

FABRICATION, CHARACTERISATION AND PROPERTIES OF
POLYSILOXANE RICE HUSK SILICA COMPOSITES

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To my precious Allah S.W.T,
who gave me new life, hope and purpose of life.

To my beloved Prophet Muhammad S.A.W,
who gave me a guidance thru his sunnah and hadis.

To Mama, Papa and my in laws,
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ABSTRACT

The polysiloxane silica composites were fabricated and characterised as to elucidate the feasibility of casting (CA) and compression (CO) method. Besides, the contribution of rice husk silica (RHA SiO₂) and crystalline silica (CS) in enhancing the composites properties were also investigated. Moreover, fabricated composites were applied in hand grinder as a vibration damper and the performance had been analysed. The important issues covered in this study were the contribution of RHA SiO₂ instead of using CS as a filler and the investigation of most ideal parameter in improving thermal, physical, mechanical and vibration properties of composites. The polysiloxane composites were analysed and compared with various parameters i.e; composition of fillers (2wt% to 12wt%) and curing temperatures (room temperature (RT), 65 and 100°C). Addition of 10wt% RHA SiO₂ had found to contribute better performance compared to CS addition, accredited to RHA SiO₂ density and surface morphology. As for the fabrication effects, CO method was found to offer composites with better tensile and vibration properties. However, as for the thermal behavior, CA method yielded composites with better thermal stability due to better filler distribution on surface of the composites. On the other hand, the increment of curing temperature does not show significant effect in improving thermal properties as the thermal stability were decreased due to interferences of curing network stability. However, the polysiloxane composites cured at 65°C and 100°C were found to offer better tensile and vibration properties. Throughout the observations, the maximum performance of thermal, tensile and vibration behavior for polysiloxane composites were achieved by addition of 10wt% RHA SiO₂, fabricated using CO method and cured at 100°C.

ABSTRAK

Komposit polysiloxane silika dihasilkan dan diperincikan bertujuan mengenal pasti sumbangan kaedah tuangan (CA) dan mampatan (CO) terhadap sifat bahan komposit. Selain itu sumbangan silika sekam padi (RHA SiO₂) dan silika terhablur (CS) dalam meningkatkan sifat bahan komposit turut dikenal pasti. Komposit polysiloxane silika turut diaplikasikan pada mesin canai tangan sebagai peredam getaran dan prestasinya dianalisa. Antara isu penting yang diketengahkan di dalam kajian ini adalah sumbangan RHA SiO₂ berbanding CS sebagai pengisi dan pencarian parameter yang paling ideal untuk meningkatkan sifat terma, fizikal, mekanikal dan getaran. Komposit polysiloxane silika juga turut dianalisa dan dibandingkan dengan pelbagai parameter seperti suhu terawat (RT, 65°C and 100°C) dan peratusan berat (wt%) pengisi, iaitu antara 2wt% ke 12wt%. Penambahan 10wt% RHA SiO₂ didapati telah menyumbang prestasi lebih baik berbanding penambahan CS, kesan daripada ketumpatan dan morfologi permukaan RHA SiO₂. Dari sudut kesan fabrikasi, kaedah CO menawarkan sifat tegangan dan getaran yang lebih baik. Walau bagaimanapun, kaedah CA telah menawarkan sifat terma yang lebih baik berikutan susunan pengisi pada permukaan komposit. Melalui pemantauan ke atas suhu terawat komposit, peningkatan suhu terawat tidak memberi kesan dalam menambah baik sifat terma berikutan terdapat penurunan di dalam kestabilan terma disebabkan oleh gangguan terhadap kestabilan jaringan terawat. Walau bagaimanapun, komposit polysiloxane terawat pada suhu 65°C and 100°C menawarkan peningkatan sifat tegangan dan getaran. Secara keseluruhan, sifat maksima bahan komposit polysiloxane boleh dicapai melalui penambahan 10wt% RHA SiO₂ sebagai pengisi, difabrikasi melalui kaedah mampatan dan terawat pada suhu 100°C.

