Systematic Design of a Horse Surgical Table

Abstract– **Surgery on a large animal like a horse, which is very heavy (500-800 Kg) and cannot be placed easily on an ordinary table, requires the specially designed surgical table. In this study, the systematic design of a horse surgical table is described. The long term objective of the project is to resolve challenges in performing operation on heavy weight animal like a horse. The distinguishing feature of the described design procedure is the use of a structured design approach, which forces the designer to systematically review and compare alternative solution options, thus preventing the selection of solutions based on prejudice or belief. The result of the design is a horse surgical table with a main frame, the lifting mechanism, hydraulic system, the height-adjustable platform and the auxiliary surface boards for resting the horse's legs, back, neck and head.**

Keywords– Systematic Design, Surgical Table, Horse and Hydraulic System

I. INTRODUCTION

A. Preface

For many years, veterinarians have been dealing with tremendous amount of challenge in performing operation on heavy weight animal like a horse. This is because of not having a well designed surgical table to facilitate the easiness and comfort during an operation. So, the concept has been initiated from this limitation and advanced itself to designing and manufacturing of the adjustable table for surgery.

The adjustable table is now considered by many companies to be an alternative piece of operation (Stroud, 2000). However, literature review showed that there is no published work in form of any article or structural design relating to development a horse surgical table. Although there are some pictures from different manufacturers and commercials with explanations, they are not scientifically documented. As a result, it becomes essential for this paper to explore the existing products in order to outline what advantages can be resulted from designing and manufacturing of the optimized-functioning surgical table (Shank and Kimzey Companies).

B. Background to Systematic Design

Engineering design is not something that is easily defined. Hyman (1998) suggests that there appears to be no common definition for engineering design except that it is a methodical approach to solving a particular class of problem. This is suggested because a feature of much problem solving is that the solutions are often arrived at without an awareness of the step involved in the process. Suh (1990) describes it as being 'a continuous interplay between what we want to achieve and how we want to achieve it'. Further helpful definitions of design are given by the Sharing Experience in Engineering Design (SEED) and by the Accreditation Board for Engineering and Technology (ABET).

The SEED definition suggests: 'Engineering design is the total activity necessary to establish and define solutions to problems not solved before, or provide new solutions to problems which have been previously been solved in a different way. The engineering designer uses intellectual ability to apply scientific knowledge and ensures the product satisfies an agreed market need and product design specification whilst permitting manufacture by the optimum method. The design activity is not complete until the resulting product is in use providing an acceptable level of performance and with clearly identified methods of disposal' (Hurst, 1999).

The ABET definition (1990) states that: 'Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, analysis, construction, testing, and evaluation'. Suh (1990) describes four components involved in the design process, each based on engineering and scientific principles: the problem definition, the creative process of generating a solution, the analytical process of determining if the solution is suitable, and the ultimate check of fidelity of the design. While this is true, the process of design often tends to is opening ended with no readily identifiable closure point. Hyman (1998) suggests that this process is continuous until the cost of continuing the design process becomes greater than the benefits of a further improvement in the design.

II. THE DESIGN PROCESS

To ascertain a systematic design procedure, the discursive design method according to directive Pahl and Beitz was selected (Pahl and Beitz, 1996). The directive divides the engineering process into seven fundamental working steps. Depending on the problem for each of these steps, several specific methods are recommended. Fig. 1 shows the steps and the referring results.

The searching matrix method projected by Roth (Roth, 1994) was employed for step one, resulting in several detailed requirement lists. For step two, directive VDI 2222 was chosen (VDI 2222, 1997). Also in step three, the method of VDI-engineering morphology was used (VDI 2222, 1997). Referring to Pahl and Beitz (Pahl and Beitz, 1996) an own pre-evaluation method was developed. Applying the pre-evaluation method, the principle solutions were combined to

two promising general concepts. These were constructed in step four and five. Then these two competing preliminary embodiment designs were evaluated by using technical and economical aspects according to Kesselring and VDI-directive (VDI 2222, 1997). The best design was selected and finalized in step six. Modeling and mechanical analysis of considered table is performed using Catia V5 R16 software (Dassault Systems Corp 2006) which would enable us to analyze the components and do the optimization (Fig. 2).

III. RESULTS OF THE DESIGN PROCESS

A. Requirements and Functional Basis of the Horse Surgical Table

A function is an action that has to be performed by the machine to reach e specific goal. In our case, important functions are energy, convert energy, apply power on positioning device, moving positioning device vertically and moving positioning device angularly. The functions are grouped in a function structure, which represents a solution on the first level of abstraction (Fig. 3). The function structure consists of several functions. Every function can be accomplished by several alternative principles, e.g., mechanical and thermal principles.

