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NEW ACHIEVEMENTS IN MANUFACTURING OF CHURCH BELLS

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ABSTRACT

Analysis, modelling and design of the bells are a topical issue for manufacturers of bells, in general, and for church bells manufacturers in particular. The transition from manual design of a bell to that achieved with the computer led to fabrication of bells capable to produce sounds of bells controlled close to those of musical instruments. It is mentioned a number of specialized software such as AUTODESK, for sizing profile of a bell; RESHAPE for analyzing and adjusting tones and WAVANAL for processing issued sound. The performances of a bell are closely related to the material used, casting technologies, possibly heat treatment and their grinding, processes that can be controlled automatically by computer.

KEYWORDS: bell, sound, software

1. Introduction

Nowadays, most foundries use computer for design bells. With the help of specialized software, the future of bell geometry is achieved, starting from the bell section. Analyzing vibrations bell, bell sound, mechanical and metallurgical properties of bell, wearing bell, the tension states during its working. It also studied the degree of impact of bell tong on the bell and is make simulation of the bell movement and bell sounds. Making a perfect bell both in terms of design, especially in terms of sound, involves collaboration between musicians, acoustic engineers, IT engineers, whistleblowers, and experts in casting bells.

Figure 1 shows cross-sectional profile of a bell (a) and possible instantaneous position of the bell and his tongue (b) during oscillation movement.

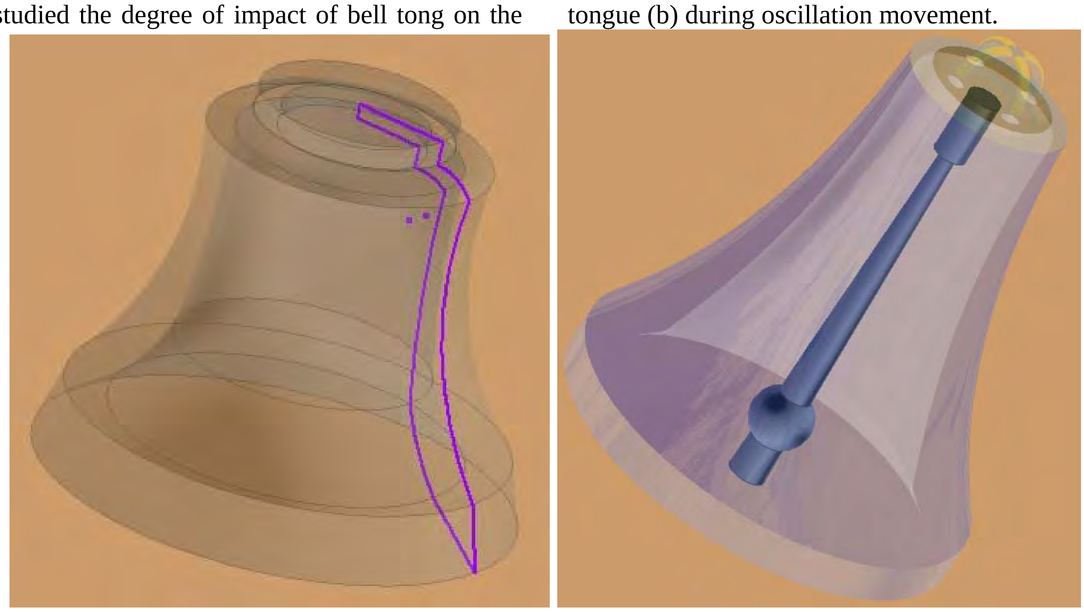

Fig. 1. *Cross- sectional profile (a) and instantaneous position of the tongue (b) of a bell.*

2. Profile Design bell

Figure 2 shows the bell shape design created with Autodesk software starts by profiling and sizing bell profile. Autodesk is a world-leading supplier of engineering software, providing companies with tools to experience their ideas before they are real. By putting powerful Digital Prototyping technology within the reach of mainstream manufacturer, Autodesk is changing the way manufactures think about their design processes and is helping them create more productive workflows.

