

الآية

قال الله تعالى في محكم تنزيله :

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Dedication

All thanks and gratefulness are for Allah, the most gracious, the most merciful.

I would like to thank the Sudan University of science and Technology and to express my sincere gratitude to my supervisors **Dr. Ahmed Ibrahim Ahmed Seed Ahmed** and **Dr. Mohammed Deen Hussein Mohammed**. I would like to acknowledge their unlimited efforts in guiding and following up the research progress, and specially their spirit – raising encouragement.

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ABSTRACT

This research work concentrated on using Ansys poly flow software and equation of percentage root square error (PRMSR) to select the best viscosity model (viscosity vs. shear rate) at isothermal condition for polypropylene. The samples were tested at different loads and constant temperature 230°C using melt flow index tester. The results for each sample were recorded and different viscosity models were checked using Polyflow and the best of them was selected using PRMSE equation. It was found that shear stress versus shear rate was Non-Newtonian and the best model was (Carreau-Yasuda law).

This model was used in analytical and simulation for die combined of two circular section tapered and non-tapered the pressure drop was studied at no-slip condition in the die wall. The governing equation of pressure drop was first derived to angle of tapered section, the best angle is 45° analytically and 45° ~50° for the simulation. For circular section the pressure drop was studied using different die lands and radii the results for die lands variations are almost the same but when varying the radius the results differ at radii less than 2 cm and approach each other at 2 cm and above. The swell ratio from this die decreased by small amount when die land was increased at linear pressure drop gradient, and it also decreased by high amount when L/D was increase at non- linear pressure drop gradient.

In screw without and with nose models the maximum extruder output were studied at different parameters such as the extruder line the simulation of two screw models gave two points with specified flow rate and pressure drop less than analytical value, the calculated pressure at flight clearance gave pressure that approached to simulation results than that at flight depth, as flight width decreased the analytical maximum output was not affected but in simulation was increased and pressure decreased, when flight clearance decreased the analytical maximum output was not affected also but in simulation the output and pressure were increased, when screw depth increased the maximum extruder output and pressure in analytical and simulation was increased, as screw speed increased the maximum extruder output and pressure in analytical and simulation was increased, as length increased the analytical was not affected, but in simulation there was a fluctuation in flow and pressure and the best length of metering zone is (12cm) 2 flights this gave high flow rate and suitable pressure drop.

In the die characteristics at operating point the maximum extruder output and pressure were studied at different parameters in the extruder line the same inter-

sected of analytical extruder line at maximum output and pressure at calculated shear rate in die with the linear equation of simulated operating points, when width decrease the linear equations of output increase and pressure decrease, as flight clearance decrease the linear equations the output decrease and pressure increase these obesity results at the simulation without die was obtained before, when flight depth decreased the linear equations the maximum extruder output analytically and simulation tended to the same values but analytically pressure higher than simulation values, as screw speed increased the linear equations the maximum extruder output and pressure analytically and simulation tended to the same values , when screw length increased the linear equations the maximum extruder output analytically was constant and pressure increased, in simulation the output was decreased and pressure increased ,the screw length was not effect in output analytically but in simulation it was.

المستخلص

يتركز هذا العمل البحثي على استخدام برنامج ANSYS Polyflow ومعادلة النسبة المئوية لمربع جذر الخطأ (PRMSR) لاختيار أفضل نموذج للزوجة (اللزوجة مقابل معدل القص) في حالة ثبوت الحرارة للبولي بروبيلين . تم اختبار العينات لإحدى عشر حمل مختلف وعند درجة حرارة ثابتة 230°C باستخدام جهاز معامل تدفق المصهور وسجلات النتائج لكل عينة وتم فحص نماذج اللزوجة المختلفة باستخدام ANSYS Polyflow وأفضل منهم تم اختيارها باستخدام المعادلة . فقد وجد أن إجهاد القص مقابل معدل القص غير نيوتوني، وكان أفضل نموذج هو (قانون كارو- ياسودا).

تم استخدام هذا النموذج في التحليل والمحاكاة لـ 10 قسامين مسلوب واخر غير مسلوب ودرسانخفاض الضغط في حالة عدم الانزلاق في جدار القالب . وقد اشتمت المعادلة التي تحكم انخفاض الضغط أولاً مع زاوية المقطع المسلوب ، أفضل زاوية 45° تحليلياً و $50^{\circ} \sim 45^{\circ}$ للمحاكاة . للقسم الغير مسلوب تم دراسة انخفاض الضغط باستخدام قيم مختلفة من الاطوال وانصاف الاقطار . نتائج اختلاف الاطوال هي نفسها تقريباً ولكن عندما تغير نصف القطر تفاوتت النتائج فقد اختلفت انصاف الاقطار أقل من 2 سمواقتربت بعضها البعض في 2 سموما فوق نسبة الانتفاخ من هذا القالب انخفضت بقيمة صغيرة عندما تمت زيادة طول القالب بعلاقة خطية لانخفاض الضغط ، وانخفضت أيضاً بقيمة عالية عندما زادت نسبة الطول الى القطر بعلاقي غير خطية لانخفاض الضغط.

