was manufactured specially for this work from low cost -local material to overcome the problems of high power and high cost requirements under the use of the imported machines. The construction was done at a private workshop in Sharkia Governorate. The machine consists mainly of feeding hopper, worm shaft, ultrasonic transmitter, regulated power supply, cylindrical barrel, cake outlet, oil drainage, power source, transmission system, main frame (Fig.1).



Oil expelling machine	
NO.	Name of part
1	Fram
2	Hopper
3	Clever Controller
4	Wire Thread Controller
5	Oil outlet
6	Barrel
7	Screw
8	Bearing
9	Belts and pully
10	Electric motor
11	Briquette outlet
12	Ultrasonic circuit

Fig. 1: The Development of the safflower oil expelling machine

The cylindrical barrel was made from a mild steel of length 420 mm, inner diameter of 165 mm and thickness of 10 mm. The worm shaft was also made from a mild steel as solid rod of diameter 80 mm and length 850 mm which was machine on their lathe at a decreasing screw pitch and diminishing screw depth. The worm shaft is settled in the barrel at a clearance of 1.5 mm between the screw diameter and inside diameter of the cylindrical barrel.

The safflower seeds are introduced into the machine through a feeding hopper; the machine transfer the seeds inside the cylindrical barrel by means of the worm shaft until crude oil is pressed out of the cake supported by the ultrasonic frequency effect. The crude oil extracted is drained through the oil channels into the oil tray where it is collected while the residual cake is discharged at the cake outlet and collected at the cake plate.

A power screw is used in the machinery to switch a rotary motion into a linear motion for power transport. Power screws normally must be designed for the smooth and noiseless conveyance of power and the ability to carry dense loads with high efficiency. Through this modification, safflower seeds entering the hopper are subjected to gradually increasing pressure as they move toward the exit end of the press under the effect of ultrasound waves, and the crude oil is extruded through a screen drilled on the vessel. The electric motor of the machine was selected based on the load characteristics of the machine, is a three-phase 50 Hz motor for continuous-duty operation with a power rating of 7.35kW.

Design Considerations Power Supply Circuit:

In most of the electronic studies or researches is needed a power supply for converting mains AC voltage to a regulated DC voltage. A power supply is an electrical device that supplies electric power to the electrical load. The main function of a power supply is to convert electric current from the main source to the correct voltage, current, and frequency to power the specified load. Therefore, power supply is referred to as electric power converters.

Design appropriate of a power supply can be the critical difference between a device working at optimum levels and one that may deliver inconsistent results. DC power supply is one that supplies a constant DC voltage to its load depending on its design.

In this design, a step-down transformer is used to step down the voltage from the input AC to the required voltage of the electronic device. This output voltage of the transformer is customized by changing the turn's ratio of the transformer according to the electronic device specs. The input of the transformer being 230 Volts AC mains, the output is provided to a full bridge rectifier circuit.

A full wave rectifier is used to convert the transformer output voltage to a varying DC voltage, which in turn is passed through an electronic filter to convert it to an unregulated DC voltage. Hence, it is finally passed towards the regulator circuit to create a fixed DC output with less ripple. Fig. 2 is presented block diagram of the ultrasonic transmitter system supporting by a regulated power supply.

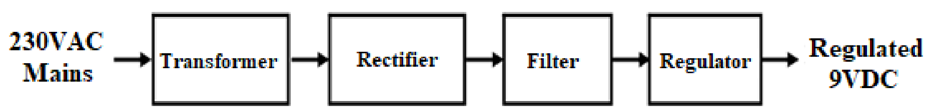


Fig. 2: Block diagram of a regulated power supply

A regulated DC power supply is essentially an unregulated power supply with the addition of a voltage regulator. This allows the voltage to stay stable regardless of the amount of current consumed by the load, provided the predefined limit is not exceeded. Main components of a regulated power supply to convert 230VAC voltage to 9VDC are shown in Fig. 3.

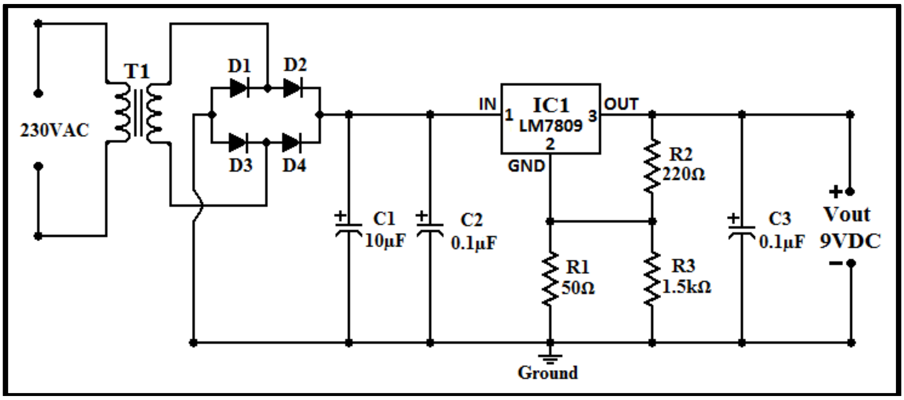


Fig. 3: Schematic diagram of a regulated power supply circuit

<u>A step-down transformer</u>

Selecting an appropriate transformer is a great importance, as well as, the secondary voltage and the current rating of the used transformer is a critical factor of power supply circuit. The current rating of the transformer depends on the current required for the load to be driven in the ultrasonic frequency circuit. The input voltage to the used 7809 IC should be at least 2V greater than the required voltage output, therefore it needs an input voltage at least of 11V. Therefore, can be chosen a 12-0-12 transformer with a current rating 500mA, the increase voltage of the transformer as a spare for what may happen from power dissipation across other circuit elements.

<u>The Full Wave Bridge Rectifier</u>

Power Diodes can be connected together to form a full wave rectifier that convert AC voltage into pulsating DC voltage for use in power supply circuit. This type of single-phase rectifier uses four individual rectifying diodes connected in a closed loop "bridge Rectifier" configuration to produce the desired voltage output. In the circuit diagram, 4 diodes are arranged in the form of a bridge.

The Smoothing Capacitor

It can be improved the average DC output of the bridge rectifier and at the same time reducing the AC variation of the rectified output by using smoothing capacitors to filter the output waveform. Smoothing capacitor connected in parallel with the load across the output of the full wave bridge rectifier circuit increases the average DC output level which converts the full-wave rippled output of the rectifier into a smoother DC output voltage.

Voltage regulating circuit

A regulated power supply essentially consists of an ordinary power supply and a voltage regulating device LM7809, as illustrated in the circuit diagram of power supply. The output from an ordinary power supply is fed to the voltage regulating device that provides the final output. The output voltage remains constant irrespective of variations in the ac input voltage or variations in output or load current.

The basic circuit required for 7809 IC to work as a complete regulator is very simple using two capacitors depending on the design. The 7809 IC circuit shows all the components required for a 7809 IC to work properly. The 0.1µF Capacitor near the input is required between the regulator IC and the power supply filter. In this circuit, VIN is the input voltage to the 7809 IC and VOUT is the output of the 7809 IC, which is regulated a 9VDC. Table 1 shows the details of IC 7805 voltage regulator

Table 1: Details of IC 7805 voltage regulator

Pin No.	Pin	Function	Description
1	INPUT	Input voltage (7V-35V)	In this pin of the IC positive unregulated voltage is given in regulation.
2	GROUND	Ground (0V)	In this pin where the ground is given. This pin is neutral for equally the input and output.
3	OUTPUT	Regulated output; 9V (8.65V-9.35V)	The output of the regulated 9V volt is taken out at this pin of the IC regulator.

The peak value of current, I_{max} flowing through the load resistance is given as follows:

$$\boldsymbol{I_{max}} = \frac{\boldsymbol{V_{max}}}{(\boldsymbol{2R_F} + \boldsymbol{R_L})} = \frac{\mathbf{50}}{(\mathbf{85}+\mathbf{50})} = \mathbf{0.370}\boldsymbol{A}$$

Where: V_{max} = Maximum voltage of step-down transformer.

R_F = Resistance of rectifier diode and R_L = The load resistance.

The current flowing is the same through the load RL in the two halves of the ac cycle. Magnitude of the output current, I_{dc} which is equal to the average value of current is obtained by the first half cycle and the second half cycle which is given by:

$$I_{dc} = 0.486\, I_{max} = 0.180A$$

Therefore, DC value or average value of output voltage across power supply circuit can be calculated using the following equation:

$$V_{dc} = I_{dc}\, R_L = 0.180 \times 50 = 9$$

On the other hand, performance of the power supply circuit can be evaluated through what known as rectification efficiency using the following equation:

$$\eta = 0.812 \frac{1 + R_F}{R_L} = 0.812 \times 0.870 \times 100 = 70.64\%$$

Therefore, a maximum efficiency of full wave bridge rectifier will be 87.00%. This means 70.64% of the input AC power is converted into DC power.

Table 2: Main components for a power supply and the ultrasonic circuit

No.	Components	Specifications	Quantity
1	Step Down Transformer, T1	230V-12V	1
2	Rectifier Diode, D1:D4	1N4007	4
3	Capacitor, C1	10µF	1
4	Capacitor, C2 and C3	0.1µF	2
5	Voltage Regulator, IC	LM7809	1
6	Carbon resistance, R1	50Ω	1
7	Carbon resistance, R2	220Ω	1
8	Carbon resistance, R3	1.5kΩ	1
9	Stable multi-vibrator	IC2 SA555	1
10	Capacitor, C4 and C5	0.1µF	2
11	Carbon resistance, R4	50Ω	1
12	Carbon resistance, R5	1KΩ	1
13	Carbon resistance, R6	2KΩ	1
14	Transistor	Q1BC548	1
15	Change resistance, VR1	1KΩ	1

Working method of power supply circuit

The power supply circuit operates in stages with each stage serving a specific purpose and thus can be summarized in the following stages: 1. AC to AC Conversion, 2. AC to DC Conversion – Full Wave Rectification, 3. Smoothing stage and 4. Voltage Regulation. The AC power supply from mains first gets converted into unregulated DC and then into a constant regulated DC with the help of this circuit. The working of the circuit can be divided into two parts. In the first part, the AC mainstream is converted into unregulated DC and in the second part, this unregulated DC is converted into regulated 9VDC. The power supply circuit consists of a step-down transformer, bridge rectifier diodes, a smoothing capacitor and linear voltage regulator LM7809 IC.

Initially, a 230V to 12V Step down transformer is taken and its primary is connected to mains supply. The secondary of the transformer is connected to bridge rectifier as a combination of 4 Diodes are used. The rectified DC from the bridge rectifier is smoothened out with the help of 10 and 0.1µF capacitors. Accordingly, the output across the 0.1µF capacitor is unregulated 9VDC. This is given as an input to the LM7809 voltage regulator IC hence it converts to a regulated 9VDC and can be obtained at output terminals of the circuit.

The ultrasonic frequency circuit

Design of the ultrasonic generator is essentially built a SA555 stable oscillator as shown in Fig. 4.

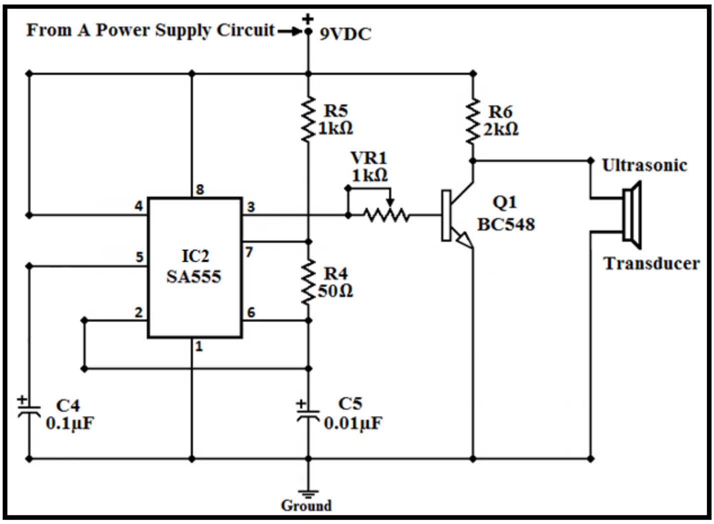


Fig. 4: Schematic diagram of the ultrasonic transmitter circuit

The stable oscillator circuit generates a frequency from 10 to 70 kHz which is used by the transmitting transducer to generate the ultrasonic wave. The voltage in a resistor–capacitor circuit (RC circuit) between charge and discharge states subjected to a step input and output of applied voltage for the stable oscillator.

Working of ultrasonic transmitter circuit

Circuit of the ultrasonic transmitter runs on a 9VDC, which was converted by using circuit of a regulated power supply. Design of the ultrasonic transmitter circuit was based on an integrated circuit. This circuit uses IC a stable multi-vibrator (IC2 SA555) and transistor (Q1BC548) to produce a pulsating ultrasonic frequency. The oscillator output is taken from the emitter of transistor Q1 to pin 3 of IC2SA555. The signal of pin 7 on IC2 causes the output signal appearing on pin 3 to be modulated or varied by the audio frequency developed by Q1. The IC2 is connected as a stable multivibrator with a frequency that is determined by C5. Frequency of ultrasonic generated can be varied from 10 to 70 kHz range by adjusting VR1 under different operating conditions.

The IC SA555 was used to work as a stable multivibrator which forms the oscillator part of the ultrasonic circuit. This IC was configured to produce a continuous serial wave pulse. And the output frequency was controlled by selection the other components of circuit like: R4, VAR1 and C5 that was estimated in design part to give required frequency output. An ultrasonic transmitter is one of the most important key components in the circuit which is responsible for converting the input pulses to ultrasonic waves of equivalent frequency.