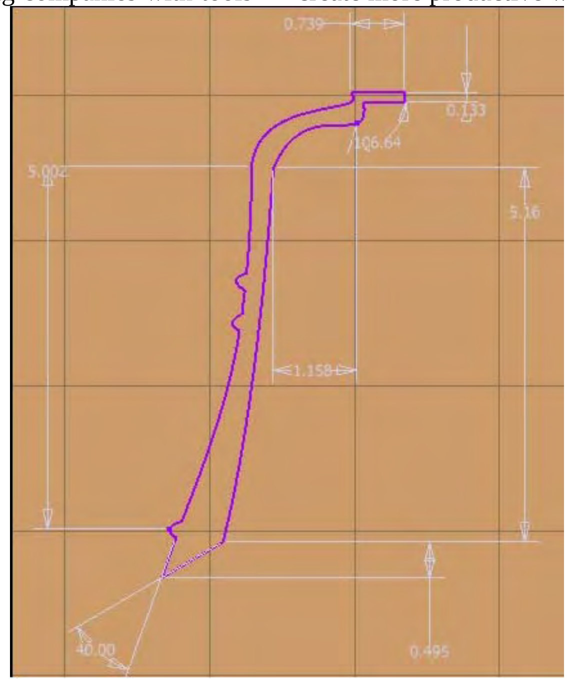

Fig. 2. *Bell shape and size obtained by Autodesk.*

Figure 3 shows the 3D image of the bell made based on two-dimensional profiles, shown in Figure 2. Bell may have very different forms from one manufacturer to another, depending on foundry tradition, the purpose of which the bell will be used or the desired sound.

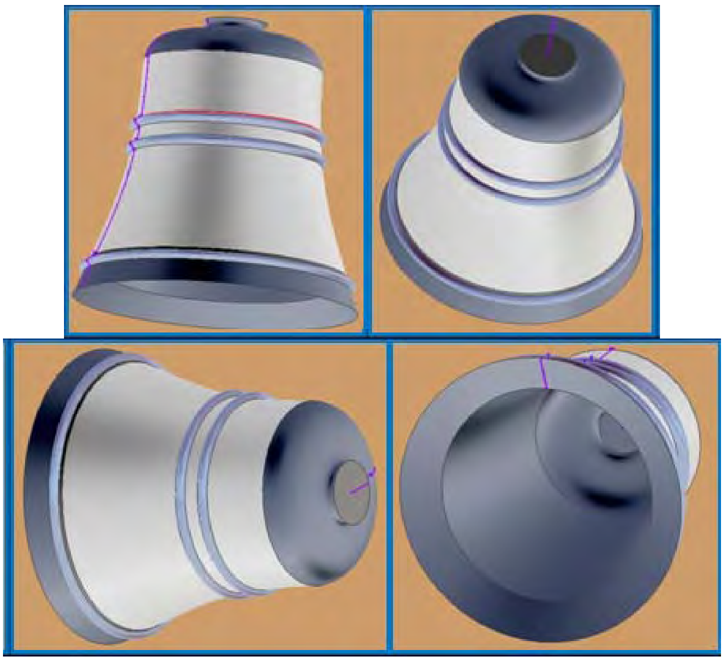

Fig.3. *3D images from 2D images of the bell, using Autodesk Inventor software.*

An important role in designing a bell is played by its own tongue. Its shape and size are the defining elements of the acoustics of a bell. In Fig. 4 the 2D profile elements of language (a) of a bell, and its size (b), both are closely related to the dimensional constructive of the bell elements.

Based on the 2D image of the bell tongue, Autodesk Inventor gets 3D image, as shown in Fig. 5.

