OPTIMIZATION OF BASS AND PLAIN STRINGS WITH PAULELLO - AND RÖSLAU PIANO WIRE

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1. Introduction

Professionals consider the difference in the timbre of bass tone between large grands and smaller grands and uprights as significant.

In addition to the well-known Röslau Piano Wire, Paulello Piano Wire has been available for a few years.

For a small grand, namely a Steinway-O with the longest bass string length 1365 mm, the optimization of the bass uses a combination of Röslau Piano Wire and Paulello Piano Wire type XM.

It has been found that in the bass the same level of inharmonicity can be achieved as that of a large concert grand. The result of this is that the bass has a more beautiful sound as compared to the sound of the original bass stringing. Also it turned out that the tuning is much easier, because the octave stretch is much less compared to the octave stretch of the original bass stringing. The analysis of the original bass stringing and the optimizations are carried out with the program Easy String Calc. version 6.04jp2.

The program analyses with standard Röslau Piano Wire.

The optimization is done in two stages, first collectively all plain strings, then collectively all wrapped strings.

The program determines automatically which keys in the bass Paulello wire type XM has to be applied to achieve the inharmonicity of a large concert grand.

In order to bring the load in the bass and treble closer to the target value of the load, Paulello wire is used.

Also it is possible to optimize every note separately. During the optimization per note, one can substitute another type of steel, e.g. Pure Sound (PS), Pure Sound Strong (PSS) or Paulello Piano Wire type XM, 0 and/or 1.

2. Comparison Paulello Piano Wire XM with Röslau wire

The modulus of elasticity for both types of wire is almost equal, namely 2,06E+11 N/m^2. for Röslau Wire en 2,02E+11 N/m^2. for Paulello Piano Wire. The density is also equal.
The table below shows the nominal breaking load for both types of wire.
This table shows that the breaking point for Paulello Piano Wire XM is significantly higher than for Röslau wire.

Wire number	Paulello xm Nominal breaking load newtom	Paulello xm Nominal breaking load kg	Röslau Nominal breaking load kg	Ratio Paulello/ Röslau Nominal breaking load
13	1398	143	114	1,250
13,5	1450	148	121	1,222
14	1539	157	128	1,226
14,5	1597	163	135	1,206
15	1806	184	142	1,297
15,5	1846	188	149	1,263
16	1895	193	157	1,231
16,5	2019	206	164	1,255
17	2141	218	171	1,277
17,5	2227	227	179	1,269
18	2289	233	187	1,248
18,5	2362	241	195	1,235
19	2456	250	203	1,234
19,5	2583	263	211	1,248
20	2599	265	218	1,216
20,5	2757	281	226	1,244
21	2841	290	234	1,238
21,5	2946	300	241	1,247

Table 1.

