CHAPTER 1

INTRODUCTION

All over the world, medical experts are agreed on the concept of “golden hour” (60 minutes) of evacuation in which the maximum lives can be saved. The historic wound and casualty data suggests that more than 90 per cent of those severely wounded die within the first hour of injury unless treated with life support. According to the statement of retired Admiral S.K. Mohanty’ (The Hindu, April 6, 2010), who served as a surgeon in Kashmir during the Kargil War, “In war zone situations all trauma patients, must be evacuated to a medical centre within 60 minutes if they are to survive.” In this connection, Katoch (Katoch R 2010) adds that in recent Iraq conflicts, one of the reasons for lowest “casualties” of U.S. Force was the rapid evacuation system.

In army field-hospitals or border static hospitals are the first surgical facility and the evacuation from the forwarded defended locality (FDL) to these hospitals can be done by air, ambulance, mules or stretcher bearers and the stretcher becomes an important link in the casualty evacuation chain in any counter-insurgency operation.

1.1 Casualty Evacuation Stretcher:
Modern day warfare is highly mechanized and technology oriented. Modern weapons are more lethal and precise, with the result, the casualty figures are likely to increase with every war and conflict.

Figure 1.1: Stretcher with casualty
Medical fraternity is geared up to minimize loss of life and limb by providing immediate first aid and speedy evacuation. Many a times, timely and fast rescue operation saves the life or limb of a casualty. Therefore, Casualty Evacuation Stretcher form a very important link in carriage of casualties’ right from the forward defended locality (FDL) to rearwards and thus, these are one of the most important requirements of armed forces. In addition to being an important component in casualty evacuation in war or in field area, the stretcher form a necessary tool when armed forces are called upon to aid civil authorities during floods, earthquakes or major accidents. The Casualty Evacuation (Casevac) Stretcher is a medical device and used to carry casualties or an incapacitated person from one place to another as shown in figure1.1. The Casevac stretcher is usually moved by two people, one at the head and the other at the feet. The casualty is placed on the stretcher and can be carried or wheeled away. The Casevac stretchers (for simplicity it may be called as stretcher afterwards).

![Figure 1.2: Existing single fold stretcher](image)

The armed forces have to be deployed in difficult terrains, high altitudes and snow bond areas where the load carrying capacity of a soldier reduces up to 70 % at a altitude from 4200m to 5800m (West, 1997) since the rate at which humans can perform physical work (power output) depends on the amount of oxygen available to the body, therefore, as the altitude increases maximal oxygen uptake falls human load carrying capacity reduces.
Current U.S. army doctrine recommends 22 kg (or 30% body weight) as “Fighting Load” and 33 kg (or 45% body weight) as “Approach March Load” for the soldiers. The “Fighting Load” is the load to be carried by avoiding detection from enemy with carefully moving is necessary, it consisted of the soldier’s clothing, load-bearing equipment, helmet, weapon, rations, bayonet and ammunition. The “Approach March Load” includes the combat load plus a pack, sleeping roll, extra clothing, extra rations and extra ammunition (Knapik and Reynolds, 2001).

The stretchers which are in use in Indian Armed Forces are sturdy but heavy as shown in figure1.2. In today’s advanced battle scenario, a soldier is required to be lightly clad and heavily armed. The existing stretchers are bulky and heavy; do not fit into the concept of modern day battle. The commonly used stretchers by Indian Armed Forces weigh between 9 kg to 14 kg and single/double folding, resulting in difficulty to carry. The stretcher is commonly made of mild steel or aluminum tubes with a stitched canvas as stretcher sheet on which the patient lies. The canvas is heavy and prone to damage as it absorbs moisture and also allows bacterial, fungal and mould growth, leading to frequent replacement, thereby financial losses.