This transmitter has the attribute of change size when regulated DC voltage is applied. Apply input signal causes oscillation and in turn to produce high frequency sound waves.

In this study. effect of the ultrasonic transmitter is produced as a result to apply an electric field in the form of regulated voltage to create mechanical deformation in the form of squeeze effect i.e. convert electrical energy into mechanical energy. The oil seeds become strained when an electric field applying voltage on them during the extraction process. The extraction machine was evaluated and tested to reach the best the oil yield and extraction efficiency under four levels of ultrasonic frequency (20, 30, 40 and 50 kHz) and four different feed rates (125, 145, 160, and 170 $kg.h^{-1}$).

Performance Indicators

The oil yield, machine efficiency and specific energy were estimated as execution indicators as follows:

Oil Extraction Yield

The oil yield, quantifies (Oy) by the volume of crude oil that the machine is capable of expelling per unit time which was calculated according to the following equation:

$$Oy = \frac{W_o}{t}$$

Where: W_o is the Weight of safflower oil collected and t is the time consumed.

Machine Efficiency

Efficiency of the extraction machine, η_m, is obtained from the ratio of the weight of the crude oil collected, W_o to the weight of oil yield in the test seed, W_s which is given by the following equation:

$$\eta_m = \frac{W_o}{W_s} \times 100$$

Power Requirement

The following formula was used to estimate the power requirement:

$$P_r = \sqrt{3} PF.I.V$$

Where:

PF is Power factor = cos φ = 0.85 at overload.

I is the current intensity and V is electrical voltage.

Specific mechanical energy

The specific mechanical energy can be calculated by using the following equation:

$$E_o = \frac{P_r}{Oy}$$

3.RESULTS AND DISCUSSION

The obtained results will be discussed in relation to the following points.

Physical properties

Some physical properties of safflower seed were determined as a function of moisture content in the range from 7.50 to 9.40%. Therefore, the geometric diameter, sphericity, mass of thousand seed and true density were shown in Table 3.

Various properties of safflower oil

The specific gravity, viscosity, heating value, flash point, carbon residue, and sulfur content were measured in this section and mean values are offered in Table 4.

Table 3. Some physical properties of safflower seed

Physical Properties	Seed Moisture Content, %			
	7.50	**8.00**	**8.50**	**9.40**
Length, mm	7.24	7.45	7.45	7.78
Width, mm	3.48	3.56	3.60	3.77
Thickness, mm	2.60	2.90	2.90	3.30
Geometric mean diameter, mm	4.03	4.25	4.27	4.59
Sphericity, %	55.66	57.05	57.32	59.00
Weight of thousand seed, g	52.60	54.40	62.20	68.60
True density, $g.cm^{-3}$	0.772	0.772	0.776	0.780

Table 4. Various properties of safflower oil and diesel oil

Property	Safflower oil	Diesel oil
Specific gravity, $kg.m^{-3}$	860	830
Kinematic viscosity, $mm^2.s^{-1}$	5.67	3.60
Calorific value, $MJ.kg^{-1}$	36.33	42.80
Flash point, °C	176	86
Carbon residue, %	0.012	12
PH value	6.90-7.30	5.50 - 8.00
Sulphur content, $mg.kg^{-1}$	0.04	10.00

The specific gravity is one of the more important properties consequently the most other properties can be associated with its. The specific gravity, it is able to provide information around fuel quality in terms of energy output and exhaust emissions.

Increasing the specific gravity leads to increase power output, at the same time can also realize a reduce levels of the emission gases and this promotes the use of biofuels. The previous values between safflower oil is too similar to diesel fuel hence, can be provided the appropriate alternative in case of use safflower oil as a second-generation biofuel source. It is worth mentioning the higher flash point temperature makes safflower oil is safer of diesel fuel.

The oil yield and specific mechanical energy

The representative oil yield and specific mechanical energy values versus the ultrasonic frequency are provided in Figures 5 and 6. The obtained results show that increasing the ultrasonic frequency level from 20 to 40 kHz measured at different feed rates of 125, 145,160 and 170 $kg.h^{-1}$ increased the oil yield by 25.62, 28.24, 29.33 and 28.86 % respectively at constant seed moisture content of 8.50% and screw speed of 65 rpm. The results also show that increasing the frequency level more than 40 up to 50 kHz measured at the same previous feed rates decreased the oil yield by 8.85, 8.48, 8.04 and 9.55%, respectively.

