TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics and Mechanics
Vol. 55, Issue II, 2012

FEM ANALYSIS APPLIED IN THE DESIGN OF ASSISTIVE TECHNOLOGY SYSTEMS

Adrian Vasile ABRUDEAN, Dan MANDRU

Abstract: *In this paper we present the steps which are necessary to send in production a Rollator. We start from a new design which has a good feedback from market, and then we change same details in order to improve the product. In detail we look at FEM analysis for same parts. We'll take only the components which are important for testing.*
Key words: *FEM analysis, assistive technology, rollator.*

1. INTRODUCTION

The sensorial and communication impairments, as well as the lack of mobility and manual dexterity lead to multiple barriers to integration in society of people with disabilities. In order to respond to their special needs, Assistive Technology (AT) was developed during the last years, as a representative component of Biomedical Engineering, [1], [2]. Development of technology for assistive devices, apparatus and complex systems has as a direct consequence an improved functionality at lower costs, meaning doubtless advantages for a large number of potential users.

The AT field is very wide and comprehensive. According to [3], all the devices and aids which help or support the functional capacity of the human being, fall under the heading of AT. The purpose of their use includes prevention, compensation, relief and neutralization of the impairments, disabilities or handicaps. Someone could fit within AT the following product categories:

- mobility aids,
- wheelchairs,
- aids for vision impaired,
- aids for hearing impaired,
- augmentative / alternative communication systems,
- aids for daily living,
- monitoring and assistive aids for elderly,
- environmental control systems,
- assistive robotics, etc.

This paper presents shortly the design methodology currently applied by the authors in developing assistive devices named rollator and gives more details concerning the Finite Element Method analysis and its benefits for the design process of AT devices.

2. THE DESIGN METHODOLOGY

The starting point of modelling is to choose the design of the product in compliance with the design of its producer. After the design was established and the market had been investigated, the designer may proceed with introduction of restrictions (criteria) that are to be taken into account for the functionality of the product and its selling success.

There are several restrictions:
a) dimension range of valid standards in order to get a correct product;
b) dimensional range we want to cover;
c) choice of production technology;
d) choice of proper materials;
e) financial evaluation of preparation and production costs ;
f) modelling of the new product;
g) simulation;
h) getting ready of the production;
h) launch of production;

Points a) and b) define the clearance dimensions of the product. Point e) shall be the subject where most references to previous points will be made in order to get the equilibrium among all criteria and also to get a competitive product. Points f) and g) may also refer to the initial phase to revise the design of the product out of technical execution reasons. In figure 1 you can see a logical scheme for product realization.

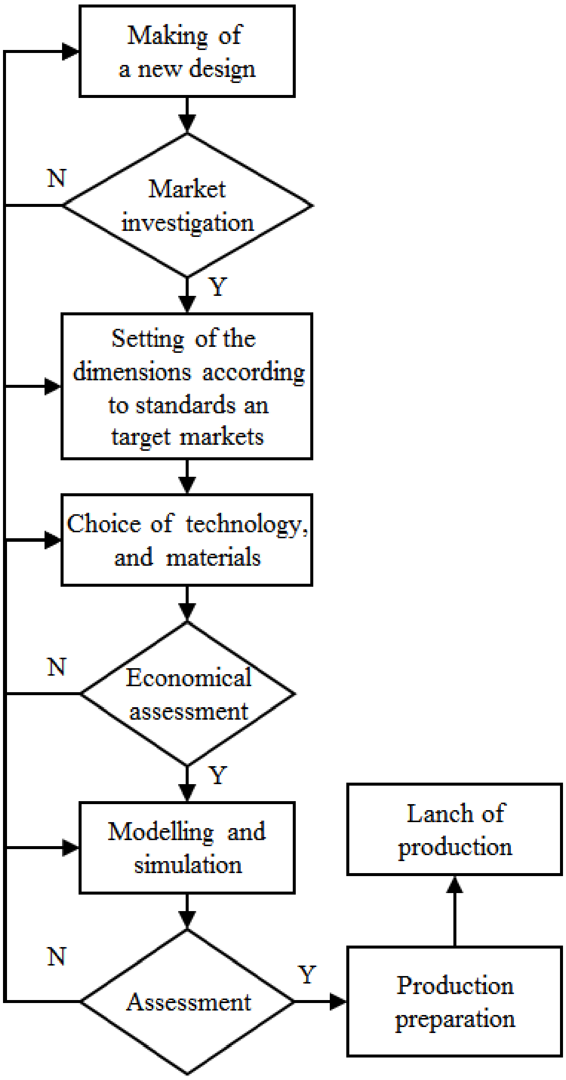

Fig.1. Logical scheme for product realization

The design is established according to the specific line of the producer and the feedback from the market.

To show this, in figures 2 and 3 you see the rollator in its design phase. One can notice that the product does not show yet deep technical details that will be given in the modelling and simulation phase only.

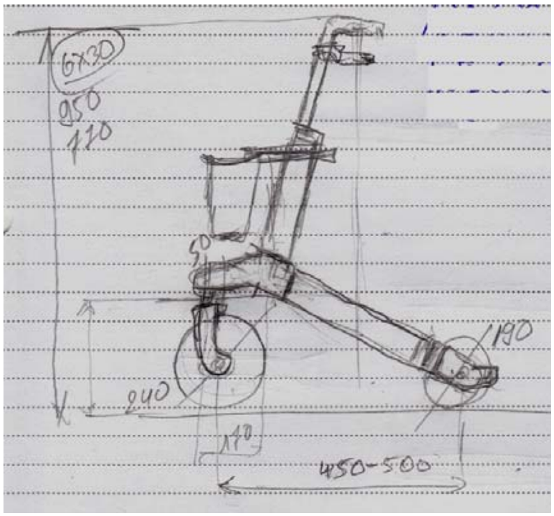

Fig.2. Sketch design

Fig.3. Product design

In the design phase we are interested in the line of the product and some information data concerning the product's functionality.

In the modelling phase the product, figure 4, is given technical details. In this respect we have to find in the modelling phase technical solutions having in mind that the plastic parts of the products will be moulded in dies.

To carry out this task the operator who models the product is meant to have a minimum knowledge about the behaviour of plastics materials during and after moulding. He/she also have to know how to make a moulding die. When moulding a piece we should know how the die is to look like and how it is going to work.

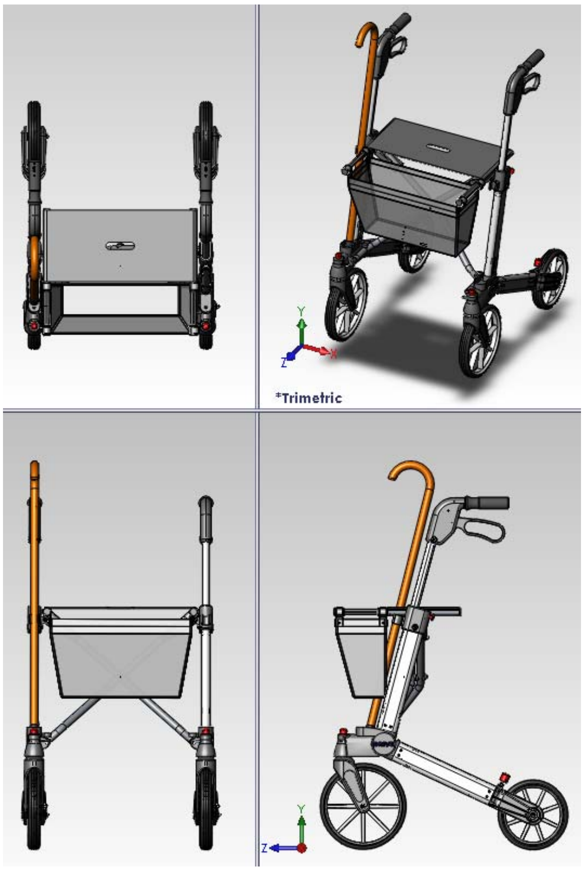

Fig.4. Designed product

In this phase we know the dimensions of rollator, taking account of the valid standards; also, we know the clearance dimensions of the product. In this phase we shall also take into account the using conditions.

3. THE FEM ANALYSIS

FEM analysis refers here to the test of some virtual loads in order to see the behaviour of the product under maximum test conditions and to find potential zones of weakened resistance and the elimination of such zones by adding some elements of resistance or by altering the shape of the product. We need to refer also to the moulding of plastics to determine the welding zones of the materials as that zone shall alter the resistance of the material.

Simulation allows obtaining best configurations of certain components, i.e. the best combination between shapes, material consumption and resistance. It is the way to avoid possible problems due to the lack of resistance at loads that we want to get as such problems are difficult to solve after the tools and dies are finished.

The rollator is designed for a maximum loading weight 130 kg. According with test standard DIN EN ISO 11199-3:2005 “Walking aids manipulated by both arms – Requirements and test methods” a FEM analysis for 120% from maximum loading weight, which means about 1600 N, is made.

In next figures we’ll show the steps to get the optimal part.

In figure 5 you can see a first version for back fork after FEM test.

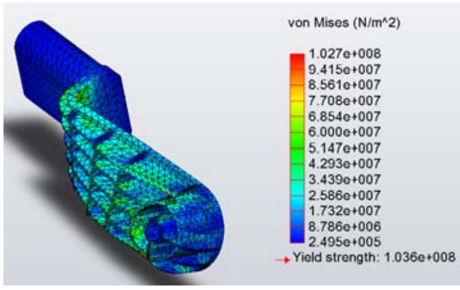

Fig.5. First solution for rear fork

After first FEM test result to change the design for rear fork. Is possible to eliminate the most of rips, and change the configuration.