TABLE OF CONTENTS

TITLE	i
DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
TABLE OF CONTENTS	vii
LIST OF TABLES	xii
LIST OF FIGURES	xvii
LIST OF SYMBOLS AND ABBREVIATIONS	xxi
LIST OF APPENDICES	xxii
CHAPTER 1 INTRODUCTION	1
1.1. Introduction	1
1.2. Problem Statement	2
1.3. Objectives	3
1.4. Scope of Study	4
1.5. Novelty and Contribution	5
CHAPTER 2 LITERATURE REVIEW	7
2.1. Filled Polymer Composites	7
2.1.1. Matrix	7
2.1.2. Fillers	9
2.1.3. Properties of Filled Polymer Composites	10
2.2. Polysiloxane Group	14
2.2.1. Types of Room Temperature Vulcanised (RTV)	
Silicone Rubber	17
2.2.1.1. Room Temperature Vulcanised One	
Pack System (RTV-1) Silicone Rubber	17

2.2.1.2. Room Temperature Vulcanised Two Pack System (RTV-2) Silicone Rubber	19
2.2.2. Types of High Temperature Vulcanised (HTV) Silicone Rubber	20
2.2.2.1. Liquid Silicon Rubber (LR)	21
2.2.2.2. Solid Silicon Rubber (SR)	22
2.2.3. Application of Polysiloxane	25
2.3. Polysiloxane and its composites Properties	29
2.3.1. Molecular Arrangement	29
2.3.2. Thermal Properties	31
2.3.3. Mechanical Properties	35
2.4. Polysiloxane Fabrication	38
2.4.1. Casting	39
2.4.2. Compression Molding	40
2.5. Silica as a Filler	42
2.5.1. Crystalline Silica	43
2.5.1.1. Phase of Crystalline Silica	43
2.5.1.2. Elemental Composition in Crystalline Silica	46
2.5.1.3. Molecular Arrangement in Crystalline Silica	47
2.5.1.4. Surface Morphology of Crystalline Silica	48
2.5.1.5. Particle Size of Crystalline Silica	49
2.5.1.6. Density of Crystalline Silica	50
2.5.2. Rice Husk Ash as Silica	51
2.5.2.1. Phase of Rice Husk Silica	51
2.5.2.2. Elemental Composition of Rice Husk Silica	54
2.5.2.3. Molecular Arrangement of Rice Husk Silica	57
2.5.2.4. Surface Morphology of Rice Husk Silica	59
2.5.2.5. Particle Size of Rice Husk Silica	63
2.5.2.6. Density of Rice Husk Silica	65
2.6. Vibration Exposure: Role of Material	66



2.7. Overview of Polysiloxane Composites Properties:	
Thermal, Tensile and Vibration	76
CHAPTER 3 METHODOLOGY	77
3.1. Raw Material and Equipment	79
3.2. Pre-Fabrication	80
3.3. Composites Fabrication	82
3.3.1. Mixing and Compositioning	84
3.3.2. Casting	88
3.3.3. Compression Molding	90
3.4. Characterisation of Raw Material and Polysiloxane Composites	91
3.4.1. Phase Analysis	93
3.4.2. Elemental Analysis	94
3.4.2.1. Energy Dispersive X-ray Spectroscopy (EDS)	94
3.4.2.2. X-ray fluorescence (XRF)	95
3.4.3. Molecular Analysis	96
3.4.4. Morphological Analysis	97
3.4.5. Particle Size Analysis	98
3.5. Physical Properties Analysis	99
3.5.1. Density Test for Polysiloxanes Composites	99
3.5.2. Bulk Density Test for CS and RHA SiO ₂	100
3.5.3. Viscosity of Polysiloxane and Polysiloxane Composites	102
3.6. Thermal Properties Analysis: Thermal Decomposition Behavior	103
3.7. Mechanical Properties Test – Tensile	104
3.8. Vibration Exposure Measurement	108
CHAPTER 4 RESULTS AND DISCUSSIONS	111
4.1. Characterisation of Silica as Filler	111
4.1.1. Phase Analysis	111
4.1.2. Elemental Analysis of Filler	113
4.1.3. Elemental Analysis of Filler in Composite Panel	116



