

**APPLICATION OF AXIOMATIC DESIGN CONCEPT ON IMPROVING
LADDER FOR PEPPER HARVESTING**

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This report is submitted in partial fulfillment of the requirements for the degree of
Bachelor of Engineering with Honours
(Mechanical and Manufacturing Engineering)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2008

UNIVERSITI MALAYSIA SARAWAK

BORANG PENGESAHAN STATUS TESIS

Judul: **APPLICATION OF AXIOMATIC DESIGN CONCEPT ON
IMPROVING LADDER FOR PEPPER HARVESTING**

SESI PENGAJIAN : 2007/2008

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This project report attached here to, entitle “*Application of Axiomatic Design on Improving Ladder for Pepper Harvesting*” prepared and submitted by MOHD RIDHA BIN NORASHIP as a partial fulfilment of the requirement for the degree of Bachelor of Engineering with Honours in Mechanical and Manufacturing is hereby read and approve by:

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Dedicated to my beloved family and friends

ACKNOWLEDGEMENTS

Firstly, I would like to express my most gratitude to The God for giving me the opportunity to breath and able to complete my Final Year Project. Thousand thank to my supervisor, Mr. Aidil Azli Alias for the excellent guidance and encouragement for me in preceding my final year project successfully. I would also like to thank to my mentor, Mdm. Ervina Junaidi for her support on this project. Engineering Faculty has taught me a great deal and has served as my test ground for taking the knowledge gained in class and applying it to a real problem Thanks goes to my family for always being supportive and concerned about my work and to my friends for giving me help when I needed it. And lastly, I would like to express my gratitude to all the staff of Mechanical and Manufacturing Engineering program that provided me with the knowledge and confidence to write this report and to all of individual which has involves directly or indirectly through this project.

ABSTRACT

Pepper harvest is a difficult operation and sometime can bring hazard. Ladder is used in this operation to assist farmers to reach the higher portion of pepper tree. It shows ladder is the important devices in the agriculture field. Ladder for pepper harvest was designed to facilitate the farmers in harvesting operation. The application of axiomatic concept is used in this project to facilitate the designing process. Location surveys for this project have been conducted at several farm and orchard at Serian area to identify farmer's problems regarding the harvesting operation. After problems are identified, the new design of ladder was proposed to fulfill the user needs. Then, from the conceptual phase, the design has through several phases steps by steps to ensure the ladder achieve the best solution and every details assumption is bring into account until the final design is constructs using computer software. The maximum allowable load for the ladder is calculated using solid modeling simulation analysis to estimate the endurance of the material proposed for the ladder and the total rough cost for the proposed ladder is estimated too, to make sure the design is affordable by the users. For the final design, the ladder is providing with platform and wheel together with the unique braking system to ensure it easy and effective for the users.

ABSTRAK

Pemetikan lada hitam merupakan salah satu operasi yang leceh dan boleh mendatangkan bahaya. Tangga digunakan dalam operasi ini bagi membolehkan petani mencapai bahagian pokok yang tinggi. Ini menunjukkan bahawa tangga merupakan alat yang penting dalam bidang pertanian. Tangga untuk penuaian buah lada hitam dicipta khas untuk memudahkan petani dalam operasi penuaian dan pemetikan lada. Konsep Rekabentuk Aksiomatis telah digunakan untuk membantu memudahkan proses rekabentuk ini. Tinjauan lokasi penanaman lada hitam telah dilakukan di beberapa ladang dan dusun lada hitam di kawasan Serian bagi mengenalpasti permasalahan mengenai penuaian lada hitam. Selepas permasalahan telah di kenalpasti, rekabentuk baru bagi tangga telah dicadangkan bagi memenuhi kehendak pengguna. Seterusnya dari peringkat konsep, rekabentuk itu melalui beberapa peringkat satu per satu bagi memastikan tangga itu mencapai penyelesaian terbaik dan sebarang kemungkinan mesti diambil kira sehinggalah rekabentuk terakhir dihasilkan menggunakan perisian komputer. Beban maksimum yang boleh di tahan oleh tangga ini dikira menggunakan analisis simulasi model pejal untuk menganggar ketahanan bahan yang dicadangkan untuk tangga ini dan anggaran jumlah kos kasar bagi tangga itu juga dilakukan untuk memastikan tangga itu mampu dimiliki oleh pengguna. Pada rekabentuk terakhir, tangga yang direkacipta dilengkapi dengan platform dan roda beserta brek khas yang unik bagi memastikan pengguna dapat mengendalikannya dengan mudah dan berkesan.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Pepper, the world's most widely used spice and for food flavoring and seasoning. Pepper is grown in Malaysia mainly in the state of Sarawak and some plantings in Sabah and Johor. Malaysia has been a major producer and exported of pepper for many years. More than ninety five percent of the production comes from Sarawak where it is the leading agricultural export crop. Pepper has been cultivated in Sarawak for more than hundred years and it becomes the culture and tradition for the Sarawak society. It generates an important source of income for an estimated 50 000 families in Sarawak and about a third of Sarawak's agriculture export earnings [5].