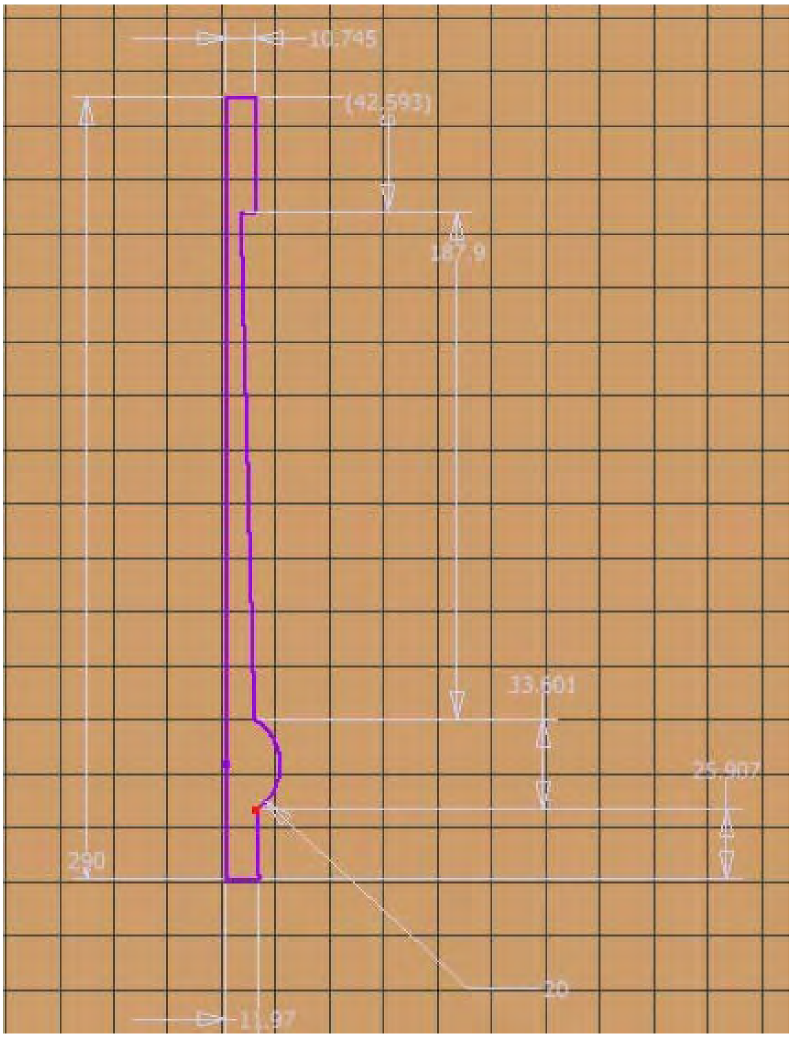

***Fig. 4**. 2D and tongue size bell obtained by Autodesk Inventor software.*

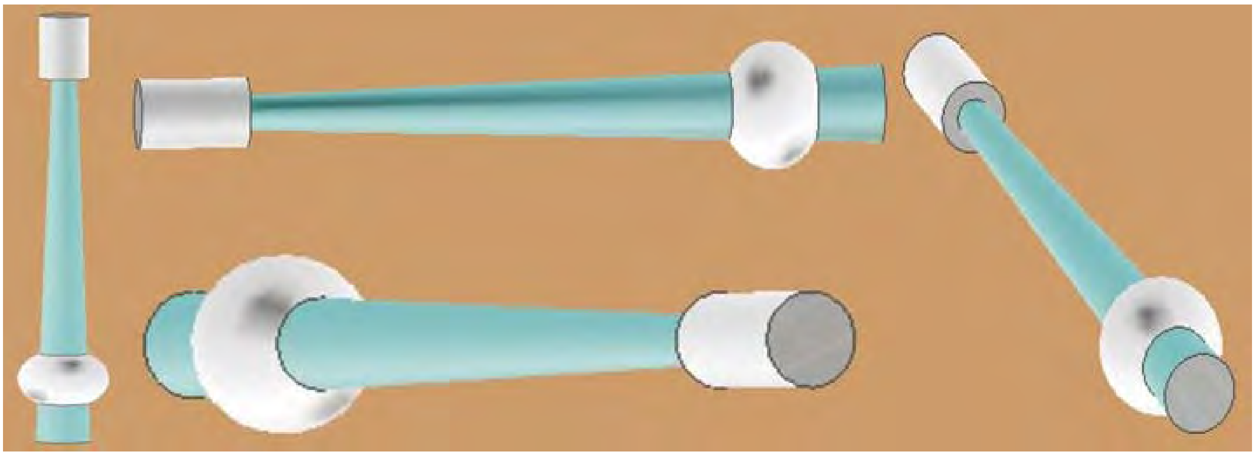

***Fig. 5.** 3D images obtained for bell tongue with Autodesk Inventor software.*

Composer Neil McLachlan [1] and sculptor Antonn Hassel [2] have managed to build a much better cup design using computer technology for the bells. Neil McLachlan said that this technology would create many opportunities for musical performances. A bell that can mimic the harmonic sequence of the human voice can produce an ear pleasing very smooth sound. Before its discovery technology, created by Western, bells were not really part of the orchestral instruments. Carilon bells, which are used in music does not require a tuning.

Complex profiles generated by computer modeling are either laser cut into steel thick sheets, allowing manufacturing of casting molds for larger bells, either are designed to have a high tolerance for manufacturing of smaller bells.

In Fig. 6 presents the 3D image of a bell, which allows spectral analysis of the sound, eventually achieving, later, a tuning thereof.

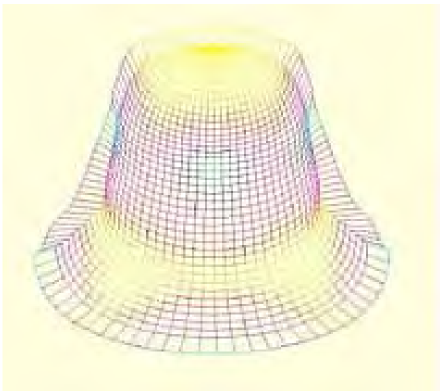

Fig. 6. *3D image of a bell with its elastic deformation.*

The sensitivity of human ear can perceive differences of sounds bell wall thickness of 50 microns and they can be detected in small bells. Australian harmonic bells are so detailed computer modeling, that the observed differences of up to 10 microns can be produced repeatedly with CNC lathes. Bells greater than 400 mm in diameter often require fine-tuning after casting them.

This process occurs on a manually operated vertical lathe.

Parties of bell that must cut are calculated by computer modeling.