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4.1.4. Molecular Analysis	117
4.1.5. Morphological Analysis	120
4.1.6. Particle Size Analysis	123
4.1.7. Density Analysis	124
4.2. Characterisation of Polysiloxane Composites	126
4.2.1. Viscosity Analysis of CS/ RHA SiO ₂ - Polysiloxane Mixture	126
4.2.2. Characterisation of CS-Polysiloxane Composites Fabricated <i>via</i> Casting Method (CS- Polysiloxane-CA)	129
4.2.2.1. Molecular Analysis	129
4.2.2.2. Morphological Analysis	133
4.2.2.3. Density Analysis	136
4.2.3. Characterisation of CS-Polysiloxane Composites Fabricated <i>via</i> Compression Method (CS-Polysiloxane-CO)	139
4.2.3.1. Molecular Analysis	139
4.2.3.2. Morphological Analysis	142
4.2.3.3. Density Analysis	145
4.2.4. Characterisation of -Polysiloxane Composites Fabricated <i>via</i> Casting Method (RHA SiO ₂ - Polysiloxane-CA)	148
4.2.4.1. Molecular Analysis	148
4.2.4.2. Morphological Analysis	152
4.2.4.3. Density Analysis	155
4.2.5. Characterisation of Polysiloxane Composites Fabricated <i>via</i> Compression Method (RHA SiO ₂ - Polysiloxane-CO)	157
4.2.5.1. Molecular Analysis	157
4.2.5.2. Morphological Analysis	162
4.2.5.3. Density Analysis	165
4.3. Effects of Types of Silica to Polysiloxane Composites Behavior	167
4.3.1. Thermal Behaviors	167



4.3.2. Tensile Behaviors	172
4.3.3. Vibration Behaviors	182
4.4. Effects of Fabrication Methods to Polysiloxane	
Composites Behavior	191
4.4.1. Thermal Behaviors	191
4.4.2. Tensile Behaviors	197
4.4.3. Vibration Behaviors	207
4.5. Effects of Curing Temperatures to Polysiloxane	
Composites Behavior	213
4.5.1. Thermal Behaviors	213
4.5.2. Tensile Behaviors	218
4.5.3. Vibration Behaviors	227
CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS	234
5.1. Conclusions	234
5.2. Recommendations	235
REFERENCES	237
APPENDICES	248
VITA	



LIST OF TABLES

2.1	Types of polymers in filled polymer systems	9
2.2	Example of fillers	10
2.3	Example of filled polymer systems	11
2.4	Functional fillers: types and predominant properties	13
2.5	General properties of RTV-1 silicone rubber	18
2.6	General properties of RTV-2 silicone rubber	20
2.7	General properties of LR	22
2.8	General properties of SR	24
2.9	Peroxide and addition curing differences of SR	25
2.10	Summary of polysiloxane application	26
Table 2.11	FTIR comparison on polysiloxane properties	30
Table 2.12	Thermal Properties of Polysiloxane	34
Table 2.13	Tensile properties of polysiloxane	36
Table 2.14	Selection of polysiloxane process	39
2.15	Identified peak in quartz crystalline silica	45
2.16	Elemental composition of crystalline silica quartz	46
2.17	FTIR Spectra of silica based on various authors	48
2.18	Crystalline silica filler sizing from manufacturer	49
2.19	Bulk density of silica	50
2.20	The range of constituent in rice husk	51
2.21	2 θ broad peak characteristic of amorphous rice husk silica	53
2.22	RHA SiO ₂ element concentration comparison	55
2.23	Band assignment of rice husk silica FTIR spectrum analysis	58
2.24	Mean particle size of rice husk silica	64
2.25	Bulk density of rice husk silica	65
2.26	Summary on role of material in vibration exposure	67