In the recent years, the pepper industry in Malaysia has been faced with many problems such as the poor processing technique, the high labor requirements and low efficiency of production due to lack of mechanization, and the lack of modern farm knowledge among pepper farmers especially in rural areas.

Until 1980, Malaysia was traditionally the largest pepper producing country in the world [6]. After that, Malaysia lost it leading position and now drops to third ranking in list of world market of pepper producer to India and Indonesia [20]. These happen due to

lack of efficiencies in production of pepper. If this problem did not take seriously, maybe Malaysia will lose the market authority to other country and it will inflict a financial loss.

Malaysian Pepper Board (MPB) is the main government agencies that entrusted with the development of the Malaysia pepper industry. MPB have undertaking the market promotion and downstream activities on pepper to assist in minimizing some of these problems and promoting the favorable growth of the pepper industry. One of the problems that highlight by the MPB is the traditionally harvesting method for pepper fruits.

1.2 Problem Statement

Harvesting of the pepper fruit or pepper berries is not an easy process to be done. The problems of harvesting pepper berries occur because of many factors. One of the factors is the harvesting method of the pepper berries as the most extensive operation in pepper industry. Majority of the farmer at Sarawak use ladder to assist them in harvesting process and most of them used their hand made ladder.

The farmers have to use ladder to make it possible for them to reach the higher portion of the pepper tree. They need to climb up and down a ladder to pick the pepper berries. Furthermore, the labor required to be constantly moving the ladder travels around the tree. But, the hand made ladder that used by most of them are not practical and unsecured. The use of their hand made ladder can turn to be dangerous because the terrain is usually on the fertile slope and mountainous terrain, and not completely level

or can be soft due to moisture. Ladder accidents are commonly occurred when such method used in the harvesting method. Figure 1.1 illustrate the example of the hand made ladder that been used by the farmers.

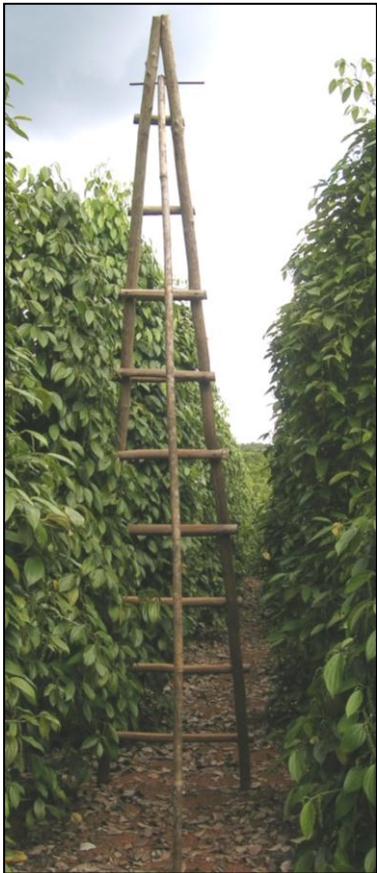


Figure 1.1: Hand made ladder for pepper harvest

1.3 Aim and Objectives

The aim of this project is to improve the existing ladder for pepper harvesting via application of Axiomatic Design concept. This project will decrease the problems related with the traditional harvesting method, which is well known as the labor extensive operations. This operation had been done manually without using any mechanical equipment and used ladder to pick the pepper berries. This method may counter risk and danger for the labor because of the labor and pepper farmer usually used their hand made ladder that is not practical to use. This proposal design of ladder for pepper harvest will assist in harvesting and reduce the risk of labor and further on will change the traditional method of harvesting to the proposed method that are lower cost, more effective, safe to use and economical.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will explain the relevant background information about the Axiomatic Design, pepper background and the problem related in this project. This chapter contains the related reading and illustration about the project that brings the better understanding in this study.

2.2 Axiomatic Design

The axiomatic approach to design differs philosophically from the current trend in the engineering field and makes it imperatives that basic principles, and the methodologies that stem from the principles, provide the conceptual framework and explicit tools for design, thus eliminating the need for an exhaustive search of all possibilities [2]. Axiomatic Design is developed by Professor Nam. P. Suh MIT, President of the Korean Advanced Institute for Science and Technology. Axiomatic design concept is a fundamental set of principles which determine whether the design is good or not.

