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COMFORTYPING – PROGRAM FOR GRIP COMFORT OPTIMIZATION

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Abstract The human hand is constantly in contact with products. In particular, the handle of work equipment, as a direct interface to the user, greatly influences the perception of fatigue, pain and comfort. Comfortable handles need right decisions regarding handle design parameters such as shape, size, material and surface. In addition, the designer must consider many factors such as grip types, coupling types and target groups. Ergonomic handle design also generally entails using many subjects for the evaluation of prototypes. This evaluation is purely subjective, and justifiably so, as handle design has a strong subjective element rooted in the communication of comfort as sensation. But this also causes high development costs and development times. Research indicates that pressure distribution while gripping has a major impact on discomfort. The aim is, therefore, to develop a program for grip comfort optimization, based on a digital hand model, taking into consideration influence factors. With this new program, the constructor should already receive information on the CAD model about handle design parameters for the design of comfortable work equipment grips, thus enabling the number of test subjects and expensive prototypes to be reduced. This journal describes a first approach of a program with a coupled multi-body and finite element simulation program (MBS/FEM program). For this, an automatic optimization (AutoDesign) of a shape change handle is simulated and then tested. In the future, a stand-alone program is to be created from this basis.

Keywords: Comfortyping; grip comfort optimization; simulation; handmodel; pressure distribution.

1. INTRODUCTION

Ergonomic handle design entails a methodical consideration of all important influence factors. The designer must always perform an analysis about all conditions and factors that may finally have an impact on the design. The most important influence factors are the hand posture (ulnar, radial, palmar, dorsal posture) and grip types (e.g. pinch grip) as well coupling types (form and force closure). Design parameters will finally be determined by considering all these factors, with the help of guidelines about e.g. hand anthropometry and dimension [1].

Handle design lacks an objective method for making comfort measurable. Take, for example, the case of vehicle seat comfort. A seat can be checked for comfortable pressure distribution and can be compared with other seats. Thus, the seat design can be objectively improved. It is also possible with FEM simulation to predict the discomfort of sitting and to improve on the CAD model [2]. The same goal pursues Anybody in relation to muscle activity. For example, can AnyBody calculate variable geometry parameters with respect to the low muscle activity [3].

In the current journal, proposed is a grip comfort optimization approach, to improve the pressure distribution on the palm by automatic shape variation with the MBS / FEM program RecurDyn. For this purpose, a digital hand model from the preliminary work of [4] is to be used.

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2. METHOD

The term "comforting" is an artistic word and has emerged from the composition of comfort and prototyping. Comfortyping is intended to function as a stand-alone simulation program, in which a digital hand model is included in the simulation environment. After importing a hand-held product as well as after selection of influencing variables, they should be calculated on the basis of their design proposals. A similar goal for assessing the ergonomics of the man-machine interface also exists as ergotyping of [5]. In contrast to this, the focus should be placed on the hand-arm system with Comfortyping. For example, it should be possible to deliver spline suggestions to the user, which can then be imported into the CAD system. For Comfortyping, a database with different influencing variables such as grip types, gripping forces as well as hand-type and handle-dependent material properties is required. The program should offer a choice of three hand types with little, much as well as medium subcutaneous fat content. The work of [1] differs fleshy, tendinous and normal skin types. In addition, it should be possible to scale the hand models by percentile and gender automatically. A snap function should allow the hand model to take the product automatically.

The first approach for Comfortyping was developed with Recurdyn (see Figure 1). Here the grip of an iron bender was taken and defined the reduction of pressure peaks as well as a homogeneous pressure distribution as a target function. The MBS / FEM program Recurdyn has an Autodesign function and can iteratively optimize geometries. In the example, a shape change handle was constructed with six cylinders and pressed onto the palm of the hand with 200 N. In addition, the handle was gripped with 50 N gripping force. The geometry and material properties from the hand (skin type dependent) and the force and movement conditions from the iron bender (product-dependent) were selected from the database. For the target definition, the reduction and homogenization of the pressure distribution were selected manually.