3. Properties of a large concert grand (Steinway-D)

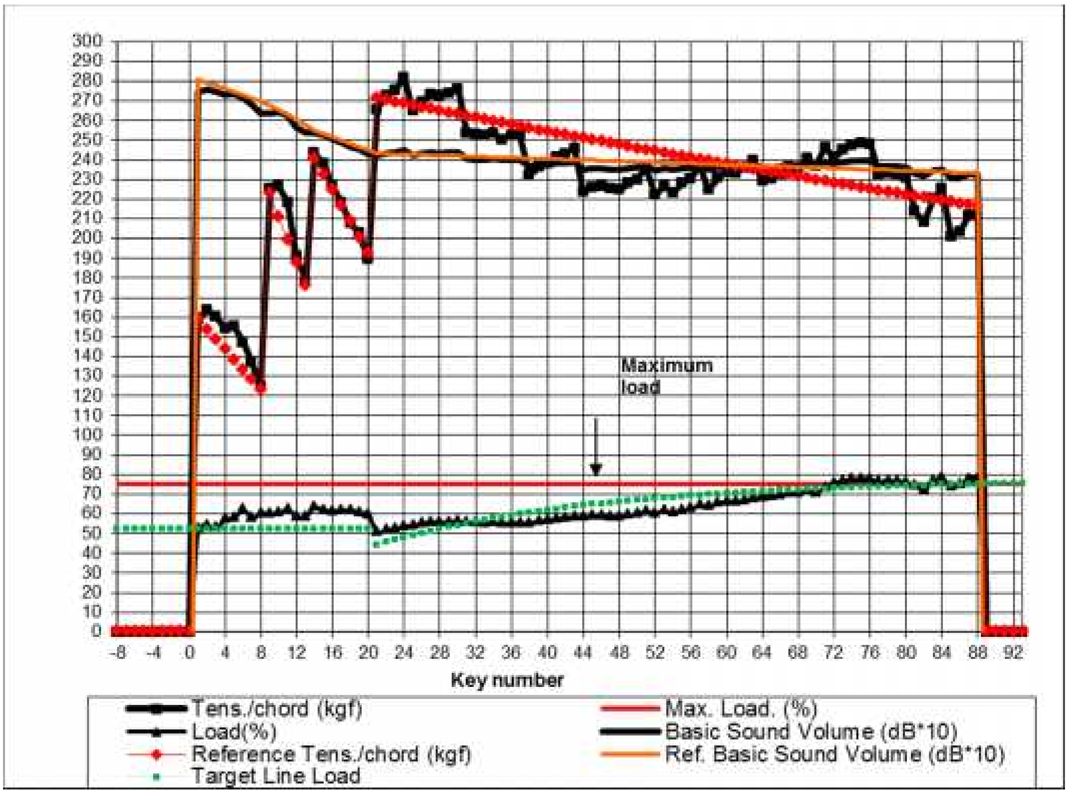

Fig. 1. Some of the properties of a Steinway-D.

Figure 1 shows the total tension of a chord in kgf, the load in % of the maximum load,

the basic sound volume in dB x 10 on the vertical axis, that is to say, for example, 230 means 23 dB and in the vertical direction each division is one dB.
The sound volume, which a tone can produce, is proportional to the total tension of the chord concerned. The basic sound volume (BSV) is equal to 10*LOG [tension of a chord], with the understanding that the jumps in tension of the chords in the bass section are corrected. This difference in tension is especially made to prevent an audible difference in sound volume by these transitions. It is commonly known, that a mono-chord with the same tension as a bi-chord sounds louder.

The reason to introduce the dB unit is that this unit is usual in acoustics. The advantage of using dB instead of using factors is, among others, that dB's can be added and factors have to be multiplied. The absolute value of the basic sound volume is of no importance, because the produced sound volume depends among others of the force with which the hammer hits the string and the properties of the hammer and soundboard. But the shape of the curve of the basic sound volume as a function of the key number is important. Research has proved, when the sound level of two tones varies less than 1 dB, this difference in loudness is not audible. A rather fluctuating curve of the tension of the chords is, if one looks to the curve of the basic sound volume, often acceptable.

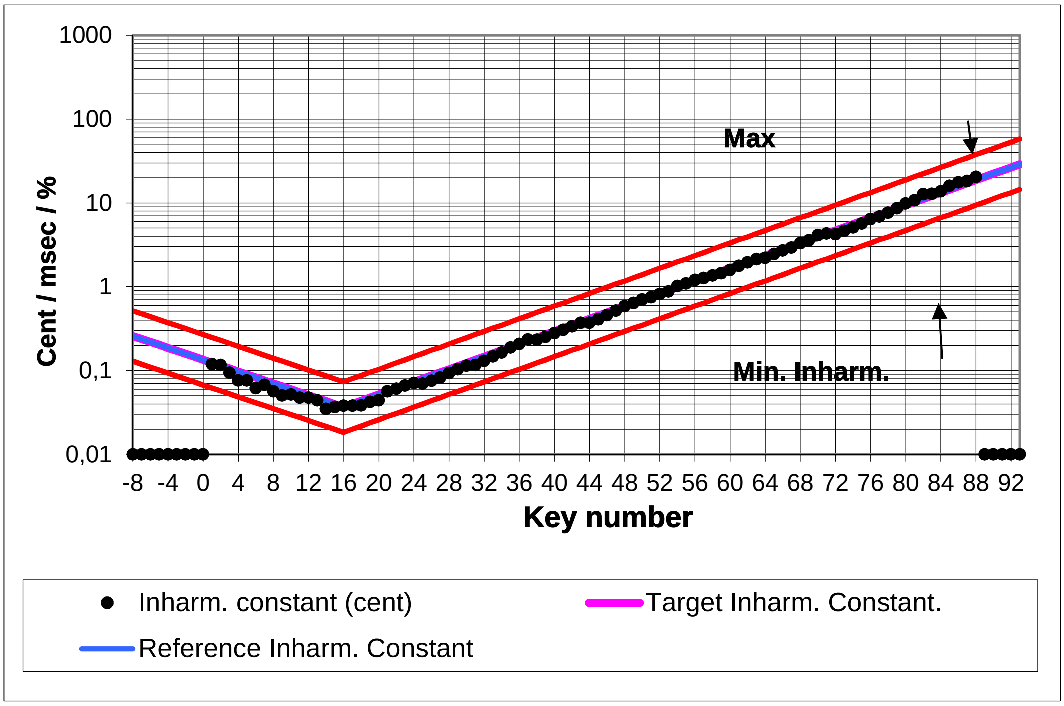

Fig. 2 Steinway-D

Figure 2 shows the curve of the inharmonicity constant of a Steinway-D.