2.27	Metal for vibration damping purposes	71
3.1	Raw material details	79
3.2	Equipments Details	79
3.3	Types of polysiloxane composites fabrication	83
3.4	Casting curing parameter	89
3.5	Compression molding curing temperature	91
3.6	Testing list and standard used throughout the study	92
4.1	Comparison of 2θ degree position of peaks obtained	112
4.2	Peak of XRD for RHA SiO_2	113
4.3	CS element concentration	114
4.4	RHA SiO_2 element concentration comparison	115
4.5	EDS profiles of CS-polysiloxane composites	116
4.6	EDS profiles of RHA SiO_2 -polysiloxane composites	117
4.7	Band Assignments of Unahan-Chem CS	118
4.8	Band assignments comparison of FTIR for RHA SiO_2	120
4.9	Particle size and percentage	123
4.10	CS size comparison	123
4.11	Particle size and percentage of RHA SiO_2	124
4.12	Comparison of CS bulk density	125
4.13	Comparison of RHA SiO_2 bulk density	125
4.14	Differences of filler volume used at 12wt% filler used	128
4.15	Molecular analysis summary of CS-Polysiloxane composites fabricated <i>via</i> CA method	131
4.16	Surface morphology characterization summary of CS-polysiloxane-CA composites	134
4.17	Density of CS-Polysiloxane-CA composite	137
4.18	Molecular analysis summary of CS-Polysiloxane composites fabricated <i>via</i> CO method	141
4.19	Surface morphology characterization summary of CS-Polysiloxane-CO composites	145
4.20	Density of CS- Polysiloxane-CO composites	146
4.21	Molecular analysis summary of RHA SiO_2 -polysiloxane composites fabricated <i>via</i> CA method	150

4.22	Surface morphology characterization summary of RHA-SiO ₂ -polysiloxane-CA composites	154
4.23	Density of RHA SiO ₂ - Polysiloxane-CA	155
4.24	Molecular analysis summary of RHA SiO ₂ -polysiloxane composites fabricated via CO method	160
4.25	Surface morphology characterization summary of RHA-SiO ₂ -polysiloxane-CO composites	164
4.26	Density of RHA SiO ₂ - Polysiloxane-CO	165
4.27	Range of decomposition temperature for polysiloxane filled RHA SiO ₂ composite and polysiloxane filled CS composite	170
4.28	Range of tensile strength for RHA SiO ₂ and CS Polysiloxane composites	175
4.29	Range of modulus elasticity for RHA SiO ₂ and CS-Polysiloxane	178
4.30	Peak tensile behavior comparison on 10wt% RHA SiO ₂ -Polysiloxane composites vs 2wt% CS-Polysiloxane-composites vs polysiloxane (CO method, 100°C cured)	179
4.31	Comparison on filler mass and volume in polysiloxane composites	180
4.32	Comparison on surface morphology and related properties of RHA SiO ₂ and CS-Polysiloxane composites and CS-Polysiloxane composites	181
4.33	Range of frequency weighted acceleration for polysiloxane filled RHA SiO ₂ and CS composites	186
4.34	Measured frequency weighted acceleration and total daily exposure duration of bare handle vs Polysiloxane vs RHA SiO ₂ -Polysiloxane composites and CS-Polysiloxane composites	187
4.35	Comparison of vibration distribution	189
4.36	Comparison on filler mass and frequency weighted acceleration in polysiloxane composites	190
4.37	Range of decomposition temperature for polysiloxane composites fabricated via CA and CO method	195

