HISTORY, DEVELOPMENT AND TUNING OF THE HANG

Felix Rohner and Sabina Schärer
PANArt Hangbau AG, Engehaldenstr.131, 3012 Bern, Switzerland

Abstract

The HANG is a new musical instrument, suitable for playing with the hands, consisting of two hemispherical shells of nitrided steel. It is the product of a collaboration among scientists, engineers and hangmakers, thanks to which we have been able to better understand the tuning process in all its complexity. Seven notes are harmonically tuned around a central deep tone (ding), which excites the Helmholtz (cavity) resonance of the body of the instrument. There are many ways to play the HANG. We show the different stages of its development over the seven years since its birth in 2000. We describe the tuning process and the musical conception of the HANG.

INTRODUCTION

The HANG was created in January 2000 by the tuners of PANArt Hangbau AG, formerly Steelpan Manufacture AG, Bern, Switzerland. It came out of twenty-five years of manufacturing the steelpan and research on its technology and acoustics. The youngest member of the family of acoustic musical instruments, the HANG is the result of a marriage between art and science. Five thousand HANG players worldwide and an ever-increasing demand show the deep resonance this instrument has with individuals. As we are only two hangmakers, our interest here is to invite scientists to continue working together to better understand this phenomenon.

FROM STEELPAN TO HANG

PANArt Hangbau AG was founded in 1993 to give cultural and commercial support to the growing steelband movement in Switzerland. Europeans were fascinated by the “sweet sound of steel” from Trinidad, coming out of refashioned oil drums. The tuners of PANArt developed techniques to satisfy the great demand for steelpans and did intense research on different materials. The aim was to get instruments with both a high buckling resistance in the individual notes and a warm, harmonious sound. This research led to a new material, steel with a high nitrogen content. The higher rigidity of the material made it possible to develop other shapes of the clamped shallow shell. The PANArt tuners realized that a steelpan could now be manufactured with the help of a press. Instead of stretching the bottom of an oil drum with hammers to make it harder and stronger, they hardened a deep drawn hemisphere. As they now had a material of consistent thickness under their hammers, they started serious empirical research on optimizing the shaping to achieve their vision of sound.

The PANArt tuners met with physicists, engineers, metallurgists, and ethnomusicologists. The most significant input came from two physicists, Thomas

Rossing and Uwe Hansen, who taught us to understand the vibration modes of resonating bodies and the recoupling effects in such complex systems.

We began to study the vibration modes of gongs, bells, all kinds of drums, bars, plates and shells. We experimented with our material to understand its laws and a large group of instruments came up called the PANG instruments.

Figure 1: The PANG instruments

Ping, peng, pong are steelpan-like instruments. Pung is a gong-like instrument, tubal is gamelan-like, pangglocke is bell-like and orage is cymbal-like.

The latest member of this family of nitrided steel instruments is the HANG.
It was born in the year 2000, when a percussionist demonstrated a ghatam to us and expressed the dream of having our PANG sounds in a resonating body that could be played with the hands.

PANArt had the know-how: the technology of deep drawing, the gas nitrided steel, the dome geometry of the notes, the octave-fifth tuning. The prototype had to be reduced in diameter from 60 cm to 50 cm to make it possible to be played on the lap.

The challenge was to bring the Helmholtz resonator, the central gong-like sound, and the tone circle, into a unified musical conception. Fewer notes could be tuned in, which meant that we would have to leave the chromatic scale behind and explore the large world of tonal systems. After one year the HANG was ready to be presented at the Frankfurt Music Fair.

To play harmonically tuned steel with the hands was a new dimension. That is the reason we called it the HANG, which means “hand” in the Bernese dialect.

In recent years PANArt has concentrated its energy on the HANG, and has discontinued building other steel instruments.

Figure 2: The HANG

Figure 3: The ding side

Figure 4: The gu side

PROPERTIES OF THE NITRIDED STEEL

Thanks to the collaboration of engineers and metallurgists, PANArt was able to try out many different sheet metals from German steel mills, among them micro-alloyed, phosphorus and dual-phase steel. The change of the structure of the steel resulting from the diffusion of nitrogen was the only one of these alternatives that led to a better material for our technical and musical requirements, which included the following properties:

High Young`s modulus
High ratio of tensile strength to yield point
Low absorption
Surface layer with a non-metallic, somewhat ceramic behaviour
Corrosion protection equal to that provided by galvanization
High resistance to aging
Low cost and clean technology
Resistance to thermal fatigue
High internal compression

The high stiffness of the material, due to its thickness, forced us to experiment with shapes and edge conditions. A uniform thickness of 0.91-0.95 mm made it possible to shape symmetrical tone fields. An elliptical dome in the middle of the tone field led to a strong fundamental with two harmonic partials, an octave and a fifth. The higher modes came to lie around the third octave due to the stiffening effect of the dome. The notes now had soft edge conditions and were embedded in the stiff concave shell. With this favourable ratio of impedance the sound acquired a strong radiation.