According to the ultimate research objective, formulated as design a horse surgical table that can do processes simultaneously, the first step in the problem definition phase was to establish the set of requirements. For this purpose, interviews were held with potential users, scientists and manufactures related to horse surgical table. The resulting requirements are listed in Table I:

B. Concept Design and Concept Pre-Evaluation

The several function structure plans were organized as morphological charts (Fig. 4). For each function, a number of possible solutions were found. In order to select only reliable and cost-efficient components, a pre-evaluation matrix was created (not shown). This methodology was utilized by Khodabakhshian et al. (2010). Each of the found 160 implementation options was pre-evaluated according to five selection criteria: 1). Function fulfillment and operational reliability, 2). Investment and implementation costs, 3). Maintenance and servicing costs, 4). Design and optical quality, 5). Positive self-made experiences. For each function, exclusively the best ranked components were chosen. These components were combined with each other. The concept solution indicated by the line in Fig. 3 is the final concept solution. Finally, in the forming phase the concept solution was worked out into a prototype.

IV. THE HORSE SURGICAL TABLE

The designed table consisted of 2 frames that one of them is fixed and the other one is moveable and connected to wheels, also can be adjustable in height. Its lifting equipment is including 4 hydraulic jacks and 8 hitch links that are connected with each other two by two. i.e., they are connected to the frame below form one side and to the moveable chassis from the other side. Jacks are 4 that 2 of them are connected to moveable frame and 2 other ones are connected to fix frame. These frame compared to the table linear axis are symmetrical two by two. This table is multi-purposes one so that it is adjustable in height and has the possibility for adjust slop in table's length with corresponding desired angle (Fig. 3). In one hand it consisting with features and criteria of design such as easiness and not being complex, low number of parts, maintenance and fixing and work easily with the least power can provide the most efficiency of movement in the favorite direction and the other hand it's belongings is very simple and have the ability to be assembled and disassemble. It is essential to state that calculation and analysis of components was done and they are submitted in another manuscript in process to publish.

V. DISCUSSION AND CONCLUSIONS

The research table was designed using a systematic design method. The advantage of using this method is that it clearly structures the design process. It provides a good overview of the complete design and because of the structured sequence of design activities; it is easy to keep track of the progress of design. Another advantage of the structured design method is that it forces the designer to look at alternative solutions and this decreases the probability of heuristic bias and increases the quality of the outcome. Although the designer is forced to thoroughly judge the identified alternative solutions when selecting the final concept, the outcome is still depending on the available knowledge of the designer about the alternative solutions. So, while the method can not guarantee that the absolute best solution possible will be selected, it certainly is superior to a trial and error approach. In a research context it is easy to identify alternative subjects that are worthwhile to investigate further, while in the same time the main line of the research remains clear. The result of the design is a adjustable table with a main frame, the lifting mechanism, hydraulic system, the height-adjustable platform and the auxiliary surface boards for resting the horse’s legs, back, neck and head. In conclusion, this table is multi-purposes one so that it is adjustable in height and has the possibility for adjust slop in table's length with corresponding desired angle. In one hand it consisting with features and criteria of design such as easiness and not being complex, low number of parts, maintenance and fixing and work easily with the least power can provide the most efficiency of movement in the favorite direction and the other hand it's belongings is very simple and have the ability to be assembled and disassemble

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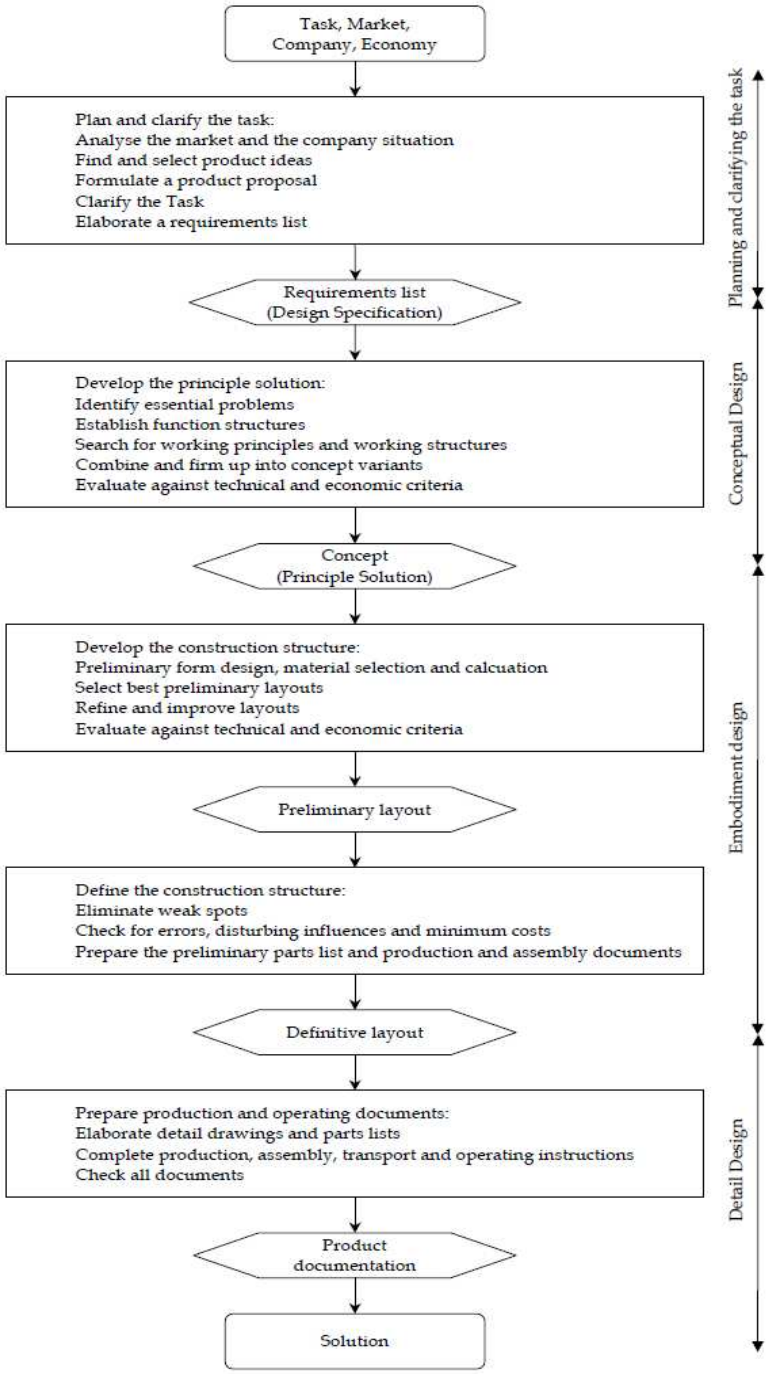