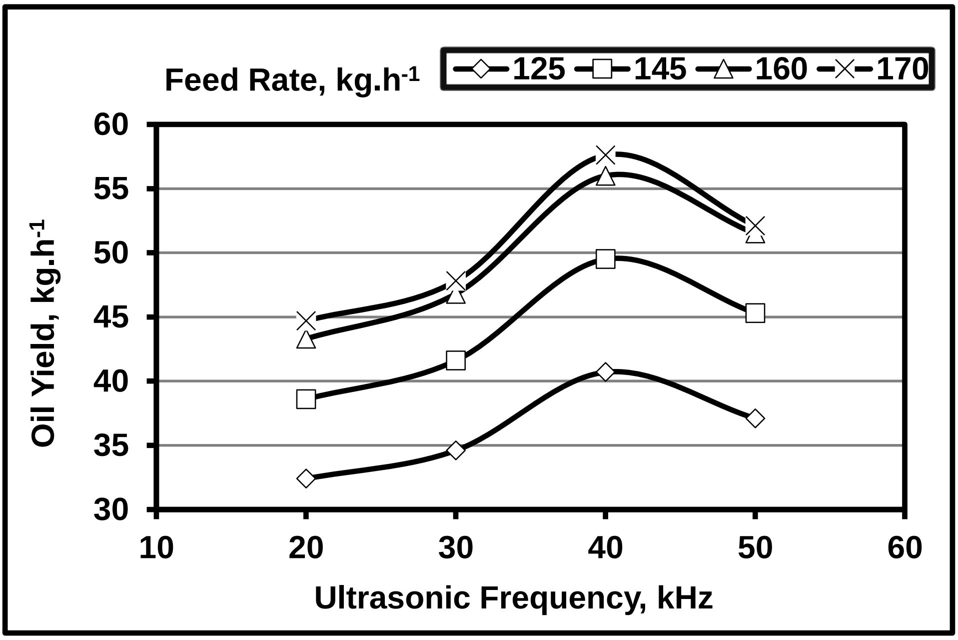


Fig. 5: Effect of ultrasonic frequency on the oil yield

The obtained results were showed that the oil yield extraction gradually increasing with the increase in the ultrasonic frequency as a result of increasing larger amplitude of ultrasonic waves transferred across bio-oil medium where a more bubbles is created and its collapsed which enhances the penetration of the continuous serial waves pulse into the cell tissues and accelerate the intracellular oil release.

Considering the specific mechanical energy, the obtained results show that increasing the ultrasonic frequency level from 20 to 40 kHz measured at different feed rates of 125, 145, 160 and 170 kg.h^{-1} decreased the specific mechanical energy from 227 to 181, from 190 to 148, from 170 to 131 and from 164 to 128 kW.h. Mg^{-1}, respectively.

Any further increase in frequency level from 40 to 50 kHz, the energy requirements will increase from 181 to 198, from 148 to 162, from 131 to 143 and from 128 to 141 kW.h. Mg^{-1}, respectively at constant the same previous seed moisture content and screw speed.