By the '80s, few improvements have been made, when the engineers of Dutch companies have started to use finite elements computerized analyzers, creating three-dimensional models to determine some mechanical properties of an object.

Using this method, engineers tuned bell, the sound improves, but decreases its harmony.

3. Software used in the design and analysis of sounds

Some programs may be used in bells computerized analysis. The following software can be mentioned: Wavanal which analysis the tuning, by using pre-recorded sounds; Rounds is used to convert the tinkle of a bell in many tinkles in changing and can also use in tuning, and the Pitcher is a simple program that can check the height of a bell sounds. A comprehensive profile of the bell made by RESHAPE software in Fig.7 is presented.

The grid shows the elements that compound the bell. The blue profile was the basic profile for this stage of design (drawing at different scales). It can see the “lace" on the inner wall that was added by the computer at this stage of design. A complex form can be observed at "foot" bell.

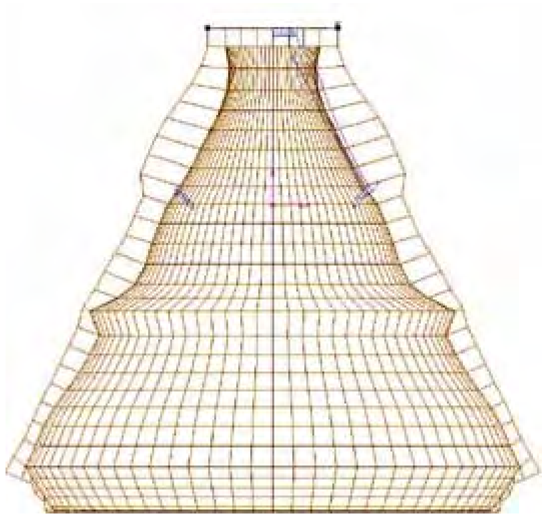

Fig. 7. *3D image of a bell made software RESHAPE software.*

The frequency spectrum for a Japanese temple bell in Kyoto in Fig. 8 is presented. The recorded spectrum by using a microphone when the tongue touches a bell in Fig. 8 is shown. There are three heights of the bell sound that take 2.5 seconds. The apparent temporal variation in the intensity of sounds emitted during the emission can be observed.

The high frequency is perceived due to presence of a very strong single component. The sharp peak at about 1.5 seconds is caused of reductions of the low frequency compound that masks a part of tone when the tongue strong beats. Average frequency that is perceived increases whiles others partial frequencies decrease.

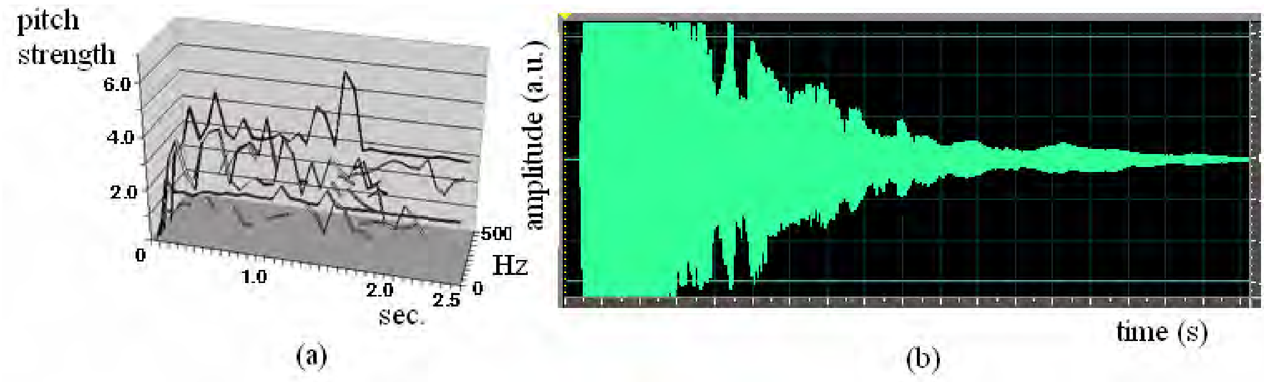

Fig.8. *Sound spectrum of a bell from a temple in Kyoto.*

The emitted sounds by a bell can be registered by multiple devices, among which the most important is the microphone. The most important criteria in selecting a microphone are quality microphone, frequency stability of the device, automatic control compared to the manual control.

4. Conclusion

For the analysis, modeling and design of bells advanced technologies are used bells, allowing their manufacturing with high accuracy. It went from manually design to that carried out by means of a computer, creating special software providing vibrational characteristics of the bell based on bell profile or alloy, such as software Autodesk – for sizing profile of a bell, software Reshape – for analyzing and adjustment of bell models or music software - like Wavanal software. Researchers in manufacturing bells field pursuit improvement of their performance starting from casting bells technology.

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