VIOLIN REPAIR AND SET UP

OPTIMISING SOUND PRODUCTION

When Sam asked me to give a talk I was thinking about how, as violin makers, we can get the best sound from any given instrument. In other words, how can we change or adjust different parts of the instrument in order to affect the sound quality as we wish.

When I first learned how to set up an instrument I got to know how each element of the set up should be in order to work well. (bridge, sound post, neck…) I did not however really learn how to see the instrument as a whole and how the interactions of all the elements work in the production of sound. So this talk is a good chance for me to examine the procedures we use almost every day in our work-shops when setting up instruments. I want to try today to see it in the perspective of optimising or at least improving the sound of the given instrument you are working with.

I will focus on three aspects of how you can improve the sound of an instrument:
I will first look at the sound box and what we can change with it.
Then I will speak about the alignment of neck and bridge with the instruments body.
Finally I will try to show you the interaction of the bridge and strings in the transmition of tension to the top of the instrument.

I- THE SOUND BOX

There are 3 essentials things we can modify in the sound box to improve the sound of an instrument:
-Arching and plate-thickness
-Tensions in the plates
-Bassbar adjustment

A- Arching and plate-thickness:

You can see on many old instruments some arching distortion. This deformation is often due to badly repaired cracks, a badly fitted bassbar or too much tension from the sound post. When doing repair I think it's important to try to go back to the original intensions of the maker of the instrument you are working on. This means restoring the original arching, in other words returning to the "natural" position of the arching. I thing it's in this natural position that the arching vibrates most freely.

If you have to press out the arching that means you certainly have some earlier plate-thickness problems, (too thin under the bridge). Because of this you often have to do a breast-patch in order to raise the thickness of the plate. In many cases you can raise the thickness by less than a millimeter and still correct the problem. Raising the thickness of the top-plate under the bridge will give the instrument more depth of sound. A top-plate which is too thin will give a clear sound but the instrument will lose natural resonance and harmonics

B- Tensions in the plates:

For sound production I think it's best to keep an instrument in a state with the minimum of unwanted tensions. For example it can be bad to have a twisted top. This can occur when the back, especially a slab cut back, is pulling the ribs and top down. A lateral tension can stop some of the plate's vibrations. It could be worth the work on some occasions to raise the ribs in order to bring the top to a flat plain on the ribs.

There are also tensions at the saddle, bridge and neck foot when the instrument is tune...

The top under this pressure has a tendency to distort this way...

I think it's useful to fit the bass bar having this knowledge of pressure and distortion in mind.

C- The bassbar:

There is a relationship between string tension, bassbar tension and arching type.
Before putting in a bassbar you should think about the structure of the instrument you are working with as well as what kind of sound you want to get. You can try to set up the instrument to optimise the kind of sound it was built for.

If you have a very stable arching, for example Stainer-type arching with thin plate-thicknesses, you can put less or no tension in the bassbar and use low tension strings. The dynamics of sound will be slower on this instrument but with rich sound colors.

With flatter arching, for example cellos by Vuillaume, the top is less resistant and usually thicker. Here it is important to fit a bassbar with more tension. This way the instrument will be able to support strings with a stronger tension and give a more powerful sound.

The fit of the bassbar is very important. It's when you put tension in the bassbar but fit it badly that you can damage and deform the arching. Think also about the position, the weight and the shape of the bassbar.

I won't speak much today about the soundpost; this is an element of set-up you are experimenting with every day.

When the sound box is in good condition and the bassbar and soundpost well adjusted and at the right position you can continue by checking the instrument's alignment.

II- THE ALIGNMENT

We want the upper nut, fingerboard, bridge, saddle and end-pin well aligned in a straight line.

An easy way to check that the end pin is at the centre of the instrument is to put the instrument on its side on a table and use a marking tool set at a fixed distance from the table. Find the approximate center of the instrument's end, then turn it over to check and adjust the marking tool as needed to find the exact center. Make sure you take into account any worn edges that may change the instrument's position.

You can use the same procedure for finding the neck position. The neck should be centered where it meets the top plate, but at the instruments back you have to use in most cases the original button position.

You should also find the centre of the instrument by measuring the top plate and decide where the bridge should be placed. Take into account as well the positioning of the bassbar and f-holes. In some cases you may have to make a compromise somewhere in order to get a good overall alignment on the instrument.

It is logical to put the bridge at the center of the plate to get more balance and resonance in the sound. You must also think about the position of the f-holes and the space between the upper eyes. It is important not to have the width of the bridge wider than the spacing of the upper eyes as this kills some important vibrations. It can in such cases be good to use a smaller than normal bridge or correct the bridge position.
You can in some cases place the bridge a little more towards the treble side of the instrument. This will give more tension on the E string; something that some soloists appreciate.

Now I would like to focus a little more on the bridge and the strings.

III- THE BRIDGE AND THE STRINGS

I will first show you what is for me an ideal bridge, then look at something that I think we are not concerned enough about, the interaction between the bridge and the strings. With this I mean the string-pressure on the bridge and from there to the instrument's top plate.
Lastly I will look at what this pressure does to the instrument and how to modify these effects

1. A-The bridge

There are five elements that are important for the best sound production of a bridge:

The wood quality
The fitting
The bridge height
The string spacing
The carving

1- The wood quality:

The first thing which is for me essential is the wood quality.

The bridge should be able to produce by itself upper harmonics. It should follow the vibrations of the strings, (and add some quality to these vibrations), without absorbing to much of them.

This is usually possible with very well-aged quality wood. We want really dry wood with good density, tight grain, small medullar rays and evenness of flame. A piece of wood that has on its own a clear and resonating sound will give you these natural upper harmonics which, transmitted to the top, will add higher harmonics to the overall instrument and give you richer and clearer sound.

If you use weak bridge wood, (large years, very flexible wood), the sound is usually unfocused, weak and with a slow response.

2- The fitting:

The second important element, as you all know, is that the bridge should fit perfectly to the top of the instrument. This means not only that each foot fits well, but that the whole bridge fits without any twist.

3- The bridge height:

The bridge should be around 33 mm high for a violin. This corresponds to a fingerboard projection of 27 mm. There is a relationship between how wide the bridge is and its height, and standard bridge models are designed to work best within this relationship.

If you make the bridge too low you get shorter movements and less amplitude from this movement. This will give you a kind of short sound which is not very resonant. If you make the bridge too high you will get wider movements. In this case the instrument will take longer to respond and feel out of control.

4- The string spacing:

The string spacing effects the instrument in much the same way as the bridge height. The closer the strings are to each other the less mobile the bridge will be. You should adjust the string spacing according to the width of the bridge being used. For example on a large cello bridge you should use a little wider string spacing.

5- The carving:

When carving the bridge you should be careful not to take away too much wood. The higher part of the bridge is most critical because it's the most mobile part of the bridge. You can effect the bridge's action quite a bit by cutting very little in this upper part. If this part becomes too flexible the sound will be less focused.

The lower part of the bridge is much more stabile, so the changes in the cut-outs are not as obvious. In general, if you carve too much from the bridge cut-outs you will get a brighter sound.

A last point to keep in mind about the bridge is the string notches. The strings should not be more than a third of their diameter into the notches. If they are deeper this can mute the sound of the instrument. The string's vibrations will be absorbed instead of transmitted by the bridge. The same problem can occur at the nut

Now lets talk a little about the strings and how they interact with the bridge.

1. B-The strings:

I would like to deal with the question of string tension and is influence on the bridge pressure on the top of the instrument.

When setting up and adjusting instruments I have often asked myself why you can get such different feelings of string tension. Sometimes a string can feel weak; without enough tension. This results in poor and "small" sound quality from the instrument. Sometimes the same string can feel too tight and strong giving a tight sound with no resonance.

The first solution I came up with was that the string tension was somehow different depending on the set-up of the instrument. Since then I have spoken with all of the major string manufacturers and they have all given me the same answer to this question of tension:

For a given string length, mass and frequency you will always have the same tension on the length of the string.

