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ANALYSIS OF ARDUINO MEGA CONTROLLER USAGE FOR THE OIL SCREW PRESS

This study delves into the application of Arduino Mega in the domain of oil pressing, seeking to comprehensively analyze its implementation, advantages, challenges, and overall impact on the efficiency of oil pressing processes. With the increasing integration of smart technologies into industrial operations, the use of microcontroller platforms, such as Arduino Mega, represents a paradigm shift towards automation and enhanced control systems. The focus of this analysis is on understanding how Arduino Mega contributes to the optimization of oil pressing procedures, offering insights into the hardware and software integration, data acquisition, control mechanisms, and potential effects on efficiency and productivity.

The hardware and software integration aspect explores the components employed in Arduino Mega implementation for oil pressing. This includes an examination of sensor integration, actuation mechanisms, and the overall architecture of the system. By dissecting these technical aspects, the study aims to provide a detailed understanding of the technological foundations supporting the implementation. Data acquisition and monitoring play a crucial role in the efficiency of industrial processes. This analysis investigates the role of Arduino Mega in facilitating precise and real-time data acquisition during oil pressing.

Control mechanisms represent the heart of any automation system By evaluating the reliability and robustness of these control mechanisms, the study aims to shed light on the efficacy of Arduino Mega in maintaining precision and stability in oil pressing operations. The analysis extends to consider the potential impacts of Arduino Mega implementation on the overall efficiency and productivity of oil pressing processes. Factors such as reduced downtime, optimized resource utilization, and improved product quality are scrutinized.

Keywords: Arduino Mega, Oil Pressing, Automation, Microcontroller, Control Systems, Smart Technology.

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АНАЛІЗ ВИКОРИСТАННЯ КОНТРОЛЕРА ARDUINO MEGA ДЛЯ ШНЕКОВОГО ПРЕСА

У цьому дослідженні розглядається застосування Arduino Mega у сфері пресування олії, намагаючись всебічно проаналізувати його впровадження, переваги, проблеми та загальний вплив на ефективність процесів пресування олії. Із зростанням інтеграції інтелектуальних технологій у промислові операції використання платформ мікроконтролерів, таких як Arduino Mega, являє собою зміну парадигми в бік автоматизації та розширених систем керування. Цей аналіз зосереджений на розумінні того, як Arduino Mega сприяє оптимізації процедур пресування олії, пропонуючи розуміння апаратної та програмної інтеграції, збору даних, механізмів керування та потенційного впливу на ефективність і продуктивність.

Аспект інтеграції апаратного та програмного забезпечення досліджує компоненти, які використовуються в реалізації Arduino Mega для пресування олії. Це включає перевірку інтеграції датчиків, механізмів приведення в дію та загальної архітектури системи. Розбираючи ці технічні аспекти, дослідження має на меті забезпечити детальне розуміння технологічних основ, що підтримують впровадження. Збір даних і моніторинг відіграють вирішальну роль у ефективності промислових процесів. Цей аналіз досліджує роль Arduino Mega у сприянні точному збору даних у реальному часі під час пресування олії.

Механізми управління є серцевиною будь-якої системи автоматизації. Оцінюючи надійність і міцність цих механізмів керування, дослідження має на меті пролити світло на ефективність Arduino Mega у підтримці точності та стабільності операцій пресування олії. Аналіз поширюється на розгляд потенційного впливу впровадження Arduino Mega на загальну ефективність і продуктивність процесів пресування олії. Такі фактори, як скорочення часу простою, оптимізоване використання ресурсів і покращена якість продукції, ретельно вивчаються.

Ключові слова: Arduino Mega, Oil Pressing, Автоматизація, Мікроконтролер, Системи керування, Smart Technology.

Staging problems

Vegetable oils are predominantly produced through the utilization of screw-type presses to extract oil from raw materials [1, 2]. The quality of the obtained oil, the efficiency of oil separation (or extraction) from oilseeds [3], energy consumption, and press productivity [4] are significantly influenced by the chosen pressing technology and the design parameters of the press [5, 6]. To enhance the automation of the pressing process for various oil-containing raw materials using standardized press equipment, it is essential to tailor its operational modes to the specific seeds of different crops. This adaptation ensures the capability to adjust specific operational parameters (such as temperature, pressure, mass, and screw speed), which are technologically set and impact crucial characteristics such as quality, productivity, and energy consumption [7].