THE ART OF TUNING

There are no schools of tuning, and only a few tuners in University projects. Tuning is difficult to learn and to teach. Why?

As A. Achong claims (Achong, 2003), steelpan tuning is an art, because there are about fifty-seven parameters to consider in tuning a sound into steel. Each tuner has his/her style. We agree. Tuning a steel instrument is an intuitive task.

PANArt tuners developed a terminology for the tuning process. Nevertheless, it has not proven possible over the last few years to teach someone to build the HANG, and many a skilled steelpan tuner refused to collaborate.

Tuning is a knowledge based on daily practice, and on the internalization of the behaviour of the forces in the steel in relation to both resonance and pitch. Many questions remain unanswered and will require further research. (Rossing 2003).

We describe here, step by step, the different stages of the shaping and tuning of a HANG. We hope that further collaboration can help to clarify this non-linear dynamic system. Steelpan and HANG are complex shell structures. The Catalan roof and Gaudi`s work attracted our interest a number of years ago, and led us to the consideration of architectural thinking with respect to the HANG. We have more to learn from the shell constructions of engineers and architects like Frei Otto of Germany, Heinz Isler of Switzerland, and Buckminster Fuller of the USA.

THE SHAPING AND TUNING OF THE HANG

Two shells (*gu* and *ding*) are deep drawn with a press from a common sheet.

The two shells are gas nitrided in an oven with an atmosphere of ammonia for a number of hours at a temperature of 600°C.

The playing surface of the ding shell (50 cm diameter with uniform thickness of 0.91-0.95 mm) is brushed with a brass brush (on an angle grinder, 3000 rotations/min.).

Seven elliptical domes are stamped around the ding, each with some blows of a hammer. Each dome is laid on a plastic ball (diameter 3-5 cm) that is covered with a rubber strip (2 mm thick). A specially shaped wooden block gets a blow of a heavy hammer in order to provoke a snap-through of the area around the dome.

The shell is annealed in the kiln for 15 minutes at a temperature of 400°C, with the following results:

Raising of the tensile strength by about 10%,
Increasing the hardness of the core,
Diffusion of the brass into the surface,
Relaxation of the introduced stresses.

The tuner starts his work with the ding side strongly clamped with a steel ring at its flange, which is 1 cm wide.

With a rounded wooden hammer, the hangbuilder stretches the areas around the domes. The introduced compressive in-plane stresses produce buckling phenomena like wrinkles in the note fields. These are reduced by upsetting the note with blows to the dome. Shaping a hyperbolic area around the dome leads to a frequency ratio of 2:3 of the (1,0) and (0,1) modes (octave and fifth). Strikes from both sides on the anticlastic ring (average curvature = 0) prepare the note to be lowered below the correct frequency (1:2:3). The tuner now forms the correct curvature around the note and at the same time eliminates stresses in the note field. This process will lower the fundamental and create a strong standing wave thanks to the right critical curvature. The note is now completely minimalized in stiffness and the impedance ratio between the convex note field and its concave neighbourhood is set. Some further strikes will be needed to raise the fundamental frequency to its correct place. The sound sculpture is now built. There are no external forces preventing it from vibrating, piston-like, and developing its mellow beauty.

Tuning is an art: dozens of parameters influence the quality of sound. Hangbuilders have to follow their own style intuitively, their own vision of a sounding sculpture.

They must master techniques that are unique in this art, such as ways to set the form, to smooth, to peen, to stretch and to upset the metal. They monitor the process by ear, observing the events on a chromatic strobotuner, along with the dance of quartz sand to check symmetry and vibration (Chladni patterns).