4.38 Schematic of morphology in CA and CO fabricated composites	196
4.39 Surface morphology characteristic on CA and CO fabricated composites	197
4.40 Range of tensile strength for CA and CO fabricated composites	201
4.41 Range of modulus elasticity for CA and CO fabricated composites	201
4.42 Peak tensile behavior comparison on CA Polysiloxane composites vs CO polysiloxane composites (10wt% RHA SiO ₂ , 100°C cured)	203
4.43 Surface morphology comparison on CA Polysiloxane Composites vs CO Polysiloxane Composites	204
4.44 Schematic of CA and CO method fabricated composites as tension load applied	206
4.45 Range of frequency weighted acceleration for polysiloxane composites fabricated <i>via</i> CA and CO method	210
4.46 Vibration behavior comparison on Polysiloxane-CA composites vs polysiloxane-CO composites	211
4.47 Density comparison of Polysiloxane-CA composites vs Polysiloxane-CO composites	213
4.48 Range of decomposition temperature for polysiloxane composites cured at RT, 65°C and 100°C	217
4.49 Range of tensile strength for RT, 65°C and 100°C cured composites	222
4.50 Range of modulus elasticity for RT, 65°C and 100°C cured composites	224
4.51 Tensile behavior comparison on RT cured polysiloxane composites vs 65°C cured vs 100°C cured	225
4.52 Comparison on relation between density and tensile behavior at different curing temperature	226
4.53 Range of frequency weighted acceleration for polysiloxane composites cured at RT, 65°C and 100°C	231

4.54 Vibration behavior comparison on polysiloxane bare
handle grip vs composites RT cured vs 65°C cured vs
100°C cured

232



LIST OF FIGURES

2.1	Dimethyl siloxane unit	14
2.2	Category of polysiloxane	16
2.3	Example of FTIR molecular arrangement analysis for unfilled and filled polysiloxane	29
2.4	TGA polysiloxane	32
2.5	Stress strain graph of Polysiloxane	35
2.6	Compression molding of polysiloxane	41
2.7	Silica phase diagram	44
2.8	XRD diffractogram of quartz crystalline silica	45
2.9	FTIR spectra of silica	48
2.10	Surface morphology of quartz	49
2.11	XRD of amorphous silica (Fernandes et al., 2016)	52
2.12	FTIR spectra of rice husk silica and rice husk silica filled composites	58
2.13	SEM images of (a) RHA before grinding; RHA after grinding with some magnifications: (b) 1250x; (c) 5000x; and (d) fumed silica	60
2.14	SEM of rice husk silica at different magnification (a) 80x; (b) 40x (c) 1000x; (d) 2000x	61
2.15	SEM image of rice husk silica	62
2.16	SEM images of untreated rice husk silica (a) 1000x magnification; (b) 10000x	63
2.17	Hand grip and coating attachment on hand drill	73
2.18	Acceleratometer attachment on hand grip	75
3.1	Overall flow chart of research methodology	78
3.2	Rice husk conversion to RHA SiO ₂	81

3.3	Fritsch Vibratory Sieve Shaker Analysette 3	82
3.4	Mixing and casting process of polysiloxane	89
3.5	Wabash hot press machine for compression molding	91
3.6	XRD Bruker D8 Advance	93
3.7	Specimen holder	93
3.8	Example of an EDS spectrum	94
3.9	Bruker S4 Pioneer XRF	95
3.10	Perkin Elemer FTIR Spectrum 100 Spectrometer	96
3.11	SEM JEOL JSM-6380LA	97
3.12	JEOL Autofine Coater JFC-1600	98
3.13	Malvern particle analyzer Mastersizer Hydro 2000MU	98
3.14	XS64 Mettler Toledo density determination kit	99
3.15	Bulk density apparatus	101
3.16	Brookfield LVDV-I Prime MLVT115 viscometer	102
3.17	Linseis Thermobalance D8762 SELB	103
3.18	Relative mass-temperature graph for decomposition temperature determination	104
3.19	Shimadzu AG-1 10kn Universal testing machine	105
3.20	Dumbbell die type C dimension and test specimen dimension	105
3.21	Prepared test specimen cut using dumbbell die type C	106
3.22	Determination of tensile behavior throug stress-strain graph	107
3.23	GWS 8-1 100CE Bosch hand grinder	108
3.24	(a) HVM100 Human Vibration Meter; (b) HVM100 accelerometer	109
3.25	(a) Polysiloxane wrapped hand grinder grip; (b) unwrapped hand grinder grip	110
4.1	XRD pattern for CS	112
4.2	RHA SiO ₂ XRD result	113
4.3	FTIR of Unahan-Chem CS	118
4.4	FTIR of RHA SiO ₂ and RH	119
4.5	SEM of CS at (a) 35 and (b) 1000 magnification	121