4. Properties of a Steinway-O with original stringing

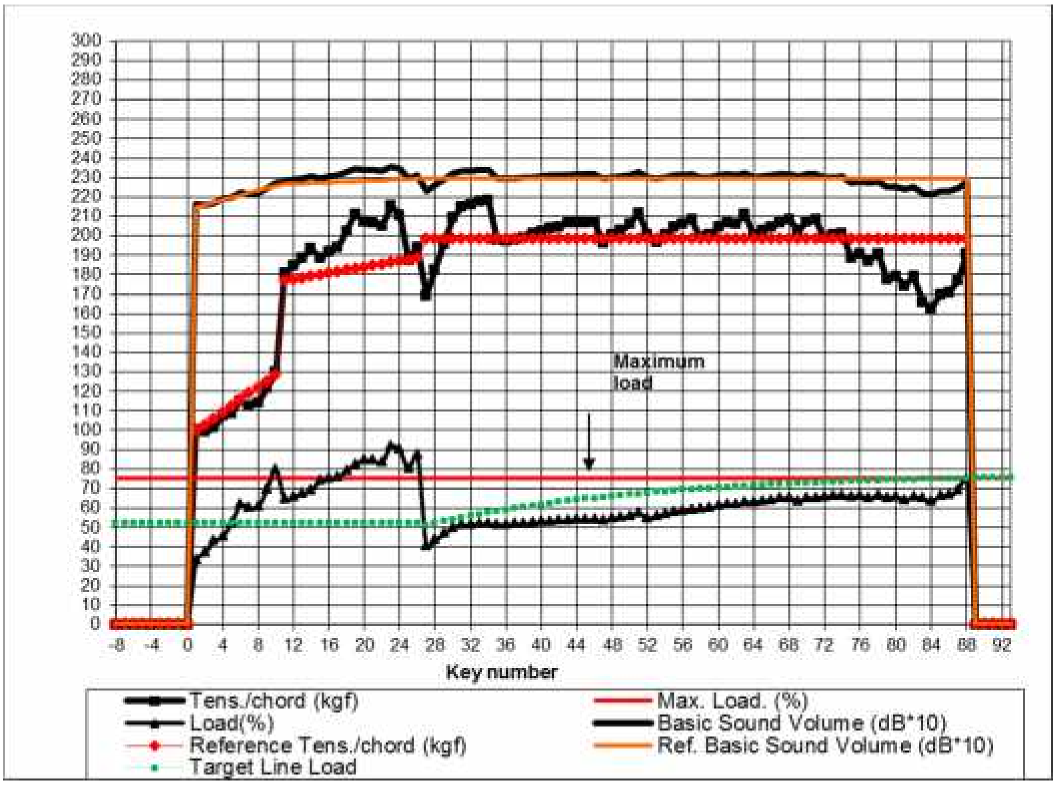

Fig. 3. Steinway-O with original stringing

Interestingly, in various places the load in the bass exceeds 75%. At one point, the load is even more than 90% of the breaking load.