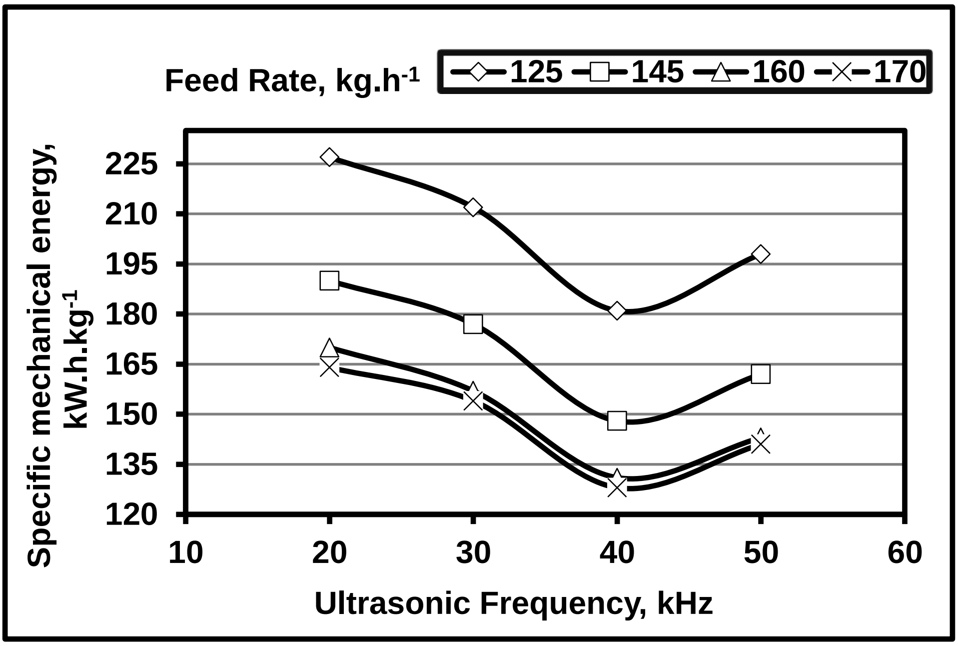


Fig. 6: Effect of ultrasonic frequency on the specific energy

The decrease in specific mechanical energy by increasing ultrasonic frequency levels were attributed to the decrease in the excessive load of seeds on the screw press surface which leads to smoothly oil flow supported by multi-vibration ultrasonic pulses and reduces energy requirements during mechanical extraction process. While, the specific mechanical energy increased by increasing frequency level upon 50 kHz due to the excessive load of both seeds and oil in the form of high viscosity materials on the machine devices which consumed more power. Because of the temperature and pressure were very high inside the bubbles and the collapse of bubbles occurred over a very short time under the highest level of the ultrasonic frequency.

Machine efficiency and energy content

The ultrasonic frequency levels had a great effect on the machine efficiency and energy content measured at different feed rates of 125, 145, 160 and 170 kg.h^{-1}. This relationship is shown in Figures 7 and 8.

The obtained data show that increasing the frequency level from 20 to 40 kHz increased the machine efficiency from 70.00 to 88.00, from 72.00 to 92.30, from 73.20 to 94.60 and from 71.00 to 91.50% ,respectively whereas further increases in the measured frequency from 40 to 50 kHz led to decrease the machine efficiency from 88.00 to 80.30, from 92.30 to 84.50, from 94.60 to 87.00 and from 91.50 to 82.90% , respectively at the same feed rates.

The results show that also, both higher and lower ultrasonic frequency values relative to the optimum value tended to decrease the machine efficiency because of the decrease in the extraction rate of the crude oil.

With regard to impact of the ultrasonic frequency levels on the energy content of safflower oil was noticed that the highest energy content values achieved (1479, 1798, 2034 and 2093 $MJ.h^{-1}$) per mega gram of extracted bio-oil measured at different feed rates of 125, 145, 160 and 170 $kg.h^{-1}$ and frequency level of 40 kHz. While the lowest values were (1177, 1402, 1573 and 1624 $MJ.h^{-3}$) under the same pervious feed rates with frequency level of 20 kHz.

This analysis shows that the higher and lower ultrasonic frequency values relative to the optimum value tend to decrease the energy content of safflower oil because of the decrease in the crude oil yield through the drainage outlet over the same unit of time. The extruder was effective because of its capacity to crush the safflower seeds during operation. The pressing zone reduced the size of the solid particles, and this mechanical action supported by ultrasonic waves led to the release of a considerable amount of the oil.