4.6	SEM micrograph of RHA SiO ₂ at (a) 350 magnification (b) 1000 magnification.	122
4.7	Viscosity of RHA SiO ₂ -polysiloxane composites	126
4.8	Viscosity of CS-polysiloxane composites	127
4.9	FTIR of CS-Polysiloxane composites fabricated <i>via</i> CA method	130
4.10	Density vs wt% of CS-Polysiloxane-CA composites	137
4.11	FTIR of CS-polysiloxane composites fabricated <i>via</i> CO method	140
4.12	Density vs wt% of CS-Polysiloxane-CO composites	146
4.13	FTIR of RHA SiO ₂ -polysiloxane composites fabricated <i>via</i> CA method	149
4.14	Density vs wt% of RHA SiO ₂ - Polysiloxane-CA	155
4.15	FTIR of RHA SiO ₂ -polysiloxane composites fabricated <i>via</i> CO method	159
4.16	Density vs wt% of RHA SiO ₂ -Polysiloxane-CO composites	165
4.17	Decomposition temperature of polysiloxane filled RHA SiO ₂ composite	168
4.18	Decomposition temperature of polysiloxane filled CS composite	169
4.19	Tensile strength of polysiloxane filled RHA SiO ₂ and CS composites	173
4.20	Modulus elasticity of polysiloxane filled RHA SiO ₂ and CS composites	176
4.21	Frequency weighted acceleration of polysiloxane filled RHA SiO ₂ and CS composites	184
4.22	Decomposition temperature of polysiloxane composites fabricated <i>via</i> CA method	193
4.23	Decomposition temperature of polysiloxane composites fabricated <i>via</i> CO method	194
4.24	Tensile strength of polysiloxane composites fabricated <i>via</i> CA and CO method	198
4.25	Modulus elasticity of polysiloxane composites fabricated <i>via</i> CA and CO method	200

4.26	Frequency weighted acceleration of polysiloxane composites fabricated <i>via</i> CA and CO method	208
4.27	Decomposition temperature of polysiloxane composites cured at RT, 65°C and 100°C	215
4.28	Tensile strength of polysiloxane composites cured at RT, 65°C and 100°C	220
4.29	Modulus elasticity of polysiloxane composites cured at RT, 65°C and 100°C	223
4.30	Frequency weighted acceleration of polysiloxane composites cured at RT, 65°C and 100°C	229



LIST OF SYMBOLS AND ABBREVIATIONS

<i>CA</i>	-	Casting
<i>CO</i>	-	Compression
<i>CS</i>	-	Crystalline Silica (Current Study)
<i>M_c</i>	-	Mass of Composite, g
<i>M_f</i>	-	Mass of Filler, m
<i>M_m</i>	-	Mass of Matrix, g
ρ_c	-	Density of Composites, g/cm ³
ρ_f	-	Density of Filler, g/cm ³
ρ_m	-	Density of Matrix, g/cm ³
RHA SiO ₂	-	Rice Husk Silica (Current Study)
RT	-	Room Temperature
RTV	-	Room Temperature Vulcanised
<i>V_c</i>	-	Volume of Composites, g
<i>wt%</i>	-	Weight Percentage

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Theoretical Density of Composites	247
B	Mixing and Compositioning of CS- Polysiloxane Composites	248
C	Mixing and Compositioning of RHA SiO ₂ - Polysiloxane Composites	249
D	Morphology of Polysiloxane Composites	250
E	Particle size of Filler	260
F	Density of Filler	261



CHAPTER 1

INTRODUCTION

1.1. Introduction

Particulate polymer composites are also known as filled polymers due to the incorporation of filler material in form of particle. Particulate composites consist of heterogeneous systems which imply that, the filler and polymers flow and disperse together during processing (Leblanc, 2009).