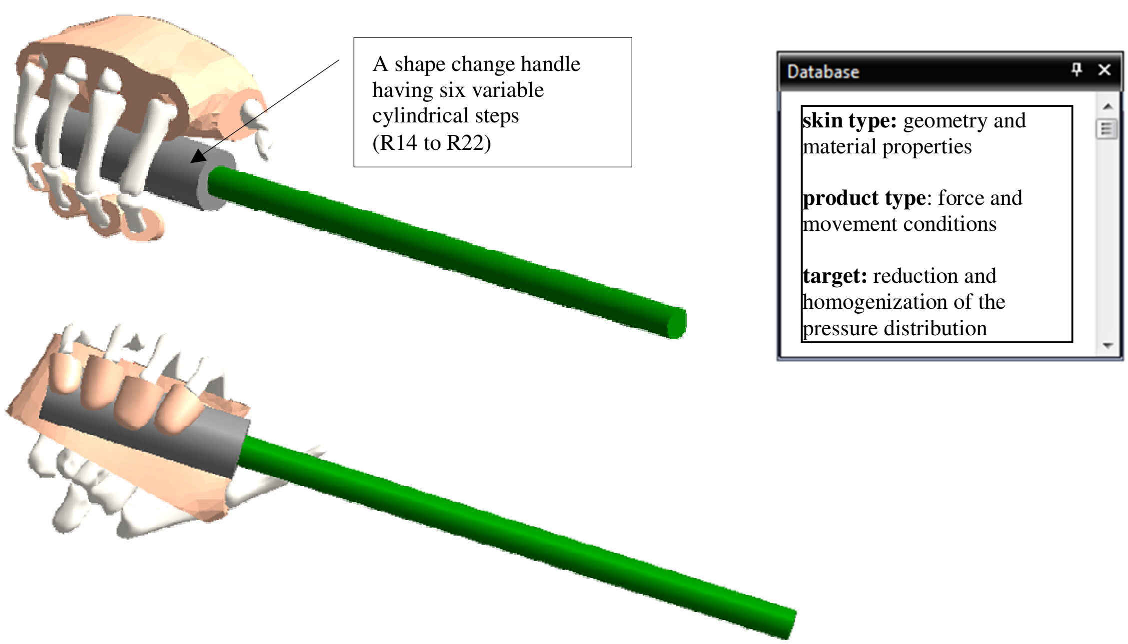

Figure 1. Approach of Comfortyping in RecurDyn.

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3. RESULTS

The results show before the optimization on the hand regions O and Q high pressure loads. The radius of all steps is R14. The pressure loads were redistributed to the hand center P with the optimization. For this purpose, the program changed the radius of the steps of the handle until a desired pressure distribution is obtained. To do this, the radius in the hand center changes to R22. This information is output as a spline into the CAD model of the handle. A pressure evaluation with different subjects confirmed the optimized grip shape as comfortable.

For comfort evaluation, the shape change handle was designed. The developed shape change handle consists of six spreader jaws, which can be moved by a threaded pin rotation. The threaded pins have right-hand and left-handed threads. The so-called entraining jaws spread the counter-jaw during an outward movement. To conceal the edges of the jaws, a rubber covering was applied. These six jaws have taken together with the width of a male palm of the 50th percentile of about 95 cm. The whole mechanism was tested by FEM for strength and is made of ABS. Various tools can be connected to the shape change handle.