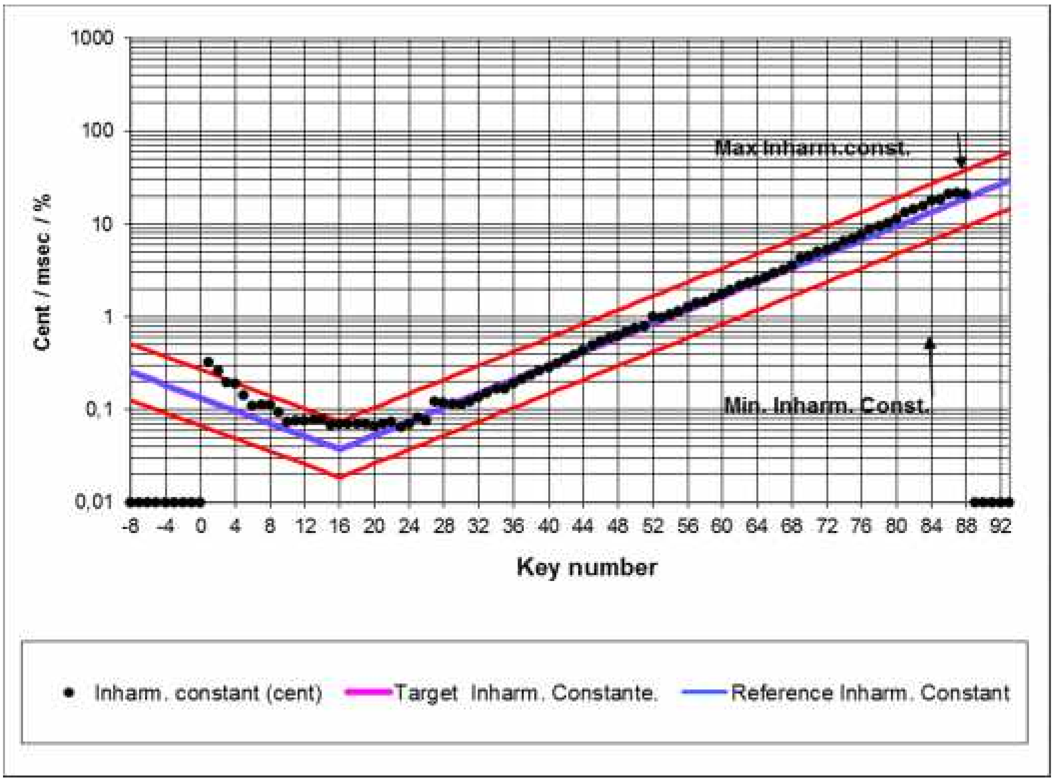

Fig.4 Steinway-O with original stringing.

The violet line is the target value of the inharmonicity constant. This target value is equal to the inharmonicity constant of a Steinway-D. The actual inharmonicity constant in the bass region is for a great extent, well above this target level.

5. Optimisation Steinway–O with Röslau wire.

Figure 6 shows the curve of the inharmonicity constant realized after optimization with Röslau Wire.