The main concepts of the Axiomatic design are:-

1. The general principles of the Axiomatic Concept and design axioms.
2. Domains.
3. Hierarchies and Zigzagging.

2.2.1 General Principles

The axiomatic design process is focused on the satisfaction of functional requirements (FRs). FRs is defined as the minimum set of independent requirements that characterize the design goals. The design must satisfy the FRs, and this is done by creating a system that uses design parameters (DPs), the elements of the design solution that are chosen to satisfy the specified FRs.

Axiomatic Design theory is consists of two axioms and some theorems and corollaries. The axioms are:-

Axiom 1 (Independence Axiom) Maintain the independence of the functional requirements.

Axiom 2 (Information Axiom) Minimize the information content of the design. The design matrix relates the FR vector to the DP vector.

The design matrix relates the functional requirements, FR vector to the Design Parameters, DP vector. Further information about the axioms and an example of design matrix relation between FRs and DPs are contained in the Appendix A.

Design matrix can be divided by three types, there is uncoupled design, decoupled design and couple design. The example of three types of difference design matrix is shown in the Appendix A. The uncoupled design represent as a diagonal matrix while the decoupled matrix represent as a triangular matrix. Each of the FRs in uncoupled design can be satisfied independently by one DP. For the decoupled design, the matrix forms in triangular as the FRs can be satisfied independently by the DPs when DPs were set in an appropriate sequence. Therefore, both uncoupled design and decoupled design satisfy the Independence Axiom.

The couple design exists if design matrix is neither diagonal nor triangular. The FRs cannot be satisfied by the DPs. Then, designer should change the design to uncoupled or decoupled design if the design was a coupled design. For correct implementation of such a design, it is necessary to set the value of DP_1 before setting the value of DP_2 .

2.2.2 Domains

In axiomatic design, the design process is described in terms of the mapping between domains. The first domain in the design process is Customer domain. This domain is the steps in recognized the customer requirement. Then, the design goals for a product are expressed in terms of Functional requirements (FRs), a minimum set of independent requirements that describe the functional needs of the design solution in the functional domain.

After that, the set of DPs have to be formulated and generated based on the set of FRs. Design parameters (DPs) are the elements of the design solution that choose to satisfy the specified FRs in the physical domain. The final domain in design process is the process variables (PVs), the elements that characterize the process that satisfies the specified DPs in the process domain.

Figure 2.1 show the mapping process between domains in the design process and relation between each domain in developing the final solution.

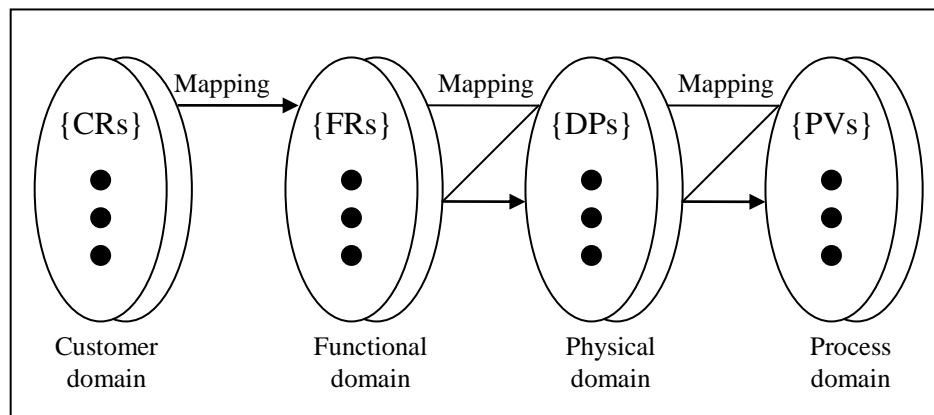


Figure 2.1: Mapping between domains

2.2.3 Hierarchies and Zigzagging

Axiomatic design begins with the most general requirements of the system, and decomposes these into sub-requirements. The decomposition is important to specific a set of element that will give apparent result in the solution. When the system design is decomposed, it necessarily to specify the set of FRs first, then move to the physical domain and construct the specific set of DPs as the solutions for the design concept.

After that, the design solution is proceeding back to the functional domain as required. Decompositions proceed from high level of design concept to lower levels and through layer by layer until the design solution can be implemented are called hierarchies. Through this decomposition process the designer establishes hierarchies of FRs, DPs and PVs.

This reversible process of between the functional domains and physical domains and progressing from a general to detailed description, is called zigzagging. Collection of FRs and DPs in the hierarchical from above to the bottom of the design concept that generated by the zigzagging method is termed the system architecture. The zigzagging method is repeated until the system achieved possibilities to construct the system from the information in the system architecture. Arrows in Figure 2.1 shows the flow of the zigzagging process between each domain.