Particulate polymer composites offer interesting mechanical, physical and rheological properties resulting from polymer matrix and filler dispersed phase interaction. Polymer matrix and filler would have to be prepared through mixing process which requires specific equipment in order to achieve uniform dispersion of fillers in the polymer matrix (Pal, 2010)

The importance of filler addition on polymer is to modify properties, either mechanical properties in example stiffness, modulus, or physical properties for conductivity or density or rheological properties such as viscoelasticity or viscosity (Leblanc, 2009).

This study focuses on improving polysiloxane properties by incorporation of silica filler. Polysiloxane or so called as silicone rubber were filled with naturally derived silica produced *via* rice husk burning designated as RHA SiO₂ and Crystalline Silica (CS). Several previous studies have shown that filling polysiloxane with reinforced filler enhanced polysiloxane in terms of its physical, mechanical and chemical properties (Ahmed, Nizami, & Riza, 2014).

Polysiloxane is categorised as an elastomer which is in the polymeric material family. Generally, polysiloxane are known for their biocompatibility, high thermal stability, hydrophobic nature, electrical and release properties (Jerschow, 2001). Polysiloxane also offer rubber-like properties due to the outstanding elasticity properties. Elasticity of rubber like material is definitely the most important parameter in reducing vibration source of machine to avoid hand arm vibration syndrome that may affect neurological and vascular disorders (Chaturvedi, Kumar, & Singh, 2012; J. Singh & Khan, 2014).

1.2. Problem Statement

The usage of engineering works and processes which involved the application of powered tool leads to exposure of hand arm vibration among operators. The vibration source may arise from rotating and percussive hand held power tool. Hand transmitted vibration also may occur from vibrating workpieces. Extreme hand arm vibration would affect hand arm neurological and motor functions and induce disturbances in finger blood flow (BS EN ISO, 2001). Current practice, the most used material as a vibration damper were polymer and elastomer material including polysiloxane. High elasticity of polysiloxane is the most suitable candidate in reducing vibration source. Thus, in order to elucidate the performance of polysiloxane and filled polysiloxane composites as a vibration damper, the contribution of silica as a filler in reducing the hand arm vibration of portable hand grinder were revealed.

Thermal degradation is a common problem of polymer material which leads to material properties decreased. Heat, lights and chemicals are the main cause of

polymer degradation (Moeller, 2007). In order to reduce the tendency of polymer to degrade, the role of silica as thermal stability agent were analysed. Silica offers high thermal properties with thermal coefficient at $0.55 \cdot 10^{-6}/^{\circ}\text{C}$, and thus by combining with polysiloxane, it had offered thermal stability.

Since silica acts as a reinforcing filler in polysiloxane matrix, it can also improve the mechanical properties of the composites. However the suitable filler-matrix ratio have to be identified, since the contribution of filler addition in enhanced material properties are limited. Once filler composition exceeds the filler maximum ratio, agglomeration or weak filler-matrix bonding of the composites will occur and lead to decrement of mechanical properties (G V Kozlov, IAnovskii, & Zaikov, 2010; Georgii V Kozlov, 2015). Thus, various parameter such weight percentage (wt%) of filler, curing parameter and characteristics of filler during mixing could be considered in order to improve the thermal, tensile and vibration behavior.

Rice husk as one of the agricultural waste is indeed one of many efforts in controlling our environment sustainability. The usage of manufactured resources compared to natural resources may produce pollution and waste that may affect our environment. Thus, the current study explored and compared the contribution two types of silica namely RHA SiO_2 and CS. The ability of RHA SiO_2 properties in replacing CS were revealed. Besides the mass production method in producing RHA SiO_2 were also revealed by controlling the incineration holding hours and temperature.

1.3. Objectives

In accomplishing successful fabrication and characterization of Polysiloxane Silica Composites, the following objectives had been fulfilled:

- (i) To investigate the suitability of naturally derived amorphous rice husk silica (RHA SiO_2) and manufactured crystalline silica (CS) as filler in polysiloxane : silica composites.

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