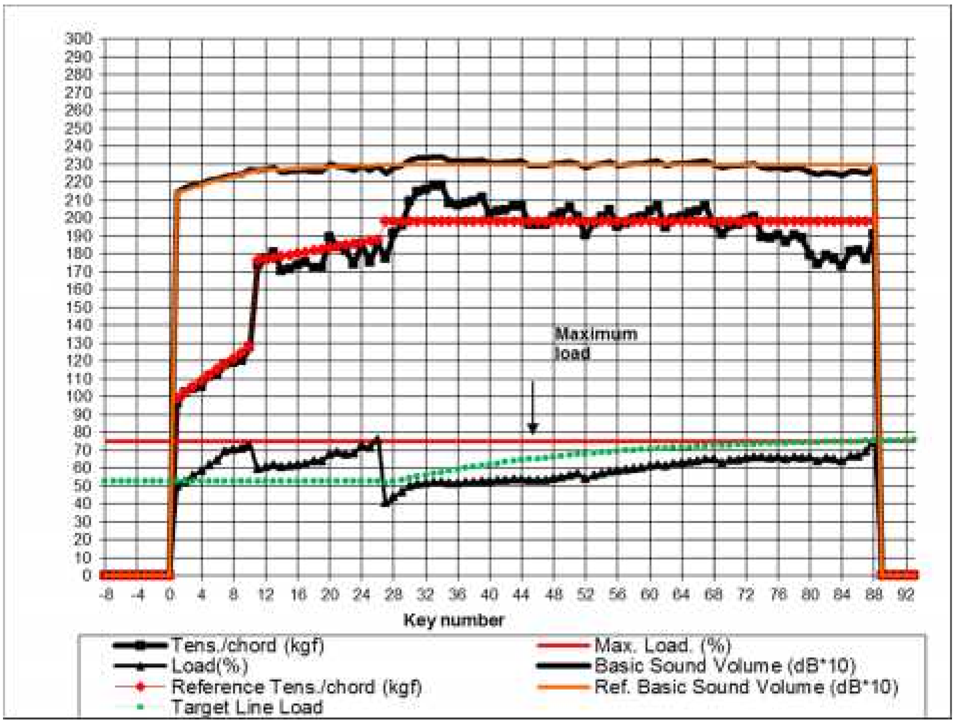

Fig. 5. Optimization Steinway-O with Röslau Wire

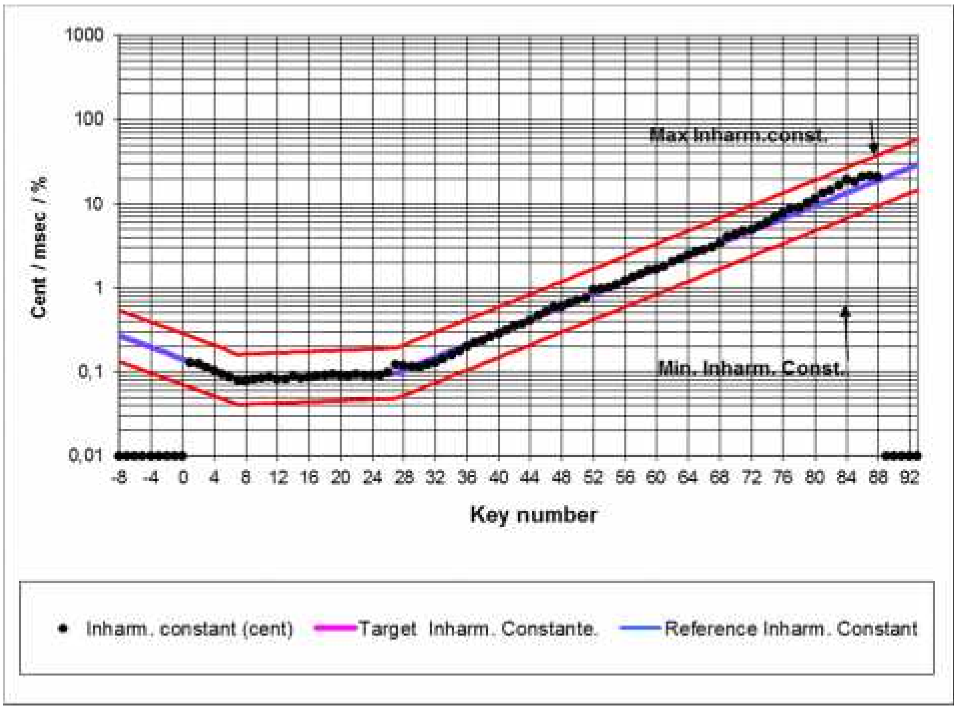

Fig.6. Optimization Steinway-O with Röslau Wire.

If we compare figure 6 with figure 2, we see that for keys 1 to 8 the inharmonicity constant of the Steinway-O is almost equal to the inharmonicity constant of the Steinway-D. For keys 9 to 26 the inharmonicity constant is higher than the inharmonicity constant of the Steinway-D. This is because keeping the load ≤ 75 %, the steel core must be thicker than is required for optimum inharmonicity. If one should optimize in such a way the inharmonicity constant is made equal to a target value equal to the inharmonicity constant of a large concert grand piano, the load on a number of keys in the bass than is >75%. See figures 7 and 8.

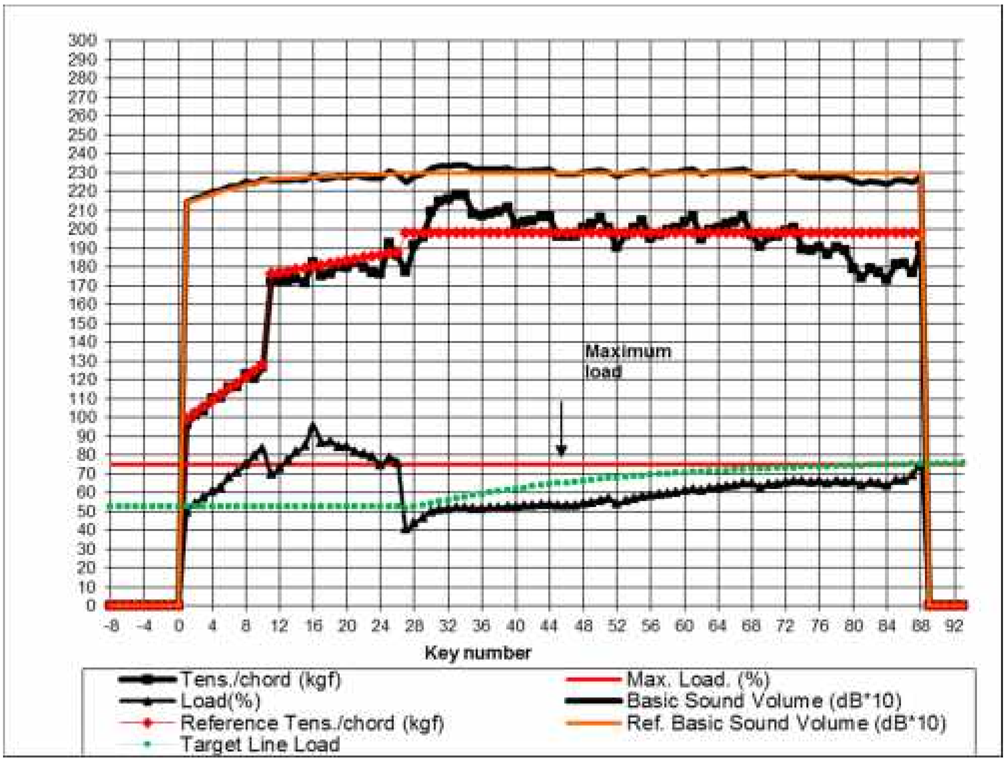

Fig. 7. Optimization Steinway-O with Röslau Wire.

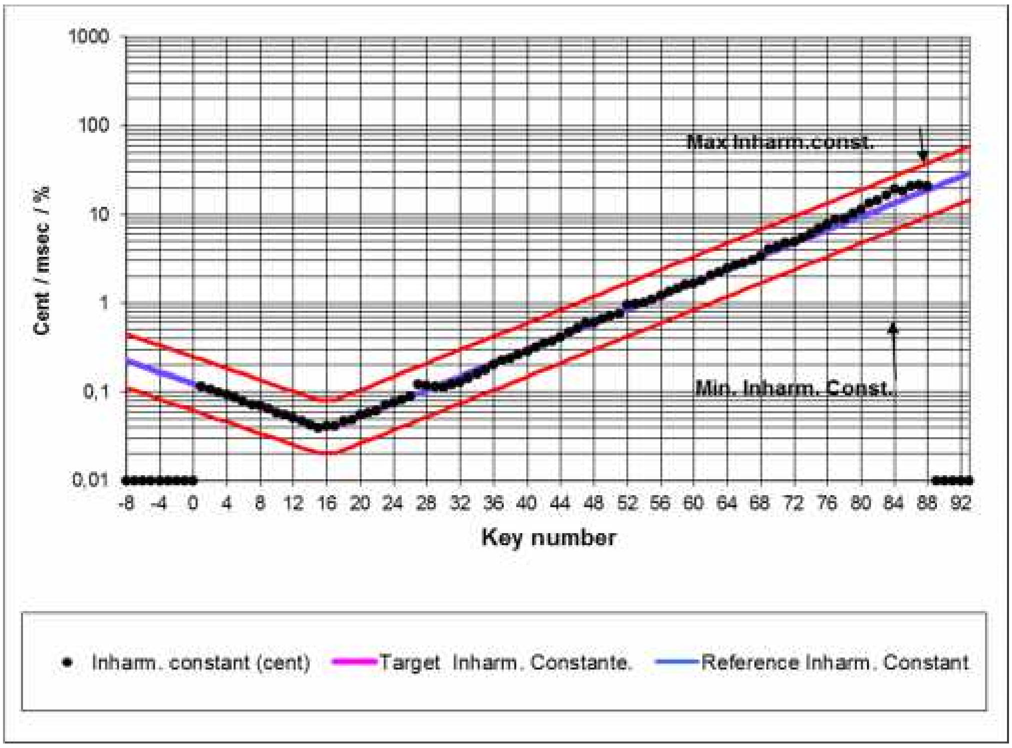

Fig. 8. Optimization Steinway-O with Röslau Wire

6. Optimization Steinway-O with Paulello Wire.

In table 1 we see the nominal breaking load of Paulello Wire type XM is higher compared to the nominal breaking load of Röslau Wire. By applying Paulello Wire type XM at those keys where, by the use of Röslau Wire, the load in the bass exceeds 75% of the nominal breaking load, it is possible to achieve an inharmonicity constant equal to the inharmonicity constant of a large concert grand. See figures 9 and 10.

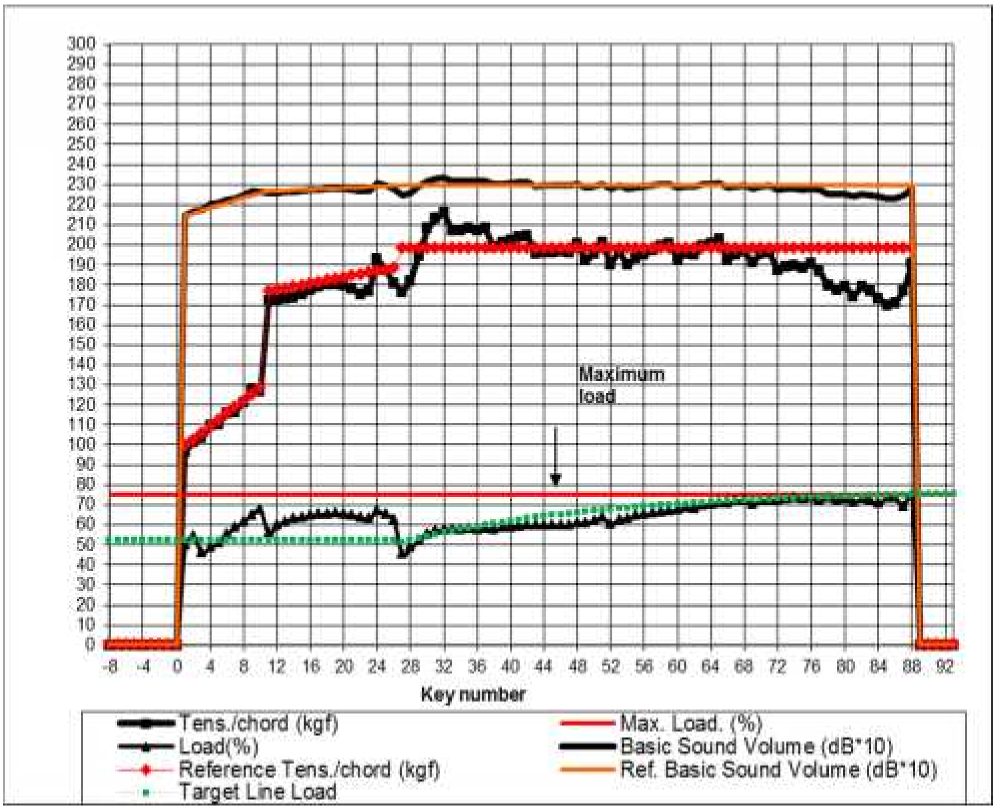

Fig. 9. Optimization Steinway-O with Paulello Wire.

