Research Paper

IDENTIFICATION AND MODIFICATION OF DESIRED FEATURES TO IMPROVE THE PERFORMANCE OF MANUALLY OPERATED WHEELCHAIR

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ABSTRACT

The concept of Product design is an approach of designing a new product or suggesting modifications for existing product. The objective is to review the existing product, evaluate it for functional as well as value added features. In this process the product may be redesigned to achieve the modified value added features. In this work, wheel chair is considered as a product. The purpose of this work is to develop the manually operated wheel chair based on review of the existing wheelchair function and modify as per need of disables. The information is gathered from hospital survey, questionnaire prepared for direct user, discussion and consultation with medical practitioner to list out the desirable function a wheelchair. The desirable functions are identified and model of suggested features is developed using CATIA software.

1. INTRODUCTION

Wheelchairs are used by people for whom walking is difficult or impossible due to illness like physiological or physical injury, accidents or disability. People with both sitting and walking disability often need to use a wheel bench. The common wheelchair system is limited in its functions, and it needs human force to move it. The other problem in the existing wheelchair is, seating is not really comfortable and types of disabilities are not considered while designing it. The design is general in nature. The objective of this work is to identify suitable wheelchair for the usage of disable people, provide more facilities on wheelchair such as, tabletop, back and neck support, thoracic support back pain relief system, storage system, safety belts, etc to make patient more comfortable and independent too.

Design of wheelchairs was mostly the result of the requirement specified by medical practitioners who always insisted on transportation needs hence it always lacked engineering/ergonomic approach. This work intends to use the technology for the benefit of physically disabled people and hence, Wheelchair, one of the largely used products by these people is selected for redevelopment study.

2. PAST STUDIES ON EXISTING WHEELCHAIR

Lot of literature is available on Wheelchair. Work on electronic wheelchair is carried out by many researchers to decrease human effort. **Zaide Bin Rahim** [1] in his project has suggested the different steps to be taken while designing the wheelchair. **Rory A. Cooper** [2] in his book wheelchair selection and configuration has suggested wheelchair selection and purpose uses. The examination of the impact of surface type, wheelchair weight, and rear axle position on older adult propulsion biomechanics is done [6]. Four types of wheelchair available in India were evaluated from physiological, anthropometric and biomechanical points of view [7]. Efforts have been made to manufacture low cost wheelchair [8]. A paper on Automatic transmission for electric wheelchairs from Journal of Rehabilitation Research by **JAMES B. RESWICK,** This paper presents a description of a new, infinitely variable automatic transmission suitable for use on electric wheelchairs (as well as other vehicles). It also presents test results of the performance of a standard three wheeled wheelchair equipped with a prototype transmission as Compared with the performance of the wheelchair without the transmission [9].

Through the literature survey carried, it is established that much of the work [10 to 13] has been done on mechanization/automation and control of wheelchairs. However it always lacked a vision on requirements of features for disabled. Hence efforts made to improve functional needs of wheelchair as specific to disability are justified.

Fig 2.1 A Three dimensional model of existing wheelchair

The wheelchair shown in figure 2.1 is the existing model of a manual wheelchair which is most commonly used by the almost all disabled people. The purpose of selecting this model is that in survey this was the only wheelchair seen used by people as it is cheap and easily available in the market.

3. DISABILITIES AND REQUIREMENT

Following are the requirements identified

- Major joint problems- These category users cannot walk at all and they are permanent user of wheelchair.
- Rheumatoid Arthritis- An autoimmune disorder that occurs when a person's immune system attacks the membranes surrounding their joints, causing them to inflame. The users comes under this category can walk but are advised not to do in severity and hence they need wheelchair.
- Spinal Stenosis or Nerve root compression - Spinal nerve root is compressed and that compressed nerve is causing pain to radiate, range of motion is limited. Depending on severity the users under this category can advise do not walk at all and hence they can be permanent users of wheelchair.
- The spinal cord injuries - It can lead to a disruption of this communication channel and can lead to paralysis. These are the most common cause of paralysis. The patients under this category are unable to walk at all and require wheelchair till they are paralytic.
- Multiple Sclerosis (MS) - MS can affect multiple parts of the body. Some symptoms include: loss of balance, problems with walking and

coordination, tremors or weakness in the legs and arms. The patients under this category must require wheelchair as they are unable to walk.