In the scenarios like war, causality evacuation is one of the important but difficult tasks and it becomes more difficult at hilly terrains, high altitude, and under extreme ambient conditions. Therefore, for the armed forces; there is need of the lightweight, backpack, safe, strong and reliable stretcher suitable to be used under extreme ambient conditions prevailing in India. The casualty evacuation stretcher is a simple but very important and necessary life supporting product. The concept of the stretcher has been used since many years and has inspired many designers. But there is hardly any indigenous effort to design the stretcher suitable for the extreme ambient conditions, in which Indian armed forces have to be survived.

Today, it is widely accepted that product design engineering plays a vital role in creating product value. It is also a truth that the appropriate tools/technique and methods can be very helpful to solve the problem in an efficient and effective way. Therefore, to design the stretcher, the Integrated Product Design approach with its tools like QFD and TRIZ have
been studied and an effort is made to apply the approaches to design a stretcher that suits to Indian conditions and meets the user needs. The brief description of IPD approach is discussed in the following paragraphs.

1.2 Integrated Product Design (IPD):

The challenges faced today required innovative and creative methods of product design and development, business and management in place of old ones. The old paradigm was based upon the theory of centrally controlled and centrally operated and most of the decisions were made at the top level.

According to Dahan and Hauser (2001), in 21st century, the important factors in product developments are customer satisfaction, time-to market, and cost reduction through total quality management, but none is viewed as a guarantee of success. The research challenges of the next decade are those that address product development as an integrated, end-to-end process that requires a detailed understanding and coordination of customers, competition, and internal capabilities.

According to the Tragg and Yuan (1998) IPD is a design methodology that incorporates a systematic way of early integration of all the activities and disciplines that play a crucial part throughout the life cycle of a product. It is the concurrent development of the product and process using cross functional teams that are strategically aligned with the needs of the customer, stakeholders, supply network and the business enterprises to optimize the design, manufacture and support of a system through the applications of technology, product-engineering, quality-tools and utilizing industry best practices. Many MNCs like General Motors, LG Electronics, Fords and Boeing are using IPD in their projects.

It was found from the literature (Benjamin, 2008; Hambali et al., 2009) that to win the market competition and customers’ satisfaction in an optimal way, various product design models, methodologies and tools developed by researchers and academicians are very essential and useful. To apply the product design model in a better way, the Integrated Product Design (IPD) approach is found better than the sequential product design approach. Therefore, the IPD approach and its tools like Quality Function Deployment (QFD), Computer Aided Design (CAD) and the theory of inventive problem solving (TRIZ) have been studied and
applied in design of the stretcher and multipurpose army field cot cum stretcher. The brief descriptions of the CAD, QFD and TRIZ are given the following paragraphs.

1.3 Computer Aided Design (CAD):
Computer aided design can be defined as any design activity that involves the effective use of computer to create, modify and document an engineering design (Fusina and David, 2000). CAD method has been used since 1960 by U.S. defence and industries. Indian defence research and development organizations started the application of the CAD since 80’s and today; it is being widely used by various Indian industries. In the present scenario, the use of CAD systems for geometrical modeling has been matured. The capabilities of CAD software have been increased and improved over the time. It allows easy, fast and cost effective performance estimation of various alternatives at conceptual and preliminary design stages. In detail design stage, CAD can refine the design in terms of manufacturability (size, tolerance, and fitment) and can provide more accurate stress-analysis (structural, thermal, magnetic, etc.) outputs. The engineering drawings and bill of materials (BOM) can be generated directly from the 3-D CAD model, which is very useful for cost estimation and product scheduling. The CAD-model can be transferred into CAM model for final realization of physical product. Therefore, CAD is very useful tool in reducing cost, lead-time and improve the quality of the product therefore applied for this research work.

1.4 Quality Function Deployment (QFD):
Dr Yoji Akao first presented the concept and method of QFD, in Japan in 1960 as a method or concept for new product development under the umbrella of Total Quality Control (Chan and Wu, 1998; Zaim 2002; Lin et al., 2004). The introduction of QFD to America and Europe began in 1983 and today, QFD continues to inspire strong interest around the world in the academia and industries. It is being applied in many industries like automobile, electronics, construction and service sectors. It is widely and effectively applied in product design and development process. It is being applied in Indian industries also in which Tata Chemicals TVS-Sunderam, NBC- bearing manufacturer are few ones.
According to the Chan and Wu (1998), the Quality function deployment (QFD) is “an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production i.e. marketing, planning, product design and engineering, prototype evaluation, production process development, production, sales. QFD is very effective decision making tool which can show the technical strength and weakness of the organization with respect to the competitor’s product, degree of technical difficulties in the design concept but it does not suggest how to improve the concept to satisfy the customer needs. To answer how the design can be improved and customer can be satisfied; the technique like TRIZ is studied and applied.

