



**UNIVERSITI PUTRA MALAYSIA**

**DEVELOPMENT OF SEMI AUTOMATIC H-OMETER EQUIPMENT**

**MOHD SAL BIN SALSIDU**

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**DEVELOPMENT OF SEMI AUTOMATIC H-OMETER EQUIPMENT**

**BY**

**MOHD SAL BIN SALSIDU**

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*Specially dedicated to My Beloved*

*Father*

Salsidu Hj. Kamsoy

*Mother*

Abing Ereh

*Family*

Allahyarhamah Sitti Adzmah Salsidu

Roziyah Salsidu

Nitih Salsidu

Muhamad Paysal Salsidu

Mohd Ainal Salsidu

Mohd Radman Salsidu

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Sugiana Salsidu

Norima Salsidu

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By

**MOHD SAL BIN SALSIDU**

**SEPTEMBER 2002**

**Chairman : Associate Professor Husaini Bin Omar, Ph.D.**

**Faculty : Engineering**

Semi Automatic H-Ometer (SAHO) equipment was developed to enhance H-Ometer testing. The SAHO was developed using a total design concept, which involved proposed design and specifications, conceptual design, detailed design, and fabrication and testing. The conceptual design was the most critical stage in the design process and two methods were used in the design of SAHO. The methods were the Product Design Specification (PDS) and Morphological Chart (MC). Based on these methods, eight possible concepts were generated. The Pugh selection method was used for the final selection of possible concepts and a combination of concepts 5 and 7 was chosen. Based on selected concepts, SAHO consists of seven major parts which are casing, vertical mover, sliding unit, stand, control unit, Automatic Probe Changer (APC) and sample stand. The major parts were modeled using AutoCAD software while the analysis of the critical parts were undertaken with Finite Element Analysis (FEA). The SAHO is likely to enhance H-Ometer testing as it will have the capability to test a variety of sample materials.



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## **REKABENTUK MESIN SEPARA AUTOMATIK H-OMETER**

Oleh

**MOHD SAL BIN SALSIDU**

**SEPTEMBER 2002**

**Pengerusi : Profesor Madya Husaini Bin Omar, Ph.D.**

**Fakulti : Kejuruteraan**

Mesin Operasi Separa Automatik H-Ometer (SAHO) telah direkabentuk untuk meningkatkan keupayaan ujian H-Ometer. SAHO direkabentuk menggunakan konsep rekabentuk keseluruhan yang melibatkan rekabentuk cadangan dan speksifikasi, rekabentuk konsep, rekabentuk terperinci, dan membina serta menguji. Rekabentuk konsep merupakan peringkat kritikal di dalam proses rekabentuk dan terdapat dua kaedah digunakan di dalam rekabentuk SAHO. Kaedah itu ialah Speksifikasi Rekabentuk Produk (PDS) dan Carta Morfologi (MC). Berdasarkan kaedah tersebut, terdapat lapan konsep kemungkinan telah dihasilkan. Kaedah pilihan Pugh digunakan di dalam memilih konsep akhir dan kombinasi konsep 5 dan 7 telah dipilih. Berdasarkan konsep pilihan, terdapat tujuh bahagian utama terdiri daripada kotak, penggerak tegak, unit gelingsir, tapak, unit kawalan, penukar probe automatik dan tapak sampel. Bahagian ini telah dimodelkan menggunakan perisian AutoCAD manakala bahagian kritikal di analisis menggunakan kaedah elemen keterhinggaan. SAHO di lihat menambah kemampuan H-Ometer di dalam menguji pelbagai jenis sampel bahan.



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## TABLE OF CONTENTS

	<b>Page</b>
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	iv
ACKNOWLEDGEMENTS	v
APPROVAL SHEET	vi
DECLARATION	viii
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF ABBREVIATIONS	xvii
 <b>CHAPTER</b>	
<b>I INTRODUCTION</b>	<b>1</b>
Background	1
Problem Statement	4
Research Aims and Objectives	5
Scope and Limitation	5
Expected Outcome of the Research	6
 <b>II LITERATURE REVIEW</b>	 <b>7</b>
Introduction	7
Applications of Measuring Device in Geotechnical Engineering	8
H-Ometer	14
Key Features of the H-Ometer	16
Testing Procedures of the H-Ometer	21
Calibration	21
Inserting Technique	26
Advance Manufacturing Technology	28
Programmable Logic Controller	29
The Components of a Programmable Logic Controller (PLC)	31
Application of PLC	35