Analysis of recent sources

A multitude of research studies delve into the intricacies of design and operational characteristics of screw-type (worm-type) presses tailored for the extraction of various oils. The impact of material feeding levels on the operational dynamics of screw-type presses is thoroughly explored in [8]. For the processing of moringa seeds, [9] introduces a novel press design, substantiated through experimental testing and optimization. In [10], the focus shifts to the examination of force, pressure, and energy distribution along a specific screw designed for pressing palm kernels.

The evolution of press design takes a flexible turn in [11], where an enhanced design for a single-screw press is developed. Meanwhile, [12] contributes a mathematical model and an exploration of diverse operational modes of screw-type presses for processing safflowers. A comprehensive investigation into the modeling, simulation, and experimental testing of dynamic processes and operational conditions of double-screw (twin-screw) presses is meticulously presented in [7, 13, 14].

For a domestic press dedicated to extruding different vegetable oils, [15] delves into the implementation of a finite-element method to analyze working regimes. In [16], the authors introduce a modernized screw-type press tailored for sunflower oil production.

Presentation of the main material

Let us analyze general design of the screw-type oil extruder in order to identify how Arduino Mega controller can improve its productivity. Figure 1 illustrates the enhanced design of a screw-type press utilized for extracting oil from various oil crops and oil-containing raw materials. The press's body and drive are positioned on a stationary base (1) to ensure stability. Power is transmitted to the screw (12) by a geared electric asynchronous motor (1) via a safety coupling (4) featuring rubber-bushed studs. The motor boasts a nominal power of 1.5 kW, while the single-stage worm gear drive allows the screw to attain a maximum rotational frequency of 60 rpm [7].

Support for the screw shaft is provided by a single-thrust radial ball bearing (6) and a single-thrust taper roller bearing (11). The press body encompasses flanges (5, 18, 19), housing (7), sleeves (8, 11), gasket (9), spacers (13, 15, 16), pressing chamber (14), and a discharging chute (17). The material to be pressed is introduced manually or automatically into the hopper feeder (3), which directs it into the sleeve (11). The screw (12) transports the material into the pressing chamber (14), where the oil is extruded [7].

At the front end of the pressing chamber, the flange (18) is installed, featuring holes for discharging the processed material. To adjust the output capacity and pressure within the working chamber, an additional flange (19) is installed on part 18. Aligning the holes in both flanges maximizes the output capacity. Slight rotation of flange 19 closes the holes in part 18, increasing pressure within the working chamber. An additional flexible hose (canvas, paper, or polyethylene) is attached to flange 18 to collect the discharged material [7].

The pressed oil exits the working chamber (14) through the discharging chute (17). This design highlights the versatility of the screw-type press, offering adjustable output capacity and pressure control for efficient oil extraction.