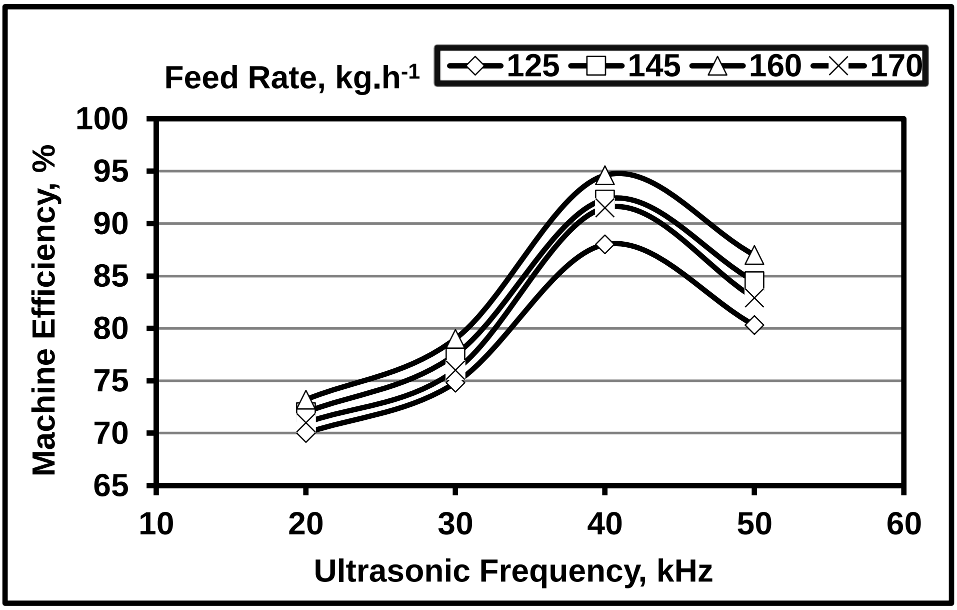


Fig. 7: Effect of ultrasonic frequency on the machine efficiency

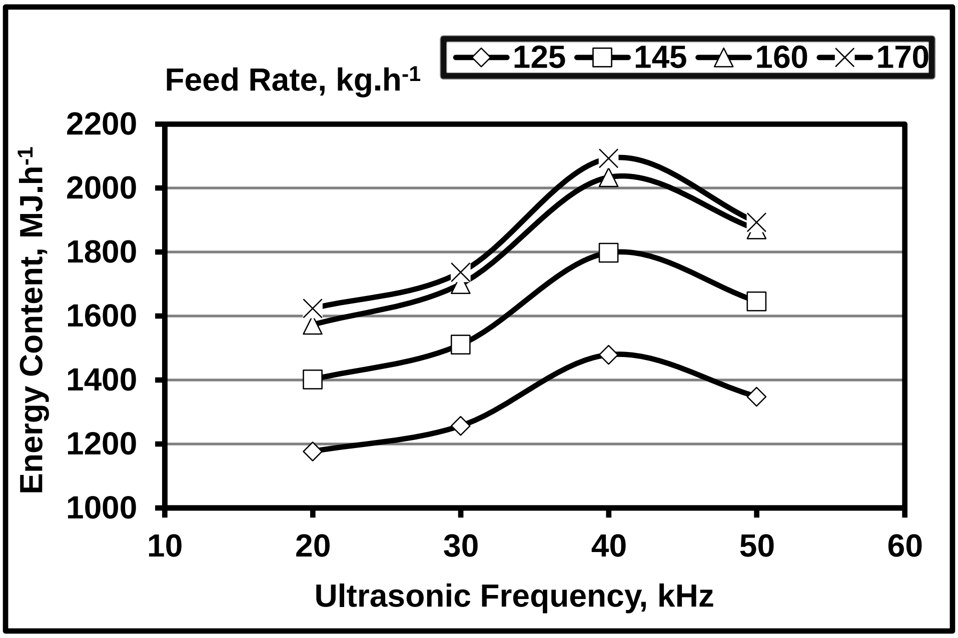


Fig. 8: Effect of ultrasonic frequency on the energy content

4.CONCLUSIONS

The current development was targeted towards increasing oil production and machine efficiency and reducing the oil losses. The developed machine has an improved efficient method using ultrasonic frequency transmitter that provides multi-vibration pulses with a regulated power supply. The developed machine can be used for safflower oil extraction at a medium scale in rural and urban regions. This machine is conceived as ideal, easily maintained for commercial uses. The machine is powered using a 7.35kW three-phase electric motor at full load for 10 working hours. Summing up the results, it can be concluded that using ultrasonic technique will enhance the performance of the extraction machine and it is capable of achieve an efficiency and energy content of 94.60% and 2034 MJ.h^{-1} by increasing in the oil yield of 29.33% during the operational period so it is recommended to using the ultrasonic technique as a proposed method in practice at a frequency level 40 kHz.

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الملخص العربي

تحسين عملية استخراج الزيت باستخدام تقنية الموجات فوق الصوتية كمصدر للوقود الحيوي من الجيل الثاني

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فى ظل تناقص موارد الطاقة المتوقع حدوثه، وزيادة الطلب على الطاقة وارتفاع أسعار الوقود و التغيرات المناخية دفع العديد من الدول إلى البحث عن مصادر بديلة للوقود وإيجاد الحلول لتجاوز مشكلة عدم الوفرة المتوقعة في مصادر الوقود التقليدية؛ لذلك يكون الوقود الحيوي هو البديل الأمثل والمستدام فى السنوات القادمة. يعتبر استخلاص الزيت من البذور النباتية من أهم مصادر الطاقة المتجددة على خلاف غيرها من الموارد الطبيعية، لذلك سعت الكثير من الدول لزراعة أنواع معينة من النباتات خصيصاً لاستخدامها في مجال الوقود الحيوي ولاسيما بذور نبات القرطم.

تناولت هذه الدراسة إنتاج مصدر جديد للطاقة عوضاً عن المصادر المتاحة من الطاقة من خلال عملية استخلاص الميكانيكى لزيت بذور القرطم باستخدام تقنية تردد الموجات الفوق صوتية وذلك بوضع الأسس التصميمية لآلة الاستخلاص لتحقيق أعلى إنتاجية، كفاءة ومحتوى طاقة من الزيت الحيوى أثناء عملية الاستخلاص وقد تمت عملية التصنيع بأحد الورش الخاصة.

كان الهدف من هذه الدراسة تعظيم إنتاجية وكفاءة ألة الاستخلاص الميكانيكى لزيت القرطم باستخدام تقنية الموجات فوق الصوتية، حيث تتميز الآلة المطورة بتقنية فعالة باستخدام منظومة تردد بالموجات فوق الصوتية بواسطة مصدر قدرة مستمر ومنظم للجهد.

