Steps in the Development of a New Skates System – Modeling, Simulation and Prototyping

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Abstract: - Skates are used by a lot of people for relaxing, having a little fun or, in competition. Especially when relaxing and fun are involved, there has been observed the need for a fast, easy and, meanwhile, safe way of transforming roller skates into ice skates and vice-versa. This paper is about the main steps followed to develop a new and innovative system for positioning and fastening ice blades or rollers assembly onto one same boot. So, aspects of modeling, simulation and rapid prototyping are presented.

Key-Words: - rollers, ice blades, new system, model, simulation, prototype.

1 General Aspects
Skating is usually considered as a mean of relaxing and having a little fun, as well as a fast way of moving from one place to the other, not to far away, as in the hypermarkets. It is also the famous “representative” of important competition sports in winter Olympics games.

A short history of roller skates and skating should mention the dates [3], [4], [5]:
- 1743 - first recorded use of roller skates, in a London stage performance;
- 1760 - first recorded skate invention, by John Joseph Merlin, who demonstrated a primitive inline skate with metal wheels;
- 1819 - first patented roller skate design, in France by M. Petitbled, similar to today's inline skates;
- 1863 - the four-wheeled turning roller skate, or quad skate, with four wheels set in two side-by-side pairs, was designed by James Leonard Plimpton

Ice skating does involve moving on ice by ice skates. It can be done for a variety of reasons, including leisure, travelling, and sports [4], [5].

A study by Federico Formenti of the University of Oxford suggests that the earliest ice skating happened in Southern Finland about 4000 years ago. Originally, skates were merely sharpened, flattened bone strapped to the bottom of the foot.

Adding edges to ice skates was invented by the Dutch in the 13th or 14th century. These ice skates were made of steel, with sharpened edges on the bottom to aid movement.

Throughout times, there where many attempts to improve rollers and ice blades skates design, even to create a system that allows attaching on the same boot, of both rollers and ice blades. Some of the patented inventions and / or purchased skates can be seen in figure 1 and figure 2.

Fig. 1 Skates US Patents [5]
Anyway, for almost all the existing solutions that enable a rollers skate to be transformed into an ice skate, there can be mentioned frequent customers „complaints” as:
- the high weight that reduces skating speed;
- the low precision of blade and rollers support orientation;
- the difficulty of attaching rollers / ice blade supports onto the boot
- the long time that takes transforming a roller skate into an ice skate.

2 Modeling and Simulation
The new skates system presented by this paper was designed, modelled and simulated in behaviour with Autodesk Inventor 2010 software.

Its component elements are shown in figure 3 (as exploded view) so, there can be noticed the dovetail guidance (3-guiding support, 5-rail), the bollard (2), the fastening system screw (4) and the nut (6).

Transforming the rollers to ice blade skates can be done by unscrewing, detaching rollers assembly from the guide (3), assembling the ice blade on and ensure fixation by the screw (4).

The rollers assembly (5) and the guidance system are made of mechanical shock resistance aluminium alloys, with percentage of Zn and Mg and Cu content not less than 10%.

There can be noticed the possibility to attach on the same boot both rollers and ice blade supports, with high accuracy and in a very short time. The joint between the boot and the rollers / ice blade supports it is done with taper head pins (7). While jointing, the supports are oriented by the dovetail guidance, by thus ensured high accuracy position. So, an image of both rollers and ice blade skates is presented in figure 4.
Once modeled the structure and components of the new skates system, simulation of their behavior in various real skating conditions, has been done [1].

So, for roller skates there were studied some specific cases, as follows.

- Rollers support strain state when compressed by the person’s weight, about 80 kg, in steady position – see figure 5.
  
  There can be noticed the highest deformation about 0.0014 mm (very low).

- Roller spokes strain state in steady position, with the hypotheses that: the force (corresponding to person’s weight) loads the two screws and the silicone section is fixed – see figure 6.
  
  The maximum displacement is of 0.0013 mm.

- Bollard strains when starting motion – see figure 7. As seen, it is a very low displacement, about 0.0010 mm.

- Rollers support strain state when stopping (breaking) perpendicular to motion direction – see figure 8.
  
  There has also been simulated the deformation of roller spokes, as shown in figure 9. The maximum displacement is about 0.0038 mm, values that does not involve “problems”
For *ice blade skates* there were studied specific cases, as presented next.

Ice blade guiding support strain state when loaded by two forces of about 40 daN (equivalent to 80 kg person’s weight) – see figure 10. There can be noticed low displacement values.

The fixing screw strains, submitted to shear loading, when starting motion – see figure 11. As observed, the screw “stands”, without failing.

Guiding supports deformation when skating – see figure 12. There can be noticed low values elastic state deformation.
Ice blade and its support strain state when stopping (breaking) perpendicular to motion direction – see figure 13.

It can be noticed the highest displacement value lower than 0.009 mm, meaning no “problems” should be involved.

3 Rapid Prototyping

One important technique of prototyping is Rapid Prototyping, RP.

Rapid prototyping is the automatic construction of physical objects using additive manufacturing technology. The use of additive manufacturing for rapid prototyping takes virtual designs from computer aided design (CAD) or animation modeling software, transforms them into thin, virtual, horizontal cross-sections and then creates successive layers until the model is complete. It is a WYSIWYG process where the virtual model and the physical model are almost identical [7].

The obtained parts are very complex and the time required for prototyping is relatively low (hours).

For prototyping the component elements of the new skates system, it was used a Z Printer 310 machine [8]. This involves powder based procedure, patented by Z Corporation and it is also known as 3D Printing – inkjet printing.

In fact, the process of 3D printing involves shooting droplets of liquid (binder) to a solid compound (plaster or resins powder). By selectively binding of powder together a layer of the model corresponding to the cross-section of the part is formed.

As the goal of the research presented by this paper was that of designing a new system for fast, accurate and easy transformation of rollers skates into ice blade skates, there were prototyped its main subassemblies.

It is figure 14 evidencing their designed models. Figure 15 shows an image taken from prototyping machine’s computer screen, that points out prototypes position inside the build chamber.

An observation should evidence the fact that it has been prototyped only the lower part of the boot – the one on which rollers / ice blade supports are attached to. It was that, because of relatively high prototyping costs.
Once the RP process over, the parts were extracted from machine’s enceinte, dried and resin impregnated, so that they became “hard” enough. They were, also, slightly manually adjusted – especially on the sides that are in contact, so that fast and accurate transformation from roller skate to ice blade skate to be possible, even on the obtained prototypes.

Images of the rapid prototyped system’s subassemblies are presented in figure 16.

4 Conclusion
This paper presents the steps taken in order to obtain a new skate system for a fast, easy and, meanwhile, safe way of transforming roller skates into ice blade skates.

Modeling of systems components, as well as simulation of various cases specific to real exploitation conditions have been done. It resulted that the designed component elements, as well as the whole system, could stand the loadings and, consequently, the displacements values would be small enough.

Rapid prototyping system’s subassemblies enabled a thorough check of how it works, meaning if really fast, accurate and easy way of transforming rollers skate into ice blade skate is possible. The result was more than encouraging one.

The product (new skates system) is lightweight due to materials and design of its component elements.

Further research should involve another new system design, if possible easier to handle and with smaller time involved

References: