INNOVATIVE MECHANICAL DESIGN

WITH A CASE STUDY OF PUMPING SYSTEMS

FOR LOW YIELD TUBE WELLS

By

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CERTIFICATE OF AUTHORSHIP / ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidate

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Glossary of Abbreviations

AI	Artificial intelligence
ASE	Analysis, synthesis, evaluation.
BFGS method	Nonlinear optimization method of Broyden, Fletcher, Goldfarb and Shannon.
CAD	Computer aided design (sometimes drafting).
CAD-CAM	Computer aided design and manufacture
CAE	Computer aided engineering
CFD	Computational fluid dynamics
CBR	Case based reasoning.
CW	Closed world condition
DAC	Double acting cable.
DFA	Design for assembly.
DFM	Design for manufacture.
DFX	Design for X.
DH-UniPump	Down-hole UniPump.
DP	Design parameter.
EDP	Engineering design process.
FEA	Finite element analysis.
FR	Functional requirement.
GA	Genetic algorithm.
IPPD	Integrated product and process planning.
KBES	Knowledge based expert system.
KBS	Knowledge based system.
LSRM	Long stroke reciprocating mechanism.
LSWHR	Long stroke well head reciprocator.
LTM	Long term memory.
MS	Machine system.
OEM	Original equipment manufacturer.
OPEC	Organization of the Petroleum Countries. http://www.opec.org/
PDS	Product design specification.
PDM	Product data management
PE	Polyethylene.
PMDC motor	Permanent magnet direct current motor.
PVC	Polyvinylchloride.
QC	Qualitative change in problem characteristic
QFD	Quality functional deployment.
SIT	Structured inventive thinking.
STM	Short term memory.
TREND-MORPH-PDS	This is the engineering design methodology developed and investigated in this thesis.

TRIZ	Teoria Resheniya Izobretatelskikh Zadatch, which translates approximately into English as: Theory of Inventive Problem Solving.
TS	Technical system.
UDE	undesirable effect.
UNDP	United Nations Development Program.
UniPump	The proposed commercial registered name for the pumping system of this case study.
VLOM	Village level operation and maintenance.

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John Dartnall, 2003

This thesis focuses on combinatorial methods of invention/innovation/design emphasizing the manipulation of form (as distinct from the manipulation of function alone) that help the designer to generate a wide range of good design alternatives. It is based on my case study of a morphological analysis of a ground water pumping system suitable for low volume flow pumping.

The first premise of this approach is that the elements and functions of mature technologies such as mechanical machines are well documented and understood. Thus, innovations are more likely to involve new combinations of existing forms than the introduction of new machine elements.

The second premise is that valuable information is available about most elements and the more popular sub-systems and machines. That information has evolved, sometimes over time spans ranging to hundreds of years, but it has not usually been systematically documented and categorised, thus leaving opportunities to investigate these areas and discover good design possibilities. Further, some valuable information is available only anecdotally or is tightly held by the managements of the companies that have manufactured the device(s) or own the intellectual rights.

In recent years a proposed "design science" has been the subject of much research and many models have been proposed of processes for designers to follow. These typically model the design process in stages, including: clarifying the problem, conceptualising, embodiment selection and detailing.

It is widely recognized that industrial invention/innovation/design processes are non-linear, and so complex that, despite extensive research, design science and models are still at an immature stage.

The literature confirms that industry is often driven by cost/time constraints and short term thinking, rather than using "design science" methods.

My methodology (abbreviated as TREND-MORPH-PDS) is an original contribution to design science. It outlines three stages to be followed by the designer:

1. *Start with a general goal(s). Break this down into sub-areas/systems, including: socio-economic, near physical environment, power source, prime mover, gearing/matching, transmission, working sub-system and control system. Research and document historical trends in each of these areas and their possible influences on the design.*
2. *Apply morphological analysis to each sub-system, using rapid graphical techniques. Move to detail design for specific alternatives as satisficing sub-systems are identified.*
3. *At all times during these stages, take advantage of design knowledge/tools that are currently available, looking for ideas and opportunities. Work constantly on constructing the Product Design Specification (PDS). The conceptual design is complete when the PDS is finalized. Detail design, which would follow from the PDS is not treated in this thesis.*

The methods and ideas put forward in this thesis and its case study are an original contribution to design science. They also identify issues and differences between design science models and the design processes seen in industry.

Several patentable inventions have resulted from my application of the methodology, and the dissertation is a significant contribution to the knowledge domains of mechanical machine design and the technology of ground water pumping.