In the bass is for the keys where Röslau Wire as core wire is applied and the load is ≤ 75 %, Paulello wire is used, to make the load as close as possible to the target value of the load.
For the plain strings is, to make the load as close as possible to the target value of the load paulello wire type 0 and/or 1 applied.

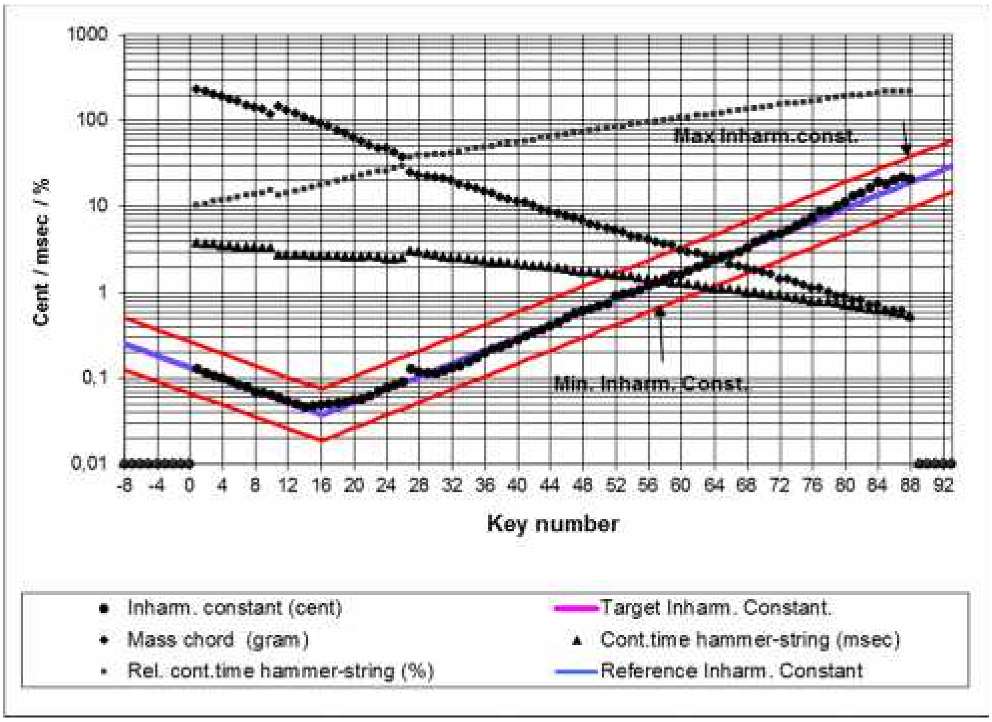

Fig. 10. Optimization Steinway-O with Paulello Wire.

7. Optimization Steinway-O with Paulello Wire type XM and optimized string length.

The professional version of the program ESC6.04jp2 gives the possibility to design the tension and the inharmonicity constant independent of each other. This possibility is mainly applicable by manufacturers, because when they design a new instrument, they have the possibility to apply string lengths calculated by ESC.
The program ESC6.04jp2 is capable of optimizing the length of the strings in such a way that the tension of the strings is very regular, while the inharmonicity constant is close to the target line. Figures 11 and 12 show the result.