The result of second FEM test for new design of rear fork is shown in figure 6

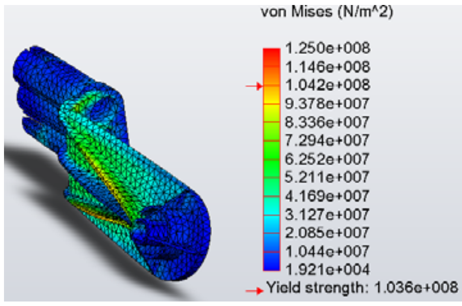

Fig.6. Rear fork redesigned after FEM analysis

After second test the result is better and was decided to eliminate the torsion from fork. Was increased the wall thickness from fork, and then applied a new FEM test. The new result is shown in figure 7.

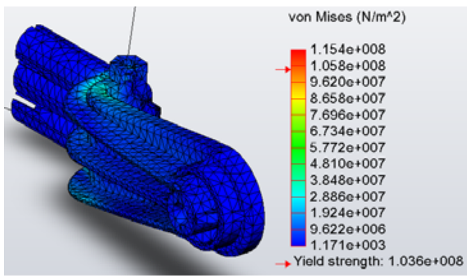

Fig.7. Rear fork optimized

The result was good, but to optimise the production process and to reduce the production costs was decided to use one fork for both sides. Again the fork was redesigned and applied a new FEM test. The result is shown in figure 8.

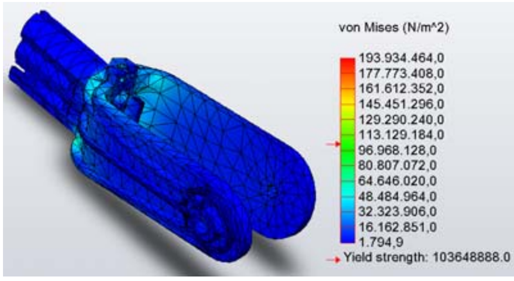

Fig.8. Final design for rear fork

We received the final design for rear fork, which is optimal from different points view: resistance, economical, production.

A similar result after same FEM analysis and same optimises is shown for Joint part in figure 9. Also for joint part is necessary to make an analysis for moulding process to see where the critical points are, and combine this two analysis for a proper result.

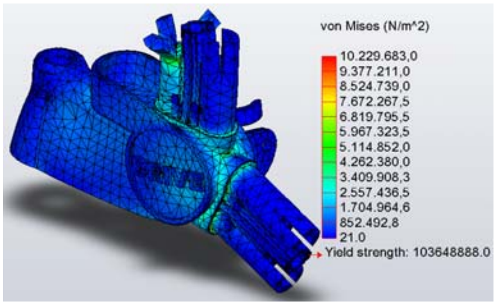

Fig.9. FEM analysis for Joint part

In figure 10 is shown the FEM analysis for handle bar. This was also optimized after same FEM analysis.

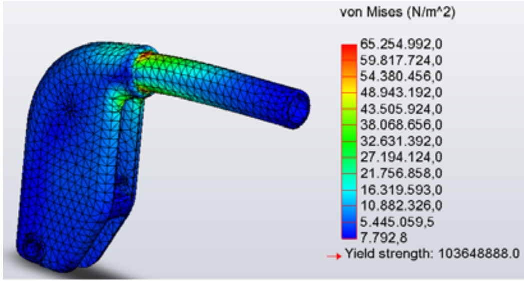

Fig.10. FEM analysis for Handle bar

4. CONCLUSIONS

Modelling and simulation of a product is a complex process that should be treated seriously

Modelling and FEM analysis of products is extremely important for the end result, i.e. to make sure that the final product meets all requirements.

One more conclusion of this work is to pay a proper attention to the operator who carries out modelling and FEM analysis as his/her knowledge is of fundamental importance.

5. REFERENCES

[1] Bronzino, J.D. (editor), *Biomedical Engineering Handbook*, CRC Press & IEEE Press, Hartford, 1995.

[2] Dee, W., Layton, N., *Hard and soft assistive technologies: Defining roles for clinicians*, Australian Occupational Therapy Journal (2008), 55, pp.61-64.

[3] Mandru, D., Lungu, I., Noveanu, S., Tatar, O., User centered design of rehabilitation engineering systems, *Acta Technica Napocensis*, series: Applied Mathematics and Mechanics, 52, vol. 1b, pag. 475-480, 2009.

Analiza FEM aplicata la proiectarea sistemelor specifice tehnologiei de asistare

In aceasta lucrare se incearca o scurta introducere in proiectarea sistemelor tehnologiei asistive. Se prezinta succint etapele necesare obtinerii unui sistem de tehnologiei asistive, anume un rollator. Sunt prezentate etapele incepand de la crearea unei schite, pana la lansarea in productie a produsului. Lucrarea se axeaza in special pe prezentarea importantei analizei FEM in proiectarea componentelor din plastic a sitemului. Este prezentata evolutia designului unei piese din plastic ca urmare a interpretarii rezultatelor analizei FEM aplicata.

Adrian Vasile ABRUDEAN, Drd.Eng., adrian.abrudean@yahoo.com, 0263-238088, Drive Medical SRL, Bistrita.

Dan MÂNDRU, Prof.Dr.Eng., dan.mandru@mdm.utcluj.ro, 0264-401645, Technical University of Cluj Napoca, Department of Mechatronics and Machines Dynamics.