Design of a System for Studying Human Gait on Different Surfaces and Slopes

Dídac Trubat Ponti

Machine Design, Department of Design Sciences LTH
Lund University
P O Box 118
SE-221 00 Lund, Sweden

Abstract

This Master Thesis contains the first stages of the development process of a system to study human gait presenting a final concept. Moreover, the Master Thesis covers the vibration analysis of a real prototype based on the concepts presented.

For the development of this project, there were almost no restrictions or guidelines. Hence, it was necessary a previous process of investigation and research before in order to start the design part, which includes user identification, benchmarking and identification of the stakeholders needs.

The design process has been systematic and based on several theories, which lead to a well-based and sound proposal. Furthermore the design of a real prototype has given the chance to make an improvement over the first concept, working on another loop of design and therefore refine the solution.

Introduction

The Division of Ergonomics and Aerosol Technology at Lund University needs to develop a device in order to carry out the study described as follow. The purpose of the study is to investigate gait biomechanics, i.e. three-dimensional ground reaction forces, on dry, wet and icy surfaces while walking down and upwards on different slopes. Therefore the study aims to analyze the slip and fall risks in relation to friction, i.e. grip or slip resistance, between shoes and the underfoot described previously in order to prevent accidents and associated injuries in various challenging environments.

Aim

The objective of the Master Thesis is to design and develop a solution a system for studying human gait on different surfaces and slopes. More over it must adapt to the required needs stated and be feasible within the Lund University capabilities.

Problem formulation

The solution presented has to be able to study human gait biomechanics within several challenging condition.

Therefore the main requirements for such a device are:

1. Calculate three-dimensional ground reactions.
2. Study surface material (tile, metal, vinyl, ice)
3. Study surfaces contaminants (dry, wet, oil)
4. Slope inclinations (from 0 to 30 degrees)
5. Walking direction study (on level, down, and upwards)
6. Bare load carried by the human subject

Method

The methodology used follows a systematic approach to the design process, where the ideas are arranged and evaluated systematically in order to result in a new or improved design concept.

The project has evolved along the process; however three main parts can be identified. Emphasize that the project does not present

a typical and linear development of the process, due to certain circumstances.

The first part is a study of the current technologies related to the project, i.e. devices and techniques used to carry out similar studies as the one described in the previous chapter. Followed by an understanding of the user needs and the technical specification related to them. The establishment of clear objectives has been the base of the project before the starting with the creative process.

The second part encompasses the conceptualization process itself. It goes through an insight of the functions that the device must contain, followed by the ideation process in order to open and stretch the solutions space. Thus helping to shape a concept.

The last part is not the natural continuation of the development process. It jumps directly to the vibration analysis of the real prototype built in the university workshop to study the human gait. Even though the real prototype has not been built by the author of this thesis it is based on the findings of the two first parts of this project.

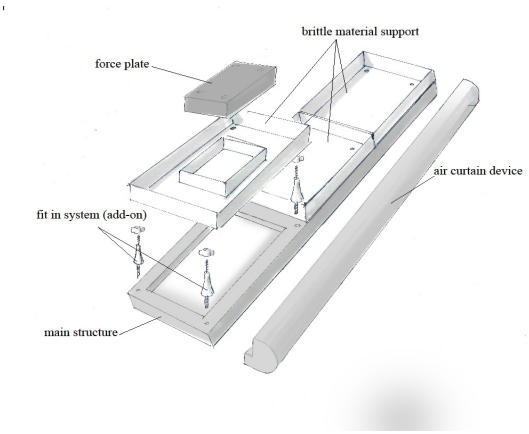
Conclusions

The final concept proposal resulting from the two first parts of the project trade-off mainly between the reliability of the force plate data, and the feasibility of designing the prototype within the university workshop resources.

The final proposal consists of a 3.5m long and 1 m wide ramp, which can change the slope powered by a linear electric actuator. The structure of the ramp is aimed to support the tested material together with the force plate (technology used to measure ground reaction forces). Due to the extreme sensibility of the force plate it has been mounted with several considerations. The main considerations are that the force plate has a heavy foundation (ten times its weight) in order to avoid internal vibrations. In this case the foundation is the same structure which is built with steel or concrete. Moreover, the walking surface of the force plate is separated at least 2 mm from the surroundings to avoid the external vibration produced by the subjects walking on the ramp.
Another feature of the device is the way of changing the material. In order to ensure a way adaptable to different materials (ice, metal sheet, title…), as well as quick and reliable bolt system is proposed. Note that this solution can be used without the support depending on the material, for instance metal sheet, which is resilient enough to stand by itself.

Finally, since it is desirable that the ramp can hold icy surfaces an insulation support plus an air curtain are included in the design. Therefore ice blocks are made in an ice chamber and then placed on the ramp which the insulation support and the air curtain keeps it in solid state.

All the proposals have been thought in order to be mainly built in the workshop of the university.



The last part of the project is not a detail presentation of the blueprints of the concept and how to build it. This part was carried out independently of this project by the Workshop of the department. However, the prototype built has some differences in comparison with the concept proposal. Basically the actuator is hydraulic instead of electric, and the real prototype has not yet incorporated the feature to bear icy surfaces.

However the real prototype has several problems regarding the reliability of the data obtained from the force plate. It has

been observed that the force plate has some disturbances when a subject is walking on the ramp. Therefore, within this project a vibration analysis was carried out in order to figure out the source of these problems. The vibration analysis was carried out with ANSYS, a software engineering tool. From the analysis it was clearly observed that the main reason of vibrations that cause the disturbance of the force plate was due to the bending of the actuator itself. Several proposals have been tested with the same software and it has been concluded that placing ratchets in strategic spots of the structure could solve the problem. Two effective proposals are to:

1) Add two ratchets under the actuator platform (Support 1)
2) Add a single ratchet under the base of the actuator lifter (Support 2)

References

Ponti, D. T. (2013). Design of a System for Studying Human Gait on Different Surfaces and Slopes, LTH Lund