	Automatic Tools Changer (ATC)	36
	Industrial Robot for Testing Application	38
	CAD/CAM	40
	Total Design Technique	42
	Market Phase	44
	Product Design Specification (PDS)	45
	Conceptual Design	46
	Materials Selection Method	49
	Design Analysis	51
	Finite Element Analysis	51
	Current Practice	53
	Design for Safety	55
<b>III</b>	<b>METHODOLOGY</b>	<b>58</b>
	Introduction	58
	Proposed Design of Semi Automatic H-Ometer (SAHO) Equipment	60
	Conceptual Design	63
	Materials Selection	65
	Design Major Parts of SAHO Equipment	66
	Design Analysis	67
	Detailed Design	69
<b>IV</b>	<b>RESULTS AND DISCUSSION</b>	<b>70</b>
	Introduction	70
	Conceptual Design	71
	Product Design Specification (PDS)	72
	Morphological Chart	76
	Generation of Possible Concepts of SAHO Equipment	79
	Pugh Selection Matrix Method	88
	Final Conceptual Design of SAHO	92
	Materials Selection	93
	Detailed Design	100
	Geometric Modeling	101
	Part 1:Automatic Probe Changer (APC)	101
	Part 2: Casing of SAHO Equipment	104
	Part 3: Stand of SAHO Equipment	106
	Part 4: Sample Stand	107
	Part 5: Vertical Mover (Ball Screw and Motor)	108
	Part 6: Sliding Units	110
	Part 7: Control Unit	111
	Design Analysis	112
	Finite Element Analysis (FEA) of critical parts	113
	Component analysis	116



Control System	136
Testing of SAHO Equipment	139
Capability of SAHO Equipment	143
Fabrication Cost	144
<b>V CONCLUSIONS AND RECOMMENDATIONS</b>	<b>146</b>
Major Findings	148
Future Studies	149
<b>REFERENCES</b>	<b>150</b>
<b>APPENDICES</b>	
1 PLC Programming	156
2 Drawing of SAHO Equipment (Conceptual and Detailed Drawing)	171
3 Assembly Drawing of SAHO Equipment	189
4 Properties of Material Used	197
5 SAHO Equipment Tests	211
6 Fabrication Costs	226
<b>VITA</b>	<b>234</b>



## LIST OF TABLES

<b>Table</b>	<b>Page</b>
2.1 A chronological record of developments in instrumentation technology	9
4.1 The major elements of PDS according to Dieter	73
4.2 Pugh concept selection method for SAHO equipment	91
4.3 Pugh selection method for casing	94
4.4 Pugh selection method for sliding unit	95
4.5 Pugh selection method for vertical mover	96
4.6 Pugh selection method for Automatic Probe Changer (APC)	97
4.7 Pugh selection method for SAHO equipment & sample stand	98
4.8 Summary of materials selection for SAHO equipment	99
4.9 Result of tensile strength of artificial specimen tested by SAHO equipment	142
4.10 Cost of SAHO equipment parts	145



## LIST OF FIGURES

<b>Figure</b>		<b>Page</b>
2.1	Types of field and laboratory testing device in geotechnical field	10
2.2	Schematic diagram of prebored pressuremeter	12
2.3	Schematic diagram of a dilatometer	13
2.4	Schematic diagram of H-Ometer probe	15
2.5	The components that make up the H-Ometer	18
2.6	Types of H-Ometer probes and their application	19
2.7	Schematic diagram of the H-Ometer set-up	20
2.8	Membrane resistance calibration	22
2.9	Membrane resistance calibration curve	23
2.10	Line calibration of the H-Ometer	24
2.11	Typical calibration curve for H-Ometer	25
2.12	Influence of borehole diameter on pressuremeter curves	26
2.13	The ladder diagram of PLC	31
2.14	Five principal components of the PLC	32
2.15	Applications of PLC outside and inside manufacturing	36
2.16	The Automatic Tool Changer (ATC) in a CNC machine	37
2.17	Components of a robot system	39
2.18	Total design model proposed by Pugh	43
2.19	Elements of the Product Design Specification (PDS)	46
2.20	Pugh Selection Method	47