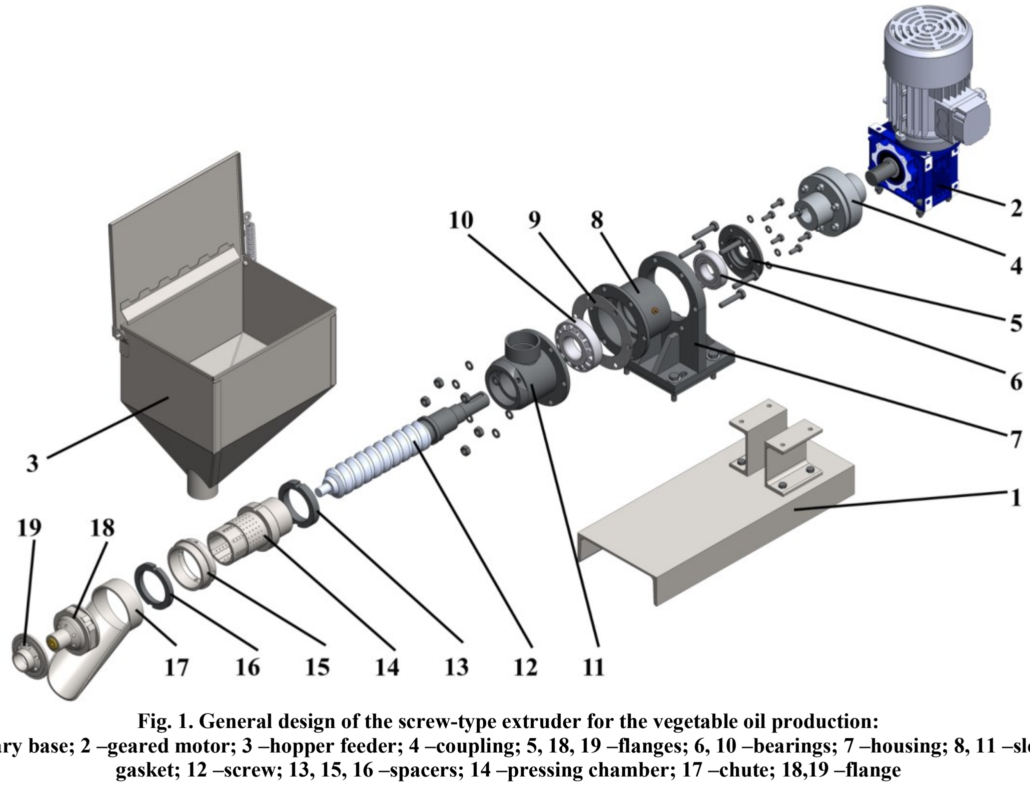

Fig. 1. General design of the screw-type extruder for the vegetable oil production:
1 –stationary base; 2 –geared motor; 3 –hopper feeder; 4 –coupling; 5, 18, 19 –flanges; 6, 10 –bearings; 7 –housing; 8, 11 –sleeves; 9 –gasket; 12 –screw; 13, 15, 16 –spacers; 14 –pressing chamber; 17 –chute; 18,19 –flange

In the ever-evolving landscape of industrial processes, the quest for efficiency and precision has led to the integration of advanced technologies. The marriage of traditional practices, such as oil pressing, with cutting-edge solutions has paved the way for enhanced control and automation. Let us explore the benefits of utilizing Arduino Mega as a controller (figure 2) for a screw oil press, particularly emphasizing its role in regulating motor speed and fan operation based on temperature and mass parameters.

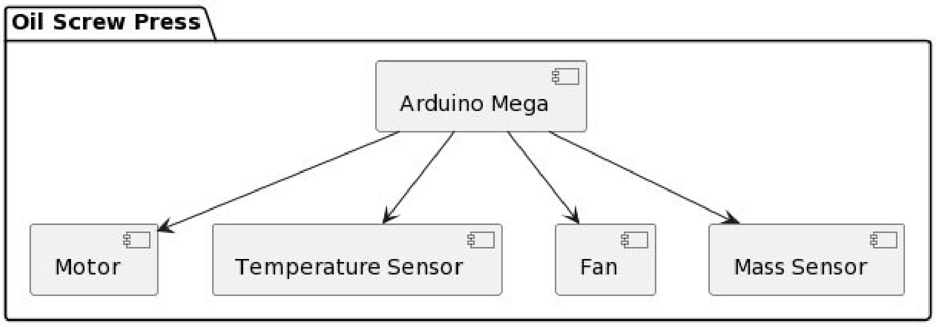

Fig. 2. Arduino Mega and components UML diagram

Precision Control. One of the primary advantages of employing Arduino Mega is its capacity for precise control. In the context of a screw oil press, where the delicate balance of temperature and mass significantly influences the extraction process, the ability to fine-tune and regulate parameters becomes paramount. Arduino Mega's robust control mechanisms ensure optimal conditions for oil extraction.

Adaptability to Variability. Oil pressing often involves variations in raw material properties, leading to changes in temperature and mass throughout the process. Arduino Mega's adaptability allows it to dynamically respond to these fluctuations. Through real-time data acquisition and monitoring, the controller adjusts motor speed and fan operation to maintain optimal conditions, maximizing efficiency despite variations in input parameters.