1.5 TRIZ (Teorija Reshenija Izobretatelskikh Zadach):
TRIZ (Theory of Inventive Problem Solving) technique is comparatively new and was not known up to 1990 but the 1st paper on TRIZ was published in 1956 in USSR. TRIZ approach can increase the ability of a person to generate creative design solutions. The tougher market competition can be faced by the industries by means of increased rate of innovation and creativity in the products design and development. TRIZ consists of comprehensive collection of techniques and forty guiding principles.

But now its popularity in the US, Japan, Pacific Rim, Western Europe and even in India is growing rapidly. Magazine (Fortune 500) listed the companies which have cited a phenomenal increase in productivity, and they credit TRIZ for the breakthrough ideas and quality solutions to tough engineering problems as fuelling. Fortune 500 is an annual list of the 500 largest industrial corporations in the US and/or other countries, brought out in the Fortune magazine on the basis of sales and gross revenue. This registered trademark is a benchmark of business excellence for any company or organization targets to achieve. India is blessed with a number of Fortune 500 companies which are perfectly in tune with international standards and service level. These companies have been contributing steadily to the GDP of the country and therefore, playing a crucial role in lifting up the economy of India. The Premier Fortune 500 includes the Indian companies and public bodies like ONGC,
Indian Oil, Bharti, Reliance Industries, Tata, State Bank of India, Wipro, HCL, etc. In India both the techniques are at infant stage; however some of the MNCs like Hewlett Packard, IBM, Motorola, and Raytheon and Xerox are practising TRIZ whereas academic institutes like IIT Bombay and India Modern TRIZ Academy are making effort to popularising the technique by organising various workshops and seminars.

1.6 Motivation:
My strong motivation factor is the Quotation of Former President of India Dr A.P.J. Abdul Kalam which is “Let my Brain Remove your Pains” Therefore to make the lives of our soldiers safe and comfortable; by using my engineering knowledge and experience through this research work was undertaken. In the present era, there is great revolution in product design and development methodology worldwide in domains like automobile, electronics, chemical, food, plastic and textile but hardly any attention is given towards the design and development of medical devices like stretcher, medical beds and so on. There are certain methods to evaluate the innovation potential of a country or organization based on many indicators like number of patents, scientific-output, creative-output, business-sophistication and market-sophistication and more but there is no method to evaluate the novelty of the product concept. However, the product novelty is very important even to survival in the market in the present era of globalization. Therefore, a gap if felt in this direction motivated me to initiate the research work.

Other motivation factors:

a. Interaction and discussion with higher official of Armed Forces (Director General, Medical Services, Deputy Director General Med Services) pertinent to the problem of Army Medical Corp personnel to evacuate the casualty in the field.

b. Special articles in the known medical journal like Medical Journal Armed Forces and Frontier Medical etc. pertaining to the casualty evacuation problems of soldiers in fields.

c. Visits to the exhibitions like International Medical Technology, Defence Expo where the focus remains on high tech devices and consumables/disposable medical items.
d. Poor attention of Indian industries towards the design and development of medical device like stretcher.


1.7 Aims and Objectives of the Research:
The main objective of the research work is to get insight of Integrated Product Design approach and its tools/ techniques to develop a customer oriented product like stretcher by understanding various pertinent issues and evolving the approaches such as:

1. IPD approach, its important tools and techniques
2. Benefits of IPD approach over the conventional approach in product design
3. Evolve an approach to evaluate the degree of novelty of a design-concept
4. Evolve an approach to improve the design concept in an innovative and structured way to meet the customer requirements for the product
5. Apply the proposed approach to design the advance “casualty evacuation stretcher” suitable to use under the extreme ambient conditions prevailing in India for satisfying the needs of our Armed Forces.
6. Validation of the proposed product design approach by applying it to design similar product like multipurpose army field cot cum stretcher.