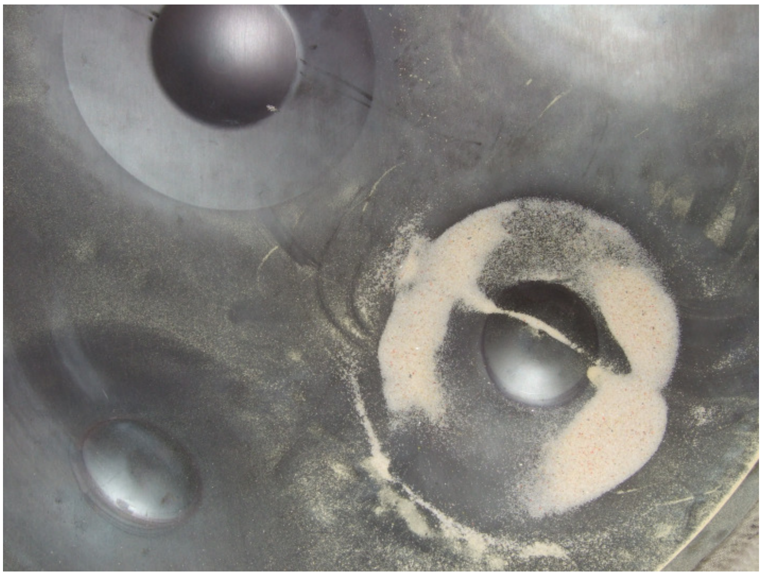

Figure 5: Quartz sand shows Chladni pattern

From the architectural and engineering point of view, the arch geometry of the concave shell as well as the geometry of the convex shell are changed into a new structure that generates bending movements under load (the impact of the player's touch). The construction has an optimal utilization of forces in the concave supporting structure as well as in the tone fields, which should be free of external forces and can therefore develop their whole potential, which is given through the material PANArt created - a powerful high-energy sheet metal.

To test the correct construction, the whole shell is tempered at a temperature of 150°-180°C. It is retuned and tempered several times, depending on the degree of detuning.

The tuner doing the *fine-tuning* adjusts symmetrical nodal lines, checks the curvature of the edges, and brings the concave construction into its plastic beauty.

Tuning the gu involves stretching the area around the gu's neck with a steel hammer, and smoothing the area with a rounded wooden hammer. The fundamental of the neck ring bell is lowered to D5, the (1,1)a to F5 and the (1,1)b to F#5.

The two shells are joined with a hybrid-polymer sealant. After one or two days, the flange protection ring (brass) is affixed. The playing surface of the HANG receives a coating of natural "hard oil".

After a number of days, depending on the humidity and air temperature, the HANG is fine-tuned again. The tuner enters with a small steel hammer through the gu and makes the final blows. The relatively small detuning occurs through oval deformation, a spring back effect.

A final tuning is done after two weeks. The tuners sign their names and the instrument receives a serial number.

Figure 6: Tuning of the fundamental

THE MUSICAL CONCEPTION OF THE HANG

Leaving behind the world of chromatic scales of the conventional steelpan, the PANArt tuners began to study tonal systems. They discovered a rich musical heritage among the world`s musical cultures, and tuned many different scales into the HANG. This ethnomusicological approach to musical conception came to an end in 2006 as the response from HANG players world-wide showed a marked preference for universal modes such as various pentatonic, and especially minor pentatonic modes.

Furthermore, there were some notes that resonated better than others. To make a step towards artistic freedom and higher sound quality, the tuners began to listen more carefully to their own responses and those of the HANG. We began to build in a kind of an acoustical cathedral, a space of sound based on the air resonance of the HANG played on the lap. This Helmholtz resonance (D2) became the fundamental of a new generation of HANG. The D2 received its octave D3 in the ding (central tone). The lowest note in the tone circle became A3, the fifth of the D3. The ding and its fifth got their octaves: D4 and A4. All HANG have this basic tonal structure.

The remaining four notes are tuned in with artistic freedom by the tuners.

The gu neck bell is tuned to a D5. The spectrum of the partials creates the somewhat mystical sound of a clay pot, similar to that of the ghatam.

The musical atmosphere can be described as a palette of intervals in a one octave range, which is suitable for all human voices. Sounds created by the hands in interaction with the playing surface are an important part of the musical expression of a HANG player. Realizing this fact, PANArt changed the quality of the surface by brushing it with brass to get a more well-integrated touch in the instrument.

CONCLUSIONS

The HANG is a new musical instrument. Individuals around the world appreciate it. There are two hangmakers worldwide. It is impossible to satisfy the growing demand. Further collaboration between art and science is needed to make it possible that other hangmakers may exist in the future.

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