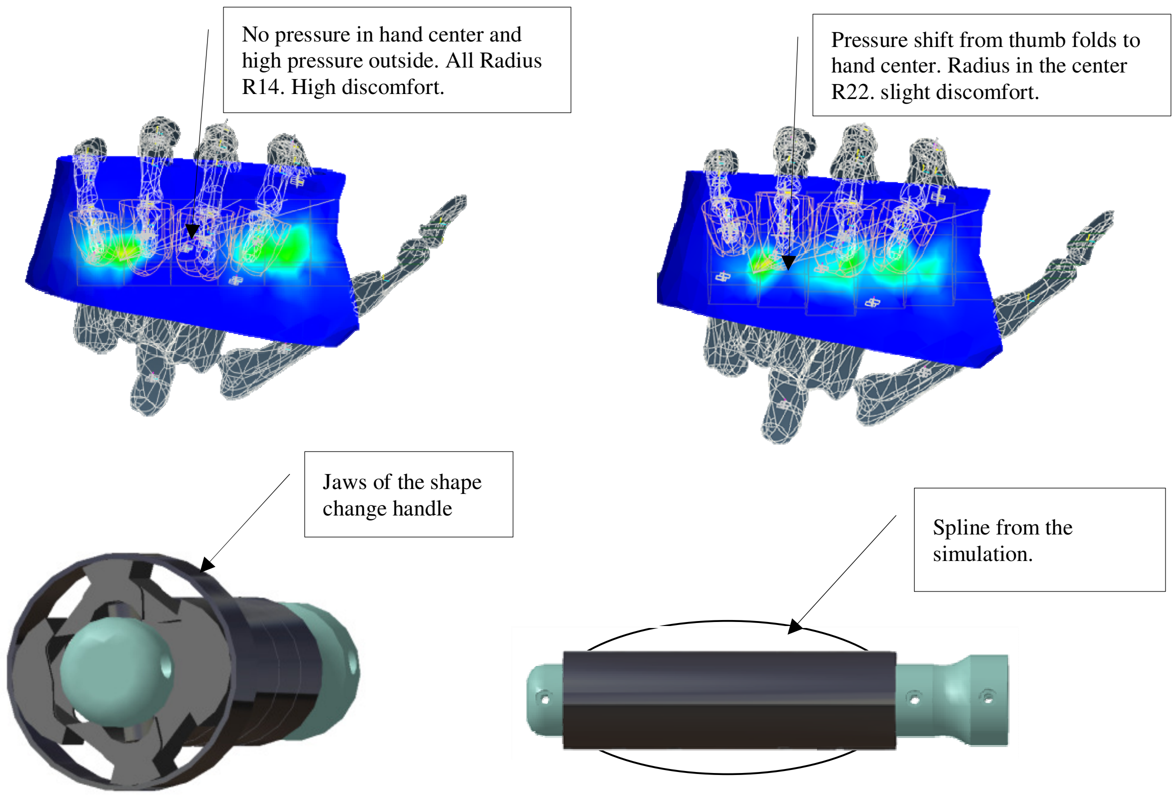

Figure 2. Results of handle comfort optimization.

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4. DISCUSSION

The developed approach of Comfortyping has shown that automatic shape optimization is possible with respect to influencing factors. In the next time, it should also be possible to simulate a tissue load not only for pressure stresses, as well as for shear stresses. For this, no hand models exist which can assess the shear stress on the palm of the hand. The shear stress is blamed for blisters and skin damage [6]. For this, there are no pain examinations, as is the case, for example, with the pressure stress. In addition, it has been shown that elderly people can feel different pressures [7]. The database must be extended for this influence factors.

A program with which the hand load in the joints can also be simulated parallel to the deformation of the material (according to [3]), belongs to a further development perspective. There are too many free open source programs available for programming Comfortyping. For example, programs such as Jfem and Impact have proven to be suitable for the simulation of the hand model based on the JAVA programming language. Table 1 gives an overview of programs for programming Comfortyping.

Table 1. Programs for programming Comfortyping.

Programs	Description
CFF [8]	CFF (Call for Finite Elements) is based on Python and Maple. The codes can´t be accessed directly. In particular, it is intended for learning purposes.
Reshape [9]	Reshape is also based on Python. It is a program specially designed for shape optimization. However, this program, which is limited to 350 elements, can´t perform any meshing.
Z88 [10]	Z88 is based on C. There are source codes and a standalone program (z88Auora) offered. The open source program was developed on Microsoft Visual Studio. The solver algorithms can perform a static FEM with any number of elements.
Hotint [11]	Hotint is based on C++ and can be freely programmed with Visual Studio. It is a MKS program and developed for mechatronic systems. Thus, even coupled FEM / MKS simulations is an open source. In the future, the program will continue to work for commercial purposes.
Jfem [12]	Jfem is based on Java and can be browsed and expanded with Eclipse or NetBean. The program is compact and simple. The algorithms enable a dynamic FEM simulation. Jfem is described in detail in the literature. The program is open source.
Impact [13]	Impact is also based on Java and allows a dynamic FEM simulation. This allows collisions or movements to be defined on the elements. It also offers topology optimization (no form optimization). The program is open source, but it provides little information about the extension.

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