في البريمة بدون اومع نموج الأنفتمت دراسة الطاقة الانتاجية القصول للبريمة عند معايير مختلفة عند خط البريمة محاكاة نموجى البريمة اعطت نقتين لمعدل تدفق وانخفاض للضغط محددة أقل منالقيمة التحليلية، والضغط المحسوب عند خلوص الريشة إعطاء نتائج ضغط اقتررب للمحاكاة من ذلك عند قيمته فى عمق الريشة في خط البريمة، وعندما انخفضت عرض الريشة لم تتأثر الطاقة الانتاجية القصول تحليلياً ، ولكن في المحاكاة اذت وانخفضه الضغط، وعند انخفاض خلوص الريشة لم تتأثر الطاقة الانتاجية القصول تحليلياً أيضاً، ولكن في المحاكاة اذت هي والضغط ، ولكن عندما زاد عمق الريشة زادت الطاقة الانتاجية القصول للبريمة والضغط تحليلياً ومحاكاة، وعندما زادت سرعة البريمة اذت الطاقة الانتاجية للضغط تحليلياً ومحاكاة، وبزيادة الطول تحليلياً تتأثر، ولكن محاكاة كان هناك تذبذب في التدفق والضغط أفضل طول لمنطقة القياس هو (12CM) ريشتنا وهذا اعطى معدل تدفق عالى وانخفاض ضغط مناسب.

عند خواص قالب عند نقطة التشغيل تم دراسة الطاقة الانتاجية القصوى للبريمة والضغط عند معايير مختلفة عند خط البريمة تقاطعه خط البريمة تحليليا عند الطاقة الانتاجية القصوى والضغط عند معدل القص في قالب مع المعادلة الخطية لنقاط التشغيل من المحاكاة، وعند نقصان عرض الريشة كانت نتائج المعادلات الخطية من المحاكاة تشير الى زيادة الانتاجية وانخفاض الضغط، وفي نقصان خلوص الريشة كانت نتائج المعادلات الخطية تشير لانخفاض الانتاجية وزيادة الضغط وهذه نتيجة عكسية في المحاكاة دون قالب التي تم الحصول عليها من قبل، وعند انخفاض عمق الريشة ابانت المعادلات الخطية ان القيمة القصوى للانتاجية للبريمة تحليليا ومحاكاة تميل الى نفس القيمة ولكن الضغط تحليليا كميتة عالية ، وعند زيادة سرعة البريمة اشارت المعادلات الخطية لزيادة انتاجية البريمة والضغط من الناحية التحليلية ومالت المحاكاة لنفس القيم، اما في زيادة طول البريمة فان المعادلات الخطية كان الانتاجية ثابتة وارتفع الضغط تحليليا ، في المحاكاة انخفضت الانتاجية وزاد الضغط ، فإن طول البريمة لم يؤثر في الإنتاجية تحليليا ولكن في المحاكاة كان إثرة واضح .

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List of abbreviation

Symbol	Description
MFI (g/10min)	Melt flow Index

PP113	Polypropylene extrusion grade product in Khartoum Petrochemical Company(KPC)
PRMSE	Percentage Roots Mean Square Error
D (cm)	Flight diameter
Db (cm)	Barrel diameter
ϕ (dgree)	Helix angle
s (cm)	Screw lead (pitch)
v	Number of flights
W_{FLT} (cm)	Flight width at direction of flow
W (cm)	Channel width at direction of flow
μ_F	Conveying efficiency
N (rev/sec)	Screw speed
ρ_b (g/cm ³)	Bulk density of the polymer
H (cm)	Flight depth
E (cm)	Flight width
δ_{FLT} (cm)	Flight clearance
L (cm)	Length of metering zone
Q_d (cm ³ /s)	drag flow
Q_p (cm ³ /s)	Pressure flow
Q_L (cm ³ /s)	Leakage flow
Q_{Total} (cm ³ /s)	Total flow
dP (dyne/cm ²)	Pressure difference across the metering zone
μ (poise)	Melt shear viscosity
P_{max} (dyne/cm ²)	Maximum pressure
Q_{max} (cm ³ /s)	Maximum flow rate
R_1 (cm)	Radius of the die
L_1 (cm)	length of the die
ΔP (dyne/cm ²)	Pressure drop over the die
K	Function of the die geometry
τ (dyne/cm ²)	Shear stress
$\dot{\gamma}$ (s ⁻¹)	Shear rate
λ (poise)	tensile viscosity
$\dot{\epsilon}$ (s ⁻¹)	tensile strain
Δp_s (dyne/cm ²)	Pressure drop due to shear
Δp_E (dyne/cm ²)	Pressure drop due to extensional flow
P2 (dyne/cm ²)	Pressure drop at die entry
Q_{die} (cm ³ /s)	Flow in die
P_{op} (dyne/cm ²)	Pressure at operating pint
Q_{op} (cm ³ /s)	Flow at operating point
T (°C)	Test temperature
F (dyne)	weigh force
S (sec)	factor of standard time (10 minutes=600s),
t (sec)	time needed for V amount of materials to flow through the capillary
m (gram)	amount of materials flowing through the capillary under t time
ASTM	American Society for Testing and Materials
R_P (cm)	Piston radius
R_C (cm)	Capillary radius

L_C (cm)	Capillary length
\dot{m} (g/s)	Mass flow rate
ρ_m (g/cm ³)	Melt density
μ_{obs}^* (poise)	Observed viscosity
μ_{fit}^* (poise)	Predicted viscosity (fit)
B_{SR}	Swell ratio
FEM	finite element method
FDM	finite difference method
BEM	boundary element method
CFD	computation fluid dynamic
μ_{∞} (poise)	infinite-shear-rate viscosity
μ_0 (poise)	zero-shear-rate viscosity
β (sec)	natural time (i.e., inverse of the shear rate at which the fluid changes from Newtonian to power-law behavior)
a	index that controls the transition from the Newtonian plateau to the power-law region
n	power-law index