2.3 Pepper Background

Pepper, the king of spices or scientific name *Piper nigrum L*, is the most important spices in the world now. Pepper which has been used as spice since 4th B. C. was brought into Malacca in the year 1583 by the Portuguese [6]. Vietnam has recently become the world's largest producer and exporter of pepper (85,000 long tons in 2003). Other major producers include Indonesia (67,000 tons), India (65,000 tons), Brazil (35,000 tons), Malaysia (22,000 tons), Sri Lanka (12,750 tons), Thailand, and China. Vietnam dominates the export market, using almost none of its production domestically.

In 2003, Vietnam exported 82,000 tons of pepper, Indonesia 57,000 tons, Brazil 37,940 tons, Malaysia 18,500 tons, and India 17,200 tons [12].

In the world market, the pepper produced in Malaysia is commonly known as Sarawak pepper. Annual Production of Sarawak pepper is in the region 20 000 tones valued at over RM 100 million and over ninety percent of this exported to over 25 destinations [5]. However, pepper industry in Sarawak still countered by a number of major production problem. A decline of pepper production in Sarawak by about fifty five percent since 1979 due to problem of low price, serious outbreak of disease and pests, and high cost of production [6]. Malaysian Pepper Board or MPB is the federal management agency that establishes to manage the pepper trade in Sarawak and entrusted with the development of the Malaysian pepper industry.

2.3.1 Pepper History

The name pepper comes from the Sanskrit word “pippali”, [,] meaning berry. This word gave rise to Greek word “peperi” [πέπερι] and Latin word “piper”. Both of these words mean “black pepper” as a substitute of “long pepper”. Present day, almost all names of pepper in European languages are derived from Latin piper and some of languages in Western Asia have also come from Greek piper, such as *al-filfil* [] in Arabic [15].

Pepper is the earliest spices known in the world as mentioned in an ancient Sanskrit literature [13]. In early historic times, black pepper was widely cultivated in the

Southeast Asia, and became an important business trade between India and Europe. Pepper also became a medium of exchange, and tributes in ancient Greece and Rome. In the middle ages, the Venetian and the Genoese became the main distributors and monopoly the world pepper trade. They enhance the great evolution in the pepper industry.

Pepper reached South East Asia in 16th century, and being grown in Jawa, Sunda, Sumatra, Madagascar, Malaysia and elsewhere in South East Asia. But these areas traded mainly with China, or just used locally. Ports in the Malabar area are the most famous port for the traders to trade spices. In the last decades of the 20.th century, pepper production increased dramatically as new plantations were founded in Thailand, Vietnam, China and Sri Lanka. In the New World, Brazil is the only important producer of pepper [15].

Black pepper, along with other spices from India and lands farther east, changed the course of world history. Black pepper also led to the European efforts to find a sea route. It was the preciousness part of these spices as a result for the European discovery and migration of the Americas [12].

2.3.2 Pepper in Sarawak

Pepper has been cultivated in Sarawak since 1856 and account for over 95% of pepper production in Malaysia. Due to this, in the world market the pepper produced in Malaysia is commonly known as Sarawak pepper.

According to national pepper investment seminar report, (1994) in Sarawak, pepper is planted by smallholder on an estimated 10,000 hectares mainly on fertile hill sloped or upland and consist about 56,000 farm family with farm sizes in range of 0.1 and 0.4 hectare each. Majority of the farms are the small orchard and owned by the small farmers. The pepper farm focuses in certain Districts of Kuching, Samarahan, Sri Aman, Betong and Sarikei Divisions.

Pepper industries in Sarawak concentrate on export market. In 1999, Sarawak produced about 21,500 tones of pepper and exports the overall estimation about 21,942 tones and valued at RM 113.2 million and RM 120.0 million respectively. This pepper has been export to over 25 destinations especially Singapore, United States, Japan, Germany, France, Republic of Korea, Netherlands, Taiwan and United Kingdom. About 95 % export forms of pepper traded globally is in the form of black and white peppercorns and the remaining 5% is made up of pepper oleoresin, pepper oil, green pepper and ground pepper [7].

2.3.3 Pepper Plant

Pepper is vines productive in the rainy season, fairly high temperatures and partial shades. Black pepper is grown in soil that is not too dry and not exposes to flooding. Pepper tree at Sarawak is planted mainly on fertile hill sloped or at upland. Figure 2.2 and 2.3 illustrates the area of pepper plantation at Serian, Sarawak which Figure 2.2 are planted on the hill slope while Figure 2.3 illustrate the pepper tree planted on the flat land area. They usually grew from stem cuttings and rarely from seeds.