2.21	The steps in constructing a finite element model	52
2.22	Example of application of FEA in design	54
2.23	Three aspects to design for safety in initial stage process	56
3.1	The methodology flow chart in this research project	59
3.2	The conceptual design stage of SAHO equipment	60
3.3	The architecture of the design for SAHO equipment	62
3.4	Circle of conceptual design in SAHO equipment	64
3.5	Common method of materials selection	66
3.6	Schematic diagram for design analysis in conceptual design of SAHO equipment	69
4.1	Conceptual design of SAHO equipment	71
4.2	Morphological chart for SAHO equipment	77
4.3	Combination of subfunction to generate possible concepts of SAHO equipment	79
4.4	Concept 1	80
4.5	Concept 2	82
4.6	Concept 3	83
4.7	Concept 4	84
4.8	Concept 5	85
4.9	Concept 6	86
4.10	Concept 7	87
4.11	Concept 8	88
4.12	Steps in concept selection in Pugh method	89

4.13	The final conceptual design of SAHO equipment	92
4.14	The 3 dimensional assembly design of SAHO equipment	102
4.15	The Automatic Probe Changer (APC)	103
4.16	Modified probe of H-Ometer	104
4.17	The casing	105
4.18	The stand	106
4.19	The sample stand	107
4.20	The vertical mover	109
4.21	The sliding units	110
4.22	The control unit	111
4.23	The beam model to determine critical parts in SAHO equipment	112
4.24	The critical part in SAHO Equipment	113
4.25	Finite element mesh model of reactive forces on the leg	114
4.26	The result from FEA on (1) stress effect and (2) displacement of part	115
4.27	Schematic diagram of APC	117
4.28	Schematic diagram of spring	119
4.29	Schematic diagram of tubing	122
4.30	Schematic diagram of shaft	123
4.31	Schematic diagram of pin	125
4.32	Schematic diagram of table work in vertical mover	127
4.33	Schematic diagram of ball screw	129
4.34	Schematic diagram of bearing	131



4.35	Schematic diagram of linear bearing	133
4.36	Schematic diagram of rod	134
4.37	Schematic diagram of arm	135
4.38	The flow chart of process operation in SAHO equipment	137
4.39	Master control in SAHO equipment	138
4.40	Drill process of artificial sample in SAHO equipment	140
4.41	SAHO equipment test curve	141



## LIST OF ABBREVIATIONS

AC	Alternating Current
AMT	Advanced Manufacturing Technology
AP	Application Protocol
APC	Automatic Probe Changer
ATC	Automatic Tool Changer
C	Spring Index
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CNC	Computer Numerical Control
CPU	Central Processing Unit
D	Diameter
DC	Direct Current
FEA	Finite Element Analysis
FMC	Flexible Manufacturing Cell
FS	Factor of Safety
$F_R$	Rating force (load)
H	High
$h_f$	Major (friction) Loss
$h_m$	Minor Loss
I/O	Input / Output
$i$	Reduction Ratio





$K_B$	Bergstrasser factor
L	Life of Bearing requirement
$L_R$	Rating life
LUSAS	London University Stress Analysis System
MTD-RC	Mountainous Terrain Development Research Centre
$N_G$	Speed at Gearhead
$P_F$	potential Force
P	Pitch
PBP	Pre Bored Pressuremeter
PC	Personal Computer
PDS	Product Design Specification
PLC	Programmable Logic Controller
R	Radius
R&D	Research and Development
RAM	Random Accesses Memory
SAHO	Semi Automatic H-Ometer Equipment
SBP	Self Boring Pressuremeter
STEP	Standard for the Exchange of Product Data
S	Specific weight of water
$S_{sy}$	Spring Yield Strength
$S_{ut}$	Spring Ultimate Strength
$T_L$	Torque Load
$T_M$	Torque Motor



$T_r$	Torque Require
$V$	Speed
$v$	Volume
VDU	Visual Display Unit
VLSI	Very Large Scale Integrated Circuit
$W$	Weight
$W_{APC}$	Weight of APC
$\Sigma+$	Summation of Better
$\Sigma-$	Summation of Worse
$\Sigma S$	Summation of Same
$\pi$	Pie
$\mu$	Coefficient
$\delta$	Spring Constant
$\eta$	Efficiency
$\eta_G$	Gearhead Efficiency
$\sigma$	Stress
$\rho$	Density
$\tau$	Shear Stress
$\tau_u$	Shear Ultimate
$E$	Young's of Modulus
$Z$	Elevation
$H_p$	Pump head