Real-Time Data Processing. The integration of advanced sensors with Arduino Mega facilitates real-time data processing. Temperature and mass sensors provide continuous feedback, enabling the controller to make instantaneous decisions. This capability not only ensures the precision of the oil pressing process but also contributes to timely adjustments in motor speed and fan operation, preventing deviations from the desired conditions.

Energy Efficiency. Arduino Mega's intelligent control of the motor and fan contributes to energy efficiency. By adjusting the motor speed based on the current load and optimizing fan operation to dissipate excess heat, the system minimizes energy consumption. This not only aligns with sustainability goals but also translates into cost savings for oil pressing operations.

Scalability and Integration. Arduino Mega's scalability makes it well-suited for various scales of oil pressing operations. Whether in a small-scale artisanal setting or a large industrial facility, the controller can be adapted to meet the specific needs of the operation. Its integration capabilities also allow seamless incorporation into existing systems, making it a versatile choice for upgrading conventional oil pressing processes.

Temperature Regulation. Arduino Mega's integration with temperature sensors enables precise regulation of the pressing temperature. Maintaining the optimal temperature range ensures efficient oil extraction while preventing degradation of the oil quality. The controller dynamically adjusts the heating elements and fan speed to achieve and sustain the desired temperature throughout the process.

Mass-Based Automation. The mass of the input material is a crucial factor in oil pressing efficiency. Arduino Mega, with its ability to process mass-related data in real-time, controls the screw press's motor speed to match the specific characteristics of the raw material. This adaptive approach ensures consistent pressure and extraction rates, enhancing the overall productivity of the oil pressing process.

The diagram on figure 3 shows an Arduino Mega controller which controls the motor and fan of the screw oil press. User starts program and then controller communicates with both the motor and fan to control their operation based on temperature and mass. The screw oil press is monitored for temperature and mass.