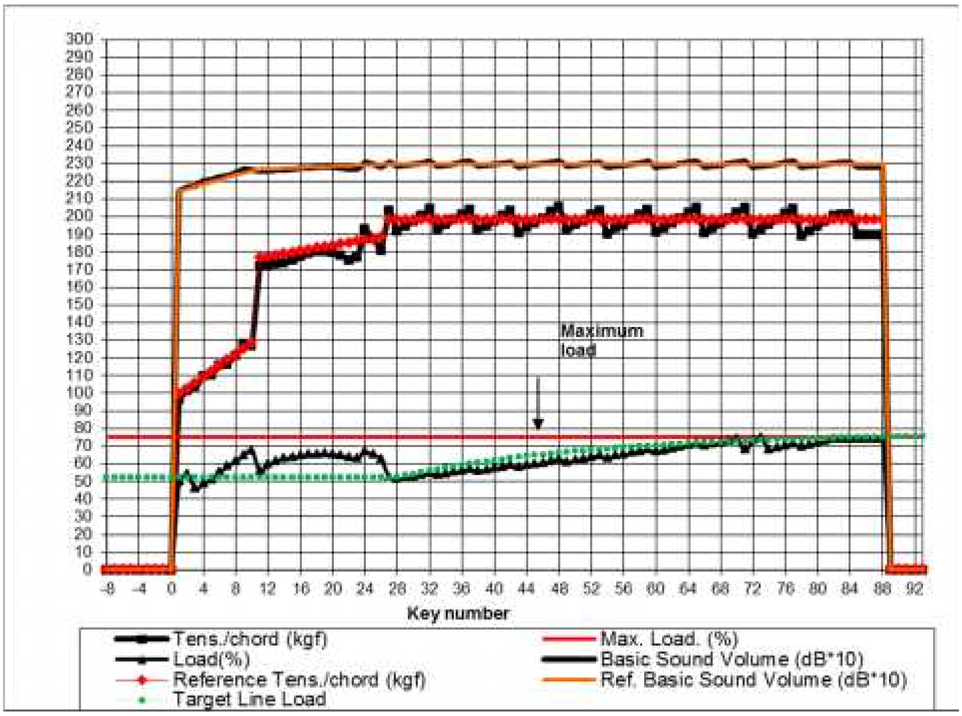

Fig.11. Optimization Steinway-O with Paulello Wire and optimized string length.

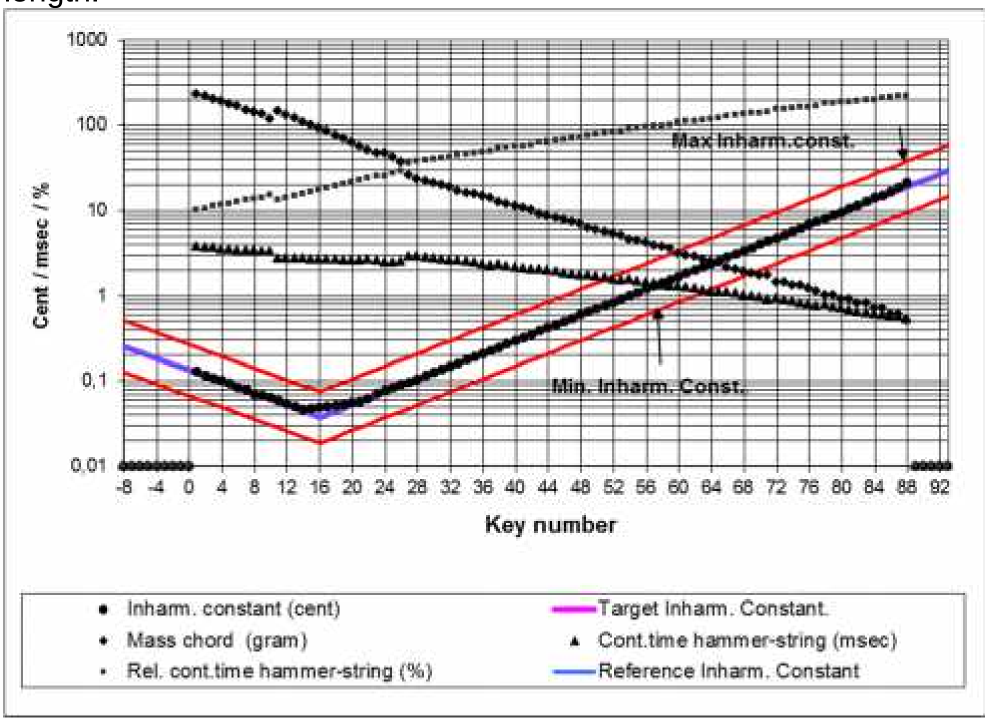

Fig.12. Optimization Steinway-O with Paulello Wire and optimized string length.

8. Test by professional pianists.

Two Steinway-O grands where restored.
One of them using a bass stringing delivered by Steinway and another with a bass calculated with the program Easy String Calc. using where necessary Paulello wire type xm.
Some professional pianists have played this two grands and they preferred the Steinway-O with a bass calculated with the program Easy String Calc., using where necessary Paulello wire type xm. A loss in dynamic sound was not found.
It is remarkable that even in this topbrand, an improvement was possible.

9. Conclusion

It has been found that by applying a combination of Röslau Wire and Paulello Wire type XM in the bass of small grands and uprights for the core wire of the wrapped strings, an inharmonicity can be achieved comparable with the inharmonicity of a large concert grand. The effect of this is that the bass has a more beautiful sound. It also turns out that the tuning is much easier because the octave stretch is much less.

10. Sound examples

For sound examples visit: http:/home.kpn.nl/~velo68

11. Video

For video presentations visit http:/home.kpn.nl/~velo68