ABSTRACT

Abdel-gawad Mohammed Abdel-gawad Saad: Design and Development of Unit for Extracting Wheat Germ Oil. Unpublished Ph.D. Thesis. Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University, 2012.

An expelling machine for extracting oil from wheat germ was designed and fabricated to be suitable for young investors. The procedures include the design stages, construction and testing. The main machine components are: Hopper (feeding inlet); expellant unit and an electric motor. The power is transmitted by means of a set of pulleys; sprockets; V-belt; chain and speed reducer (gear box). The expelling unit consists of two screw expellant shafts with two expellant barrels.

The expelling machine evaluated at five screw speeds (25, 35, 45, 55, and 65 rpm); four levels of press head clearance (0.5, 1, 1.5, and 2 mm); studying influence of the preheating process (in the range of 60-70°C) by the water at different atmospheric steaming periods (0, 10, 20, and 30 min) to change the initial moisture content of raw material (13.2%) to different levels (15.4, 16.2, and 16.8%). and influence of heating stabilization process (9.5% of moisture content) on expelling machine performance to determine the best Machine capacity (kg/h); Oil recovery (%); Residual oil (%); Oil productivity(L/h); Specific energy consumption (kWh/kg_{feed}); and Barrel temperature(°C). also, determine the economic feasibility for developed expelling machine.

Results showed that the expeller could be pressed wheat germ on two stages to give a better performance at as following.

1- The maximum machine capacity (42.6 kg/h) was obtained from stabilized wheat germ (9.5% moisture content) at 2mm outlet clearance and 65 rpm of screw speed.
2- The maximum oil recovery (63%) was obtained from stabilized wheat germ (9.5% moisture content) at 0.5mm outlet clearance and 25 rpm of screw speed.

3- The maximum oil productivity (2.36 L/h) was obtained from stabilized wheat germ (9.5% moisture content) at 2mm outlet clearance and 65 rpm of screw speed.
4- The minimum SEC (0.0304 kWh/kg_{feed}) was found from wheat germ (13.2% moisture content) at 2mm outlet clearance and 65 rpm of screw speed.
5- The minimum barrel temperature (51.1°C) was found from raw wheat germ (13.2% moisture content) at 2mm outlet clearance and 25 rpm of screw speed.

Keywords: Oil Extraction, Expelling machine Design, Wheat Germ Oil, Economic Feasibility.

LIST OF CONTENTS

LIST OF SYMBOLS

V	The flow rate of fluid, m^3/sec.
R	Pore radius, m
ΔP	Pressure drop across a pore of length, Pa
L	Pore length, m
µ	Coefficient of viscosity, Pa.sec
L_p	Hydraulic conductivity of plasmodesmate, m^3/sec. Pa
q	The flow rate of fluid
k	The coefficient of permeability
ρ	Fluid density
g	Gravitational acceleration
$\frac{\Delta u}{\Delta z}$	Hydraulic gradient in the fluid (pressure difference Δu over distance ΔZ).
σ_t	Total applied pressure,
σ_i	Kernel pressure; the pressure carried by the medium skeleton
U	Inter-kernel fluid pore pressure; the pressure carried by the medium fluid
Q_T	Theoretical volumetric flow rate of wheat germ, cm^3/h.
$\dot{m}$	The maximum required mass flow rate
ρ_g	Wheat germ bulk density, g/cm^3
η_f	Feeding efficiency
η_v	Hopper volume efficiency
t_{int}	Time interval between filling and re-filling up the hopper
Q_{act}	Actual volumetric flow rate of wheat germ, cm^3/h
V_H	The hopper actual volume, cm^3
D_h	Upper hole diameter of the hopper, cm.
h_h	Height of hopper, cm.
x	Sidelong length of the hopper, cm
θ	The inclination angle of hopper
φ	The repose angle.
Ƥ	Screw pitch
N	Number of turns of screw.

L_S	The axial length of the screw shaft.
d_S	Outer diameter of screw shaft.
l	Lead of screw.
λ	Lead angle
L_t	The thread length of the screw of one turn.
L_T	The total thread length (helix length).
Z	Variable distance measured along screw helix
α	Taper angle of the screw shaft.
H_1	Height of the thread at the starting point of the turns of the screw shaft, mm.
H_2	Height of the thread at the end point of the turns of the screw shaft, mm
T_s	Torque of the screw shaft, Nm.
P	The power requirement for extraction oil process, W
$V_{displacement}$	Volume displacement per one revaluation, m^3
P_2	The maximum presser applied on the threads, MPa
F_a	The maximum unit force applied on the threads, N
t	Thread width, mm
r	The radius to the inner diameter of screw shaft, mm ($d_1/2$);
d_1	Smallest diameter of the screw shaft, mm.
J	Polar moment of inertia of circular cross section, mm^4
K_f	Stress concentration factor
M_s	Moment at the most critical cross section arising from the weight of the screw shaft.
R_s	Reaction forces acting on the screw shaft at two ends.
W_s	Weight of the screw shaft, N.
τ_{max}	Maximum shear stress, MPa
δ_s	Yield strength
ρ_t	The true density of the bulk wheat germ material, Kg/m^3;
M	Weight of the bulk wheat germ sample, Kg
V_t	Real volume of the bulk wheat germ sample, m^3
BD	Bulk density of wheat germ, kg/mm^3

W_{Bulk}	Weight of bulk wheat germ, kg
V_{Bulk}	Volume of bulk wheat germ, mm^3.
W_T	Weight of sample before drying, g
W_D	Wheat of sample after drying, g
P_m	Machine capacity, kg/h.
W	Machine feeding, kg
t_0	Machine operating time, h
W_C	Mass of cake, kg.
O_C	Oil content of cake, kg
W_m	Mass of sample, kg
O_m	Initial oil content of sample, kg
I	Line current strength, Amperes.
V_0	Potential difference, Voltage
$\cos\theta$	Power factor, equal 0.85
SEC_1	Specific energy consumption of expelling machine
SEC_2	Specific energy consumption needed for steam generation in the steaming unit or for heating in rotary heat stabilization unit
SEC	Total specific energy consumption of wheat germ oil extraction
C_{gas}	Natural gas consumption by m^3
T_c	Total hourly cost, EGP/h.
C	Initial price of the machine, EGP.
h	Working hours per year.
L_f	The estimated life-expectancy of machine in years.
i	Annual interest rate, (0.1 of initial cost)
t_a	Annual taxes and overheads, (0.01 of initial cost).
r_a	Annual repairs and maintains rate, (0.1 of initial cost).
S_1	Price of electricity, EGP/kWh.
S_2	Price of natural gas, EGP/m^3.
P_m	Machine capacity kg/h.
m_s	The operator monthly salary, EGP/month