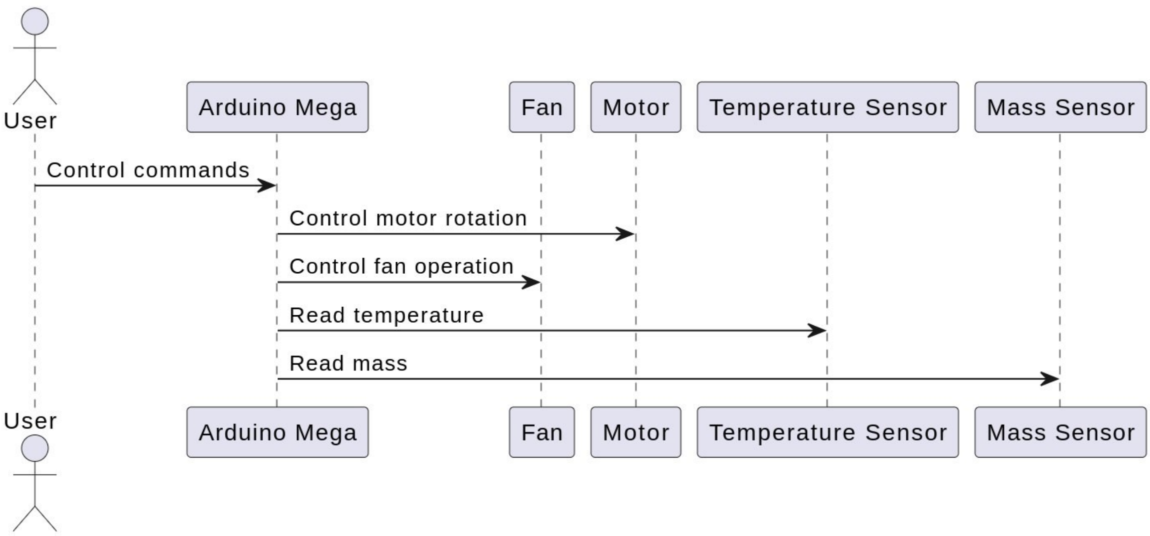

Fig. 3. User interaction with the screw oil press UML diagram

Based on the above, function for cooler control can be described as:

```
// Function of fan control
void controlCoolerSpeed() {
  float tempValue = sensors_3.getTempCByIndex(0);
  if (tempValue < COOLER_MIN_TEMPERATURE) {
// Off fan if temperature lower COOLER_MIN_TEMPERATURE
    coolerSpeed = 0;
} else if (tempValue >= COOLER_MIN_TEMPERATURE && tempValue < COOLER_MAX_TEMPERATURE) {
    // Control fan speed MIN_MOTOR_SPEED до MAX_MOTOR_SPEED
float speedRange = MAX_MOTOR_SPEED - MIN_MOTOR_SPEED;
float temperatureRange = COOLER_MAX_TEMPERATURE - COOLER_MIN_TEMPERATURE;
coolerSpeed = MIN_MOTOR_SPEED + (tempValue - COOLER_MIN_TEMPERATURE) * (speedRange /
temperatureRange);
 } else if (tempValue >= COOLER_MAX_TEMPERATURE) {
//Set max fan speed if temperature is higher COOLER_MAX_TEMPERATURE
    coolerSpeed = MAX_MOTOR_SPEED;
}
  coolerSpeed = constrain(coolerSpeed, 0, MAX_MOTOR_SPEED); //limited fan speed
  analogWrite(COOLER_PIN, coolerSpeed); // Set fan speed
}
// Function of fan control of motor
void controlCoolerMotor() {  float tempValue = sensors_2.getTempCByIndex(0);
  if (tempValue >= COOLER_MOTOR_MIN_TEMPERATURE) {
    digitalWrite(COOLER_MOTOR_PIN, HIGH);  } else {
    digitalWrite(COOLER_MOTOR_PIN, LOW);  }
  // Output of fan speed
  Serial.print("Cooler Speed: ");
Serial.println(tempValue >= COOLER_MOTOR_MIN_TEMPERATURE ? "HIGH" : "LOW");
}
```

Based on the analysis of implementing Arduino Mega as main controller for screw oil press, the upgraded version of the screw press was suggested on figure 4. Model contains the installed controller, control elements, temperature sensors, mass sensor and fan.

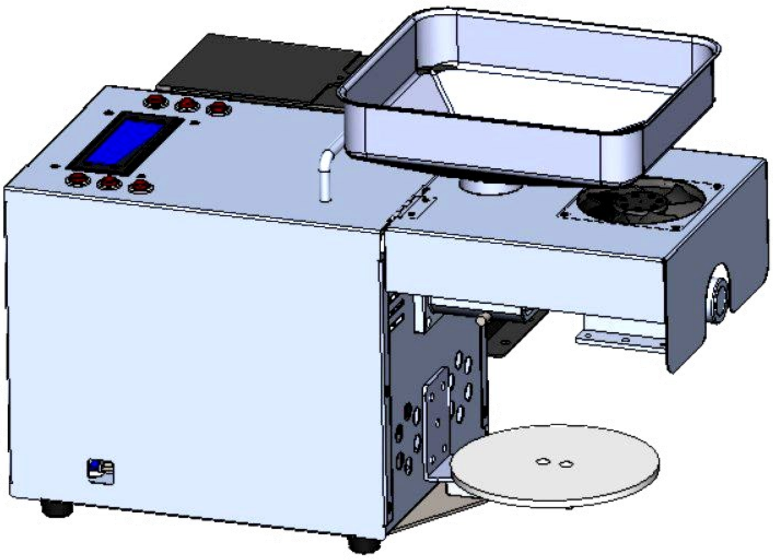

Fig. 4. Upgraded screw oil press

Conclusions

In conclusion, the utilization of Arduino Mega as a controller for a screw oil press heralds a new era of efficiency and adaptability in the oil pressing industry. Its precision control, adaptability to variability, real-time data processing capabilities, energy efficiency, scalability, and integration make it an invaluable tool for optimizing oil pressing processes. Motor speed and fan operation can be dynamically controlled based on temperature and mass using the Arduino Mega controller.

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