حيث شملت عملية تصميم وإنشاء دائرة إلكترونية كمصدر قدرة مستمر بمنظم للجهد مما يسمح للجهد بالبقاء مستقرًا بغض النظر عن كمية التيار المستهلكة مكونة من محول لخفض الجهد من (٢٣٠ إلى ١٢ فولت) من التيار المتردد بعد ذلك يتم تصحيح الجهد باستخدام قنطرة من الثنائيات (الدايود) التى تقوم بتحويل موجات الجيب السالبة إلى سلسلة من القمم الإيجابية وفي اللحظة التي يتم فيها تصحيح الجهد، عندئذ لا يزال هناك تذبذب في شكل الموجة يتم تنعيمه بواسطة المكثف الأول ، الثانى والثالث مما يقلل بشكل كبير من كمية تدلى الجهد وكذلك ينعم جهد الخرج

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وزيادة السعة التخزينية للمكثف تنتج عادة مصدر طاقة أعلى جودة وبمجرد اكتمال تحويل الجهد إلى ٩ فولت مستمر لا يزال هناك بعض التموج لذا يتم تمرير الجهد من خلال منظم LM7809 لإنشاء خرج ثابت من التيار المستمر مع أقل تموج في الجهد. وبالتالى تصبح كمصدر قدرة لتشغيل مولد الموجات الفوق صوتية بترددات مختلفة فى مدى من ١٠ إلى ٧٠ كيلوهرتز.

حيث استندت عملية تصميم وإنشاء دائرة محول الموجات فوق الصوتية على منظومة الدائرة المتكاملة هذه الدائرة تستخدم IC مستقراً (IC2 SA555) وترانزستور (Q1BC548) لإنتاج تردد فوق صوتي نابض، يتم أخذ خرج المذبذب من باعث الترانزستور Q1 إلى الطرف ٣ من IC1SA555. تتسبب إشارة الطرف ٧ فى إشارة الخرج الظاهرة على الطرف ٣ أو تغييرها بالتردد الذي تم تطويره بواسطة Q1. يتم توصيل IC1 كمركز متعدد ، مستقر وثابت بتردد يتم تحديده بواسطة C5. يمكن أن يختلف تردد الموجات فوق الصوتية المتولدة من ١٠ إلى ٧٠ كيلو هرتز عن طريق ضبط المقاومة المتغيرة (VR1) تحت ظروف التشغيل المختلفة. تم استخدام IC2 SA555 لإنتاج نبض موجة متسلسلة مستمرة فى المدى الترددى المذكور سالفاً. وتم إنتاج تردد الخرج والتحكم فيه عن طريق اختيار المكونات الإلكترونية مثل: R4، VAR1 و C5 التي تم تحديدها واختيارها في الجزء الخاص بالتصميم لإعطاء ناتج التردد المطلوب. يعد جهاز الإرسال بالموجات فوق الصوتية أحد أهم المكونات الرئيسية في الدائرة المسؤولة عن تحويل نبضات الإدخال إلى موجات فوق صوتية ذات تردد مكافئ.
حيث تمت التجارب تحت أربعة مستويات مختلفة من التردد فوق الصوتي (٢٠ ، ٣٠ ، ٤٠ و ٥٠ كيلو هرتز) وأربعة معدلات تلقيم (١٢٥ ، ١٤٥ ، ١٦٠ ، ١٧٠ كجم/س) بأخذ القياسات التالية: عائد الزيت، محتوى الطاقة للزيت المستخلص ، كفاءة الآلة والطاقة المستهلكة كما تم تقدير خصائص الزيت الحيوى المستخلص مثل: الوزن النوعي ، اللزوجة ، القيمة الحرارية ، نقطة الوميض ، متبقيات الكربون ومحتوى الكبريت تحت أفضل عوامل للدراسة ومقارنة ذلك بخصائص زيت الديزل.
ولقد ساهمت الاستخلاص بواسطة الموجات فوق الصوتية فى تحسين إنتاجية الزيت بنسبة ٢٩,٣٣٪ ، وتم تحقيق أعلى قيمة لمحتوى الطاقة بقيمة ٢٠٣٤ ميجاجول لكل ساعة بضبط مستوى التردد عند ٤٠ كيلو هرتز وبمعدل تلقيم قدره ١٦٠ كجم/س. سيكون هذا مفيدًا لآلة الاستخراج لاسترداد كمية أكبر من محصول الزيت من نفس الكمية من بذور القرطم طوال فترة التشغيل. كما أشارت النتائج المتحصل عليها إلى تحقيق كفاءة بلغت ٩٤,٦٠٪ مع خفض استهلاك الطاقة بنسبة ٢٢,٩٤%.