OPTIMISATION OF INJECTION MOULDING PROCESS PARAMETERS USING TAGUCHI AND DESIRABILITY FUNCTION

VIVEKANANDAN A/L PANNEERSELVAM

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and, in my opinion, this thesis is adequate in terms of scope and quality for the award of Master of Science.

_____

(Supervisor's Signature)

Full Name : ASSOCIATE PROFESSOR IR. DR. FAIZ BIN MOHD TURAN

Position : ASSOCIATE PROFESSOR

Date : 3 SEPTEMBER 2020

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

(Student's Signature)

Full Name : VIVEKANANDAN A/L PANNEERSELVAM

ID Number : MFM17001

Date : 3 SEPTEMBER 2020

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VIVEKANANDAN A/L PANNEERSELVAM

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ABSTRAK

Pembuatan produk plastik semakin meningkat mengikut keperluan masyarakat. Jadi, proses kitar semula juga menjadi tumpuan yang amat besar untuk mengitar semula produk plastik yang telah digunakan. Walaubagaimanapun, kelemahan mekanikal plastik yang dikitar semula menjadi masalah besar kepada industri plastik. Antara punca utama yang menyebabkan kelemahan mekanikal ialah variasi parameter proses dalam suntikan acuan. Jadi, parameter proses ini perlulah dikawal dengan mengunakan kaedah optimum yang sesuai. Oleh kerana itu, tujuan utama penyelidikkan ini dilaksanakan adalah untuk mengkaji impak parameter-parameter suntikan acuan terhadap kekuatan mekanikal bagi produk plastik kitar semula dan mengoptimumkan proses parameter yang telah dikenal pasti. Bagi mencapai matlamat tersebut, parameter proses yang penting telah dikaji daripada penyelidikan yang telah dijalankan sebelumnya. Kemudian, satu percubaan awal dilaksanakan dengan menggunakan parameter proses yang dipilih dari penyelidikan terdahulu untuk mengenal pasti nilai parameter proses bagi eksperimen utama. Eksperimen utama dijalankan dengan menggunakan L27 OA. Sifat mekanikal produk diukur dari segi kekuatan tegangan dan modulus lenturan masing-masing. Kaedah fungsi "desirability" telah digunakan untuk menkaji dua kriteria kualiti secara serentak. Parameter proses yang optimum dan kesan setiap parameter proses terhadap produk yang dihasilkan juga telah diselidik kaji. Daripada analisis dan hasil experimentasi, parameter proses yang paling banyak memberi kesan terhadap kekuatan tegangan adalah suhu cecair, masa suntikan dan tekanan pegangan. Parameter proses yang paling penting pada modulus lenturan ialah suhu cecair, masa pemegang dan tekanan suntikan. Parameter proses yang optimum adalah 180°C suhu cecair, tekanan suntikan 55 MPa, kelajuan suntikan 30 mm/s, masa suntikan 8 Sec, tekanan pemegang 20 MPa, masa pegangan 3 Sec dan masa penyejukan 25 Sec. Parameter ini telah mengoptimumkan kualiti produk sebanyak 199 kgf/cm^2 kekuatan tegangan dan menghasilkan modulus lenturan sebanyak 10005 kgf/cm^2. Pekara ini, menunjukkan bahawa plastik yang dikitar semula berpotensi digantikan dengan plastik mentah. Oleh itu, permintaan sumber asli dan penggunaan tenaga akibat pengeluaran plastik mentah dapat dikurangkan dan masalah alam sekitar akibat pelupusan plastik juga boleh dikurangkan. Akhir sekali, tindak balas parameter proses terhadap sifat mekanikal plastik yang dikitar semula seperti kekuatan mampatan perlulah diselidiki kaji di masa hadapan untuk mendapatkan sifat mekanikal yang lebih baik.

ABSTRACT

A large amount of plastic parts presently produced, makes it imperative to search for an alternative for recycling or making use of these materials, since they are not biodegradable. Injection moulding, one of the most prevalent plastics processing technique facilities these recycled materials to be substituted for virgin material in producing plastic parts. However, the deterioration in mechanical properties of the part made of recycled plastic is the major drawback that limits the usage of recycled plastic. One of the foremost causes is variation in processing parameters. It is of critical importance to effectively control all the influencing processing parameters during the manufacturing process by an appropriate optimisation method. Therefore, the main goal of conducting this research is to primarily investigate the effects of injection moulding parameters on the mechanical properties of plastic part made of recycled plastic and to optimise the identified process parameters. In order to achieve the goal, the significant process parameters is identified with proper research on previous studies. Then, a preliminary experiment is conducted by using the selected significant process parameters from previous researches to identify the process parameters value for the principal experiment. In this research, the principal experiment is conducted using recycled polypropylene by adopting L27 OA. The mechanical properties of the specimens are measured in term of tensile strength and flexural modulus respectively. From the experimental analysis and results, it is shown that the most significant processing parameters affecting the tensile strength are melt temperature, injection time and holding time. The most effective process parameters on flexural modulus are melt temperature, holding time and injection pressure. The optimum process parameters is 180°C of melt temperature, 55MPa injection pressure, 30mm/s injection speed, 8s injection time, 20MPa holding pressure, 3s holding time and 25s cooling time. These parameters have optimise the part quality to 199 kgf/cm^2 of tensile strength and can result in flexural modulus of 10005 kgf/cm^2. This proves that recycled materials are potentially substituted for virgin material. Therefore, the demand for natural resources and energy consumption due to virgin material production can be reduced and environmental problems due to plastics disposal can be diminished as well. Further in future, more responses on mechanical properties of material such as impact strength and compressive strength should be investigated to obtain even better properties of recycled PP.

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LIST OF SYMBOLS

α	Alpha
μ	Micro
D	Overall desirability function
wt%	Weightage percentage
A	Melt temperature
B	Injection pressure
C	Injection speed
D	Injection time
E	Holding pressure
F	Holding time
G	Cooling time
H	Mould temperature

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CRTM	Compression resin transfer moulding
DOE	Design of experiment
DSC	differential scanning calorimeter
EFB	Empty fruit brunches
(EPDM)/PP	ethylene-polypropylene
GAIM	Gas assisted injection moulding
HDPE	High dense polyethene
LDPE	Low density polyethylene
MAPP	Maleic Anhydride Grafted Polypropylene
MFI	Melt flow index
MPa	Mega Pascal
PE	Polyethylene
p-HDPE	pure high-density polyethylene
PIM	Plastic injection moulding
PP	Polypropylene
PP-HA	Polypropylene-Hydroxyapatite
Psi	Pound force per square inch
r-HDPE	recycled High dense polyethene
RSM	Rough surface method
RTM	Rotation transfer moulding
SSE	Sum of squared error
UV	Ultraviolet
WSD	Wood saw dust

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