# CHAPTER I

## INTRODUCTION

### Background

Instrumentation technology has seen much development. It has moved from simple mechanical tools to more sophisticated electronic digital systems that are in use today. According to DiBiagio (1999), the improvements in instrumentation have caused a dramatic growth in the science of measurement known as *Metrology*. Consequently, the capability of instrumentation has increased with improvements in quality, consistency and safety. Direct manual operations have consequently been reduced a great deal. In the engineering field, the impact of instrumentation has been significant because all engineers do indeed rely on measurements. In general, instrumentation helps to bridge the gap between theory and practice by providing the inputs for both engineering designs and theories and growing us a fair indication whether our designs and theories work in practice. That is why Research and Development (R&D) in field measurements and instrumentation has become an integral part of engineering. A new design and invention on testing equipment with a high capability and ease of handling deserves greater attention.

The H-Ometer is a new testing device that was successfully developed for testing weak materials like weak rock and hard soils (Omar and Salsidu, 2001). It is a steel cylindrical probe with an expandable membrane designed to apply uniform pressure to the walls of a cavity, such as a borehole. The probe is inserted into the predrilled sample and connected to the control unit via tubing. Then, it is inflated using de-aired fluid until the specimen fails in tension. H-Ometer is basically a device to solve the problems arising at the investigation stage in civil engineering work related to foundation (Omar et al., 2001).

This new testing device was developed specifically to test weak rocks (Omar, 2001) and hard soils (Omar et al., 2000a; Omar et al., 2001). For pavement layers, a testing equipment known as PENCEL pressuremeter is used to test the strength of pavement layers for use in airport and highway design (Strydom and Sander, 1994). So different types of testing equipment specific to one or two materials (samples) is common. However, there is a need for testing devices which are multifunctional, have high capability with automated operations and exhibit more safety features.

The H-Ometer has enhanced capabilities. It is a new semi automated machine that was developed for testing various types of materials. This testing machine can be used not only for weak rock and hard soils but also for compacted soils and pavement materials (Salsidu et al., 2002a).

The Semi Automatic H-Ometer (SAHO) Equipment is a machine with semi automatic in movement during test operation and it built for laboratory used. As mentioned before, the advantage of this machine is its capability to test different types of materials with different levels of hardness. This is achieved by developing a component in SAHO which allows for replacement of different sizes of H-Ometer probes for testing different samples (Salsidu et al., 2002b). The pavement (hard material), weak rock (brittle material) and hard soil (soft material) are tested to obtain the indirect tensile strength or modulus strength of these materials which in turn is used to predict performance of these materials (DiBiagio, 1999). So by investigating the indirect tensile strength of various materials, the performance of these materials and their application in engineering particularly in geotechnical and geological fields is likely to see rapid expansion.

SAHO was developed using Advanced Manufacturing Technology (AMT) concepts and tools such as Programmable Logic Controller (PLC) and Automatic Tool Changer (ATC) in CNC machine. In the AMT field, the PLC and ATC have greatly influenced the capability in the manufacturing sector (Salsidu et al., 2002b).

In the past, research work carried out by Omar (1995) concentrated on comparing the H-Ometer with other available testing devices. This was important to check the reliability of this device with established equipment in the market (Omar, 2002). Subsequently, a study was carried out to analysis the reliability of

H-Ometer in measuring indirect tensile strength using finite element analysis (Juraidah, 2001).

In summary, previous research focused on enhancing the H-Ometer by reducing the manual component and increasing automated operations in testing. New features are added to enhance the capability of H-Ometer with this new features, the H-Ometer would have the capability to test samples of hard soil, weak rock, compacted soil and pavement materials.

### **Problem Statement**

In the instrumentation field, manual operations and lack of skill among technicians will lead to poor results in testing (Omar et al., 2001). This problem is aggravated in the case of weak rock and hard soil that break easily and pose problems to design engineers when their strength parameters are being measured. Weak rocks are often characterized by extreme difficulties in obtaining intact and reliable samples for laboratory testing. So, equipment or devices with automated operations will reduce errors during testing.

The H-Ometer was initially developed for manual operation during testing. The development of SAHO will allow for semi automatic operation of the H-Ometer. The SAHO is a new testing device that was developed for testing materials in the laboratory. It will lead to an improved capability for the H-Ometer.