1.8 Research Methodology:
In this thesis, the research adopts an Integrated Product Design (IPD) approach, utilizing different kind of sources, methods and theories to satisfy the research objectives. The literature and product survey includes concepts, product development models and existing stretcher designs with their advantages and limitations.

The research efforts have focused on building up a broad theoretical foundation based on literature review, case studies, and various product design tools and techniques like CAD, TRIZ and QFD to build a systematic integrated design approach to address the problems in design of the product like casualty evacuation stretcher to be used under the extreme ambient conditions. The design data was collected through literature review, product reviews (patented and commercial similar products designs), stretcher manufacturer’s news-letters. Customers’ needs and requirements were collected through structured questionnaires from surveys, group discussions and interviews.

1.9 Outline of the Dissertation:
The thesis is divided into seven chapters and the structure of the dissertation is as follows:

Chapter-1 provides the brief introduction of the casualty evacuation stretcher, existing designs of the stretcher and the needs of the light weight backpack stretcher. It briefly introduces the integrated product design approach and its various tools like CAD, QFD and TRIZ, then it discuss the aims and objectives and research methodology.

Chapter-2 discusses the literature review pertaining to the product design models, methods and tools, then advantages of design models followed by various design approaches like sequential, concurrent and integrated product design. IPD approach is discussed in detail by describing the definitions, principles, advantages and limitations. It also includes brief description of the product “requirement analysis process” and types of the reviews. The
Chapter deals with Quality Function Deployment (QFD), its history, implementation procedure, structure, advantages and its limitation. It is followed by the innovation in the product design, innovation type, innovation indicators, types of newness and TRIZ, an innovative problem solving tool to improve the design concept.

Chapter-3 describes the literature review pertaining to the designs of the medical stretcher, its types, BIS standards for dimensions, specification of canvas and load bearing capacity of the stretcher which is followed by gap analysis between the user needs and existing designs of the stretcher.

Chapter-4 describes the output of the research work. It discusses the detail description of the proposed design methodology, followed by detail description of proposed design model. It describes the proposed approach to evaluate the degree of novelty of a design concept. Finally it suggests the QFD integrated TRIZ (QIT) approach to improve the design concept to ensure a customer oriented product.

Chapter-5 discusses the design of the “light weight foldable stretcher” by applying the proposed approach. It includes stretcher needs analysis, customer survey details, evaluation of novelty of the stretcher concept, application of QFD to design the stretcher. It describes the detail design procedure of hinge joint and other components like main beam, fabric, spreader bar, locking mechanism etc. It includes various types of tests like bond strength test, shear and fatigue test of metal composites components then static, dynamic load tests and user field trials to verify the stretcher design. Finally it discusses the improvement of the stretcher design by applying the proposed QIT approach. At the end of the chapter there is the summary of advantages gained in the design of the stretcher by applying this proposed IPD.

Chapter-6 describes the design of the multipurpose army field cum stretcher (MPAFCS), which includes the need and requirement analysis of the MPAFCS, details of market survey
and the gap analysis, followed by evaluation of the degree of novelty of the MPAFCS concept. It gives elaborated description of the QFD to design the hinge joint other components like frame, main beam, spreader bar, locking mechanism, strip joint and fabric etc of MPAFCS. Further it discusses the static load testing of alpha product then improvement of the concept by applying the proposed QIT approach to eliminate the gaps between the designed and required product attributes. It also discusses the details of the improvement made in the components of the MPAFCS, then the static and dynamic load testing of beta product and final specification of the MPAFCS design.

Chapter-7 discusses the conclusion, which includes the advantages of the proposed approach in the design of stretcher and MPAFCS designs and recommendation and direction for future work.