UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF SEMI AUTOMATIC H-OMETER EQUIPMENT

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MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA

2002

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BY

MOHD SAL BIN SALSIDU

Thesis Submitted in Fulfilment of the Requirement for the Degree of Master of Science in the Graduate School Universiti Putra Malaysia

September 2002

Specially dedicated to My Beloved

Father

Salsidu Hj. Kamsoy

Mother

Abing Ereh

Family

Allahyarhamah Sitti Adzmah Salsidu
Roziah Salsidu
Nitih Salsidu
Muhamad Paysal Salsidu
Mohd Ainal Salsidu
Mohd Radman Salsidu
Darwina Salsidu
Sugiana Salsidu
Norima Salsidu
Sitti Julaidah Salsidu

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science.

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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.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains.

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.

ACKNOWLEDGEMENTS

In the Name of Allah, Most Merciful & Most Compassionate

I wish to acknowledge my supervisor, Assoc. Prof. Dr. Husaini Omar for his untiring supervision and encouragement. I would also like to thank to my supervisory committee consisting of Assoc. Prof. Dr. Napsiah Ismail and Dr. Rosely Ab. Malik for their comments and suggestions.

Special thanks are also extended to the Ministry of Science, Technology and the Environment, Malaysia (MOSTE) for the funding of this study under the National Science Fellowship (NSF) scholarship. I also wish to place on record my gratitude to my parents who were and are constantly praying for my success.

The author is also grateful to the following for their support and contributing: Mr. Tajul Ariffin, Mr. Ahmad Zaidi Hampden, Ms. Azura Ahmad, Mr. Saiful Iskandar Khalit, Ms. Azfariza Azizi, Mr. Adnan Arifin, Mr. Rozaini Md Yusof, Mr. Aziman Madun, Mr. Ratnasamy Muniandy, Mr. Zaharudin Hisam and all MTD-RC staff.

Mohd Sal Salsidu

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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
$\sum +$	Summation of Better
$\sum -$	Summation of Worse
$\sum S$	Summation of Same
π	Pie
μ	Coefficient
δ	Spring Constant
η	Efficiency
η_G	Gearhead Efficiency
σ	Stress
ρ	Density
τ	Shear Stress
τ_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 insert 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 enhances 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.