- Post-polio syndrome (PPS) - is a condition that affects individuals who had polio. The symptoms of PPS include muscle weakness that gradually gets worse, shrinking of the muscles, breakdown of joints, increased bone deformities etc. The patients under this category are permanent user of wheelchairs.
- Hemi-paresis – The partial side of body affected by paralysis. The one side of users of such category remains always deviated and need a side support always when sitting on wheelchair.
- The users comes under permanent disability like polio, lost their legs in accidents are unable to walk. They come under the category of permanent wheelchair users.

More than hundreds such disabilities can be the cause of use of wheelchairs. Hence it is necessary to have large survey of such users.

3.1 Survey of direct users

The product development process is mostly driven by the users need. Direct user survey is the best activity to know the users need. A questionnaire was prepared for the direct users to get more requirements from them, about the wheelchair. Some selected questions of questionnaire are as shown in table3.1.

Table 3.1: Sample questionnaire for direct users

Sr.	Questions
1.	Which type of wheelchair are you using?
2.	Are you satisfied with your wheelchair?
3.	What are the uncomfortable things you feel about your wheelchair?
4.	Which type of modification you suggest in your wheelchair?

The total 20-25 numbers of long term direct users were contacted. In the response of all these type of questions there are so many ideas are generated, and many objectives were prepared. The responses from the direct users are shown in table 3.2:-

Table 3.2: Responses of users

Sr.	Response of the user
1.	All are using manually driven wheelchair.
2.	Some were satisfied with wheelchair but expecting some extra comfort. Whereas large number of users were not satisfied
3.	Mostly all required a working table on the top of chair for doing daily work.
4.	Many of users need a head support at the back.
5.	The back rest should be adjustable.
6.	The fixed front rigging is uncomfortable.
7.	No provision for keeping water bottle.
8.	Not comfortable while watching TV.
9.	Can't work on laptop.
10.	Not satisfied with the seating arrangement.
11.	Not satisfied with the color, every time they feel like a patient when sits on it.
12.	Can't keep head comfortable
13.	Problem of back pain after long seating

From this questionnaire the following issues are short listed as most of the users have point out them.

1. Provision for head rest is desirable for almost all type of disabled patients.
2. Provision for head and neck support is essential for the patients having increased forward flexion.
3. The front rigging i.e. leg rest and foot rest should be adjustable.
4. The back rest should be comfortable and adjustable.
5. At least a small tabletop is essential on the chair.
6. Color is also considerable issue.
7. Need of some small compartments for keeping daily usable stuff.

3.2 Discussion and consultation with medical practitioner

Merely considering the users' requirements was not sufficient to finalize objectives of product design approach for wheelchair. As the product is in concern with medical field it was decided to take opinion of medical practitioners. To know/gather more information, apart from orthopedic practitioners the views of other medical practitioners are also considered. The suggestions and opinion from these practitioners are listed as follows.

1. Instead of only head rest it is suggested there should be head and neck support. The patients having problem of forward flexion but with mobility, or having problem of loss of muscle tone due to neurological conditions a head support should be there which will be able to hold the head of such users.
2. The patients having problem of side deviation may be due to hemi-paresis or any other neurological disorder a side support is essential for them. Such users don't have any control on affected side and hence their one side is always remaining deviated.
3. There are so many accidental cases came where the legs have to be kept in different tilted positions. In such cases the fixed front rigging is not suitable hence the leg rest should be adjustable so that the patient can be free to keep his/her leg in comfortable position.
4. Height of the back rest is major problem it should be adjustable and having push back mechanism for more comfort to the patients.
5. Adjustable top should be there on chair because it is essential for the patients for performing daily works of eating, writing or using laptops.

After considering all the aspects it is seen that added features will increase the value of regular wheelchair. All the issues, responses and suggestions are studied and objectives are categorized according to the necessity. The objectives of product design approach for wheelchair according to importance are as shown in following table 3.3.

Table 3.3 Objectives of Product Design Approach

Sr	Objectives	Importance	Justification
1	Provision of Head and Neck support	Provide support to head of increased forward flexion user. Also can be used as head rest for relaxation.	With extreme forward flexion often risk respiratory issues due to occlusion or impingement of their airway.
2	Provision of firm seat and back system	Help the user to move back and ensures increased sitting tolerance and comfort.	The bed sore problem may occur due to continuous sitting. Back movement for relaxation is not possible.
3	Provision of Thoracic support	Provide support to side deviation disabled user	Patients with hemi paresis don't have control on affected side.
4	Provision of adjustable front rigging	Help the user to keep leg at any desired angle.	Users with leg fractures, injuries, fracture neck femur needs to keep leg in desired comfortable position which may vary case to case.
5	Provision of tabletop on chair	Each and every user needs table top for one or many reasons.	If not provided unable to arrange tabletop every time. Users with shoulder problem cannot stretch hands to reach separate table.