Fig. 1: Common Pahl and Beitz-procedure of systematic development and design

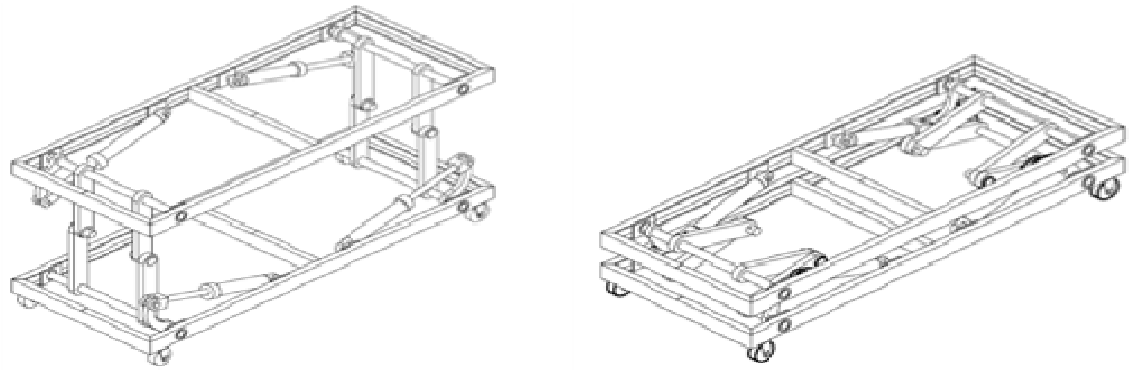

Fig. 2: General view of proposed table: (a) In Max height; (b) In Min height

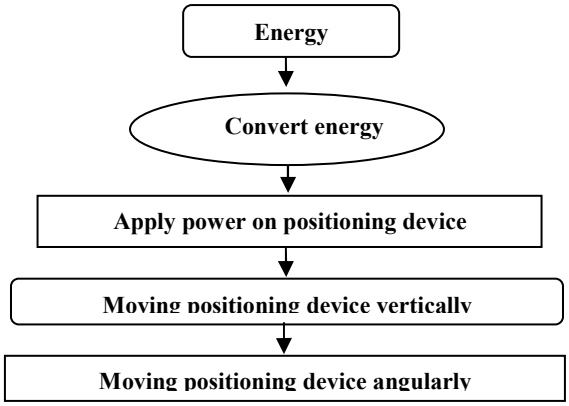

Fig. 3: Function structure

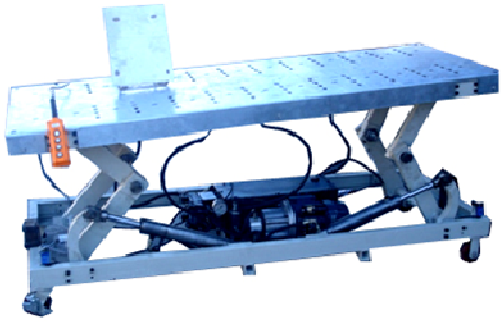

Fig. 5: Photograph of the fabricated adjustable horse surgical table

Table I: The resulting requirements

Fixed requirements	Variable requirements
- Producible in sample workhouses - Competitive with available machines - Different from variable models	- Safe for people and animal - Reliable functioning - Longevity of machine

Solution / Function	A	B	C	D
Energy and power	Power point	Electric rotator	Mechanical	Hydraulically
Movement angularly	Trapezoidal screw drive	Tribological rolling pairing	Hydraulic cylinder	Vertical linear
Movement vertically	Friction gear	Engine brake	Tribological rolling pairing	Hydraulic cylinder

Fig. 4: Morphological chart