

Effect Of Oil Palm Fibre Addition On The Mechanical Properties of
Shell Mould Investment Casting

SOH WEN HANN

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ABSTRACT

This research is aimed to investigate the effect of addition of organic fibre on the mechanical properties of the investment casting ceramic mould based on different length of fibres in the investment. Modulus of rupture (MOR) and permeability of the ceramic mould are evaluated. The MOR test contains three systems: green (undewaxed), green (dewaxed) and fired. The permeability test contains two systems: green (dewaxed) and fired. For the variation of fibre length, 3mm, 5mm, 7mm, 9mm are established. In each system, the MOR and permeability are compared between the fibre addition specimens and the non fibre addition specimen. Oil palm empty fruit bunch fibre is used as the additive in the investments. Colloidal silica and zircon sand are used to produce the ceramic mould. Firing temperature used is 700°C. MOR three point bending testing machine is used to evaluate the strength of the mould. Permeability tester is used to evaluate the permeability of the mould upon the addition of fibres. The results obtained indicated that for the MOR test, the green (dewaxed) system has the highest MOR values than the fired and green (undewaxed) systems. The fired system is shown to have lowest MOR values among the three systems. For the permeability test, as expected. the fired system fibre addition specimens have higher permeability value than the green system.

ABSTRAK

Pengkajian ini bertujuan untuk mengkaji kesan tambahan fiber atas sifat-sifat mekanikal seramik acuan dalam tuangan invesmen berdasarkan panjang fiber yang berlainan. Modulus of Rupture (MOR) dan ketelapan seramik acuan dikaji. Ujian MOR terdiri daripada 3 sistem: hijau (tanpa panyalilinan), hijau (degan panyalilinan) dan penembakan. Ujian ketelapan terdiri daripada 2 sistem: hijau (dengan panyalilinan) dan penembakan. Untuk panjang fiber yang berlainan, 3mm, 5mm, 7mm, 9mm ditubuhkan. Untuk setiap sistem, MOR dan ketelapan dibandingkan diantara spesimen yang ditambah fiber dan spesimen yang tiada fiber. Fiber kelapa sawit diguna sebagai tambahan dalam invesmen. Colloidal silica dan pasir zircon diguna untuk membuat acuan seramik. Suhu penembakan digunakan ialah 700°C. Mesin MOR digunakan untuk mengukur kekuatan acuan. Mesin ketelapan digunakan untuk mengukur ketelapan acuan. Hasil yang didapati menunjukkan bahawa untuk ujian MOR, sistem hijau (dengan panyalilinan) mempunyai MOR yang paling tinggi dibandingkan dengan sistem hijau (tanpa panyalilinan) dan penembakan. Sistem penembakan didapati bahawa mempunyai MOR yang paling rendah diantara 3 sistem-sistem tersebut. Untuk ujian ketelapan, macam yang dijangkakan, sistem penembakan dengan tambahan fiber mempunyai ketelapan yang lebih tinggi daripada sistem hijau.

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LIST OF SYMBOLS

Si	Silicon
HCL	Hydrochloric acid
O	Oxygen
Cl	Chlorine
C	Carbon
H	Hydrogen
Hg	Mercury
Na	Sodium
Zr	Zirconate
N	Nitrogen
Pa	Pascal
MOR	Modulus of rupture

CHAPTER 1

INTRODUCTION

1.1 History of Investment casting

The investment casting or lost wax process has been utilized through history for some 5000 years for the production of ornamental objects, statues and jewelry. It is considered the most ancient of metal casting arts. Technological advances have also made it the most modern and versatile of all metal casting processes.

Investment casting methods are regarded as precise fabrication processes for components having intricate shape and requiring excellent surface finish and dimensional accuracy¹. These methods, which include shell moulding, solid mould casting and numerous similar methods, have been used for decades in jewellery, for casting artworks, in surgery implants and in dental applications.

History of the "lost wax" process can be traced back to 4000 B.C and the use of the process by early civilizations is recorded through the Egyptian and Roman eras to the Bronze Age and Medieval times in Europe². The Aztec gold-smiths of pre-Columbian Mexico used the lost wax process to create much of their elaborate jewelry, and some very nice examples of these works are from the tribe of Quimbaya,

who lived in a little area between the Cauca River and the Micos and Gaiaya rivers. The few castings which survived the plunder of treasure hunters show complete mastery of a difficult and involved technique that must have taken years of trial and error to develop.

Investment casting process emerged in the early 1940's in USA and UK and this process benefited from the jewelers and dentists' work, contributing a major breakthrough for manufacturing of complex components with high precision, accuracy, complex geometries and sizes and good surface finish². Until today, many researches have been done to improve and enhance the investment casting process, reducing the defects and other problems associated with process.

1.2 Recent researches in Investment casting process

In this research by Qingbin Liu, Ming C.Leu, Von L.Richards and Ross Laurent³, the researches used ice as the pattern for the investment casting. The advantages of the ice are cheap, readily availability, contractions during melting, high quality and good surface finish. The ceramic moulds were done at sub-zero temperature in favor of the ice pattern used. Experimentation was carried out to evaluate the fracture toughness of the ice pattern-made ceramic mould. Surprisingly, the samples tested had exceedingly low strength which led to more understanding and analysis of the failure of the mould. However, the ice pattern method proved to be viable method as this was demonstrated with casting of M8 bolt by the researches.

The addition of fibres into the slurry to improve the conditions of the investment casting has steadily become a practice for the foundries and manufacturer. The use of alcohol based binder such as ethyl silicate has been limited environmental protection bodies due to the toxic fumes and gas emitted. The use of colloidal silica

binder which is water based thus increases. However, the water based colloidal silica gels very slowly and needs of expensive polymer additions such as latex polymer.

In the research by S.Jones and C.Yuan ⁴, nylon fibres was added to the colloidal based slurry and the results on the strength and permeability of the mould were compared to the polymer addition slurry. The addition of fibres has proven a viable method rivaling the use of expensive polymer with improved permeability and enhanced green strength.

Another research was also done to address the above problems. In this research by Lee C.S and Sulai E ⁵, rice husk had been used as the additive to the slurry instead of fibres. Experiments were done to test the strength and the permeability of the ceramic mould produced. Mould permeability showed improvement with the addition of rice husk. However the strength decreased with the addition of rice husk. Further work will be done to address this problem.

1.3 Problem statement

The use of fibre as an alternative to the expensive polymer to improve the permeability and strength had been researched by S.Jones and C.Yuan ⁴. However, the research on how the orientation of fibre and fibre length in the slurry will influence the mould strength and permeability has never been done. In this paper, the effect of variation in fibre length on the mould green and fired strength and permeability will be studied

1.4 Objectives

- 1) To determine the viability of organic fibres in producing investment casting ceramic mould
- 2) To study the effects of oil palm fibre addition to the mechanical properties such as strength (green and fired) and permeability of shell mould of investment casting based on different fibre length.
- 3) To compare the permeability and strength of fibre-modified ceramic mould to the ordinary mould.

1.5 Scope

For this thesis work, couple of scopes are defined to achieve the objectives of the project and are shown as below:

- 1) The fibre length is varied for 3mm, 5mm, 7mm, 9mm.
- 2) Refractory binder used is colloidal silica.
- 3) Refractory filler used is zircon sand.
- 4) Fibre used is organic oil palm fibre.