4. GEOMETRIC MODELING OF DESIRABLE FEATURES

After considering various issues, needs of users, suggestions of medical practitioners and ergonomic point of user the finalized desirable features as set in previous discussion the geometric modeling of all finalized features are done using CATIA V5R19 version. The desirable features described below.

4.1 Head and Neck Support

Breathing is often overlooked during the seating and wheeled mobility evaluation in the pursuit of alignment. Individuals with extreme forward flexion often risk respiratory issues due to occlusion or impingement of their airway. To avoid the bending of head in downward position while sitting on wheelchair, head and neck support is designed. It holds the head in straight position. Keeping the average head circumference of adult in consideration and posture of human skull, head and neck support is design as shown in figure 4.1.

Fig: 4.1 Three dimensional model of Head and Neck Support

Fig: 4.2 Three Dimensional model of Firm Seat and Back System

4.2 Firm Seat and Back System

Firm seat and back systems for wheelchairs help to keep correct positioning of patient's bodies that need additional support. A modularly built back system for individual care is suggested here. It supplements the seating system and ensures increased sitting tolerance and comfort. Also adjustable head and neck support attached on the back side of back rest as shown in figure 4.2 is used to solve the height problem of user. The head and neck support can be used as head rest for relaxation.

4.3 Thoracic Support

Thoracic supports suggested here is a rectangular shaped devices that mount to the back posts of the wheelchair and rest against the user's trunk the three dimensional model of thoracic pad is shown in figure 4.3. Thoracic supports were developed to provide anterior support. This is best suitable for the user suffering from side deviation disability due to any injury, or neurological disorder like hemi-paresis.

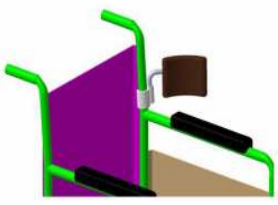

Fig: 4.3 Three dimensional model of Thoracic support

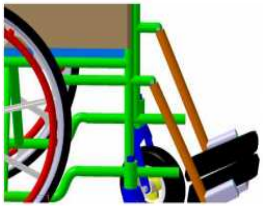

Fig: 4.4 Three dimensional model of Front Rigging

4.4 Front Rigging

Front rigging is the collective term for footrest and leg rests. Leg rests consist of an elevating support bracket with swing-away mechanism, pivot-and slide- tube with foot-plate as shown in figure 4.4. Adjustment is critical with respect to the distribution of the loads over the thighs and buttocks. Elevating front riggings needs adjustable footrests and leg rests for those patients with conditions, such as edema arthrodesed knee, and leg in a cast that require that one or both legs be elevated. Considering all this factors the suggested front rigging is having facility of adjustable leg rest.

4.5 Tabletop Arrangement

A tabletop on wheelchair is attached to the armrests as shown in figure 4.5 to create a work surface. Tabletop of different shapes and sizes can be used according to type of arm rest. For long or full embodied armrest the design of tabletop can be used as suggested in figure 4.5. This top table creates a convenient surface for eating meals, writing letters, reading books or magazines, and performing desktop tasks. Sometimes it can be used as hand rest in forward position during relaxing.

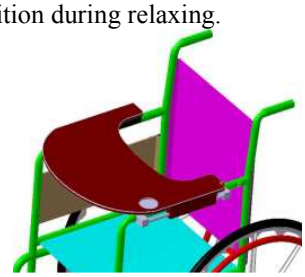

Fig. 4.5 Three dimensional model of tabletop

5. DISCUSSION AND CONCLUSION

Wheelchairs used by disadvantaged people are developed based on the inputs provided by mostly medical practitioner. Though there are many numbers of disabilities making the use of wheelchairs necessary, the types of wheelchairs available are few. The objective has always been the transport of disabled than considering it as a permanent/long term seat for the patients. Obviously much of the variation and modification till date were directed towards Automation for transportation.

However while making study on this project it was found that there is a need to shift designers focus from wheelchair as a means of transportation to wheelchair as a means for long term use as a seat. In this project the focus, therefore, has been on the comfort of the patient.

The existing commercial wheelchair has been modified through fabrication and it has been checked that the suggested design work satisfactorily. The value additions made were appreciated by both the patients and medical practitioners.

Though the list of modifications is limited it has been possible to address the needs of many types of physical disability through these modifications. Hence it can be concluded that this work has successfully shifted the focus of design of wheelchair from mere transportation means to the comfort requirement of the patients.

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