So it is not the string tension that changes but its effect on the pressure on the top of the instrument. I have recently been investigating how this pressure changes and can be changed. As each brand of strings have different tensions and behave differently in regards to this question of pressure, we will assume for the following discussion that we are using a single type of string. Beginning with this string we have two variables:
-String length as related to string tension.
-String angle over the bridge as related to downward pressure.

1- String length as related to string tension:

Each string manufacturer is making their strings to work best at a certain string length. If you have a shorter string length than this “normal” length the string tension will be less than it should. You can see this for example if you put full size strings on a small instrument. This leads to a sloppy, “rubber-band” feeling in the strings. Try using a string built to give a stronger tension to correct this.

If you have a longer string length than normal the string tension will increase. This will give a harder, tighter feeling to the string. To correct this you can use a string built to give a lighter tension.

2- String angle over the bridge as related to downward pressure:

I will try to explain what I call the string angle over the bridge and try to show how this string angle can effect the downward pressure on the top of the instrument, thus effecting the reaction of the top plate to string vibration.
Here is a drawing we can work from together with a formula for calculating this downward pressure...

When I speak about the string angle over the bridge I mean angle A. The total angle A is divided into angles B and C on each side of the bridge.

T is the string tension. String tension is the same on both sides of the bridge. This is why when you have an after-length of 1/6 of the total string length you get a tone two octaves and a 5^{th} higher than the open string.

P is the downward pressure transmitted by the strings onto the bridge and thus to the top plate.

We will use these variables in calculating the actual pressure transmitted to the top of the instrument. I got from Mr Maillot, (director of Corelli Strings), a simple formula to give you this downward pressure when you know the string tension and the string angle. For discussion purposes we will consider tension T as one single element, reacting as if it is one string.

The formula is as follows: $P=T^* (\cos b+\cos c)$

For this calculation we will simplify the formula a little and assume that angles B and C are equal, giving us the total of angle A. We then can use the following formula:

P=T*2*(cos a/2)

If we apply this formula using a set of normal strings, and with tension T as the sum of the tensions of the four strings, we get some interesting results:

In this example the string tension stays the same, it is only the string angle over the bridge that changes. Changing this angle can change the pressure transmitted to the instrument's top quite a bit. As you can see from this example, a change of as little as 2 degrees in string angle can make the pressure go up or down by about 14%.

This formula can help you in adapting the downward pressure to best suit the needs of a given instrument. You must also keep in mind that different brands and types of strings will react differently even at the same string angle. You should experiment to find out which string angle used with which strings brings out the optimal sound for a given arching type.

Mr Maillot from Corelli strings also suggests that the bridge can act as an absorbent of vibrations and not a transmitter. Think about certain lengthwise string vibrations. (See drawing of bridge and strings.) These lengthwise vibrations are going back and forth over the bridge from the nut through the bridge to the saddle and back. If the string angle is too high the bridge will absorb too much of this lengthwise energy from the strings and they won't resonate freely. If in the opposite case the string angle is too low, not enough energy will be transmitted through the bridge to the instrument.

Here are some thoughts on how to adjust the string angle of an instrument:

-One way is to reset the neck while keeping the same bridge projection; by changing the neck foot height you can change the string angle by 4 or 5 degrees. For a violin I sometimes change the neck foot height from as much as 2mm to 9mm. This can change very much depending on the arching of the instrument. For example, you need a higher neck foot on an instrument with a high arch to prevent a string angle to be too strong.

-Another way to change the string angle is to add a wedge under the fingerboard. This is quite a good way if you have at the same time to correct the neck thickness and the sideways tilt of the fingerboard.

-A third and more simple way of changing this angle is to raise or lower the saddle height.

If you in your work make a habit of adjusting the string angle you will start to get a feel for how this works and what is best for a given instrument. When setting up an instrument it is good to start with the bridge height and string angle you want and then adjust the neck, fingerboard and saddle in relation to this goal.

CONCLUSION

The violin is a vibrating box which produces its best sound when a delicate balance is found between its components. To find this balance we must understand how each instrument is built. A certain type of arching will need more downward pressure to produce its best sound while another type will need less pressure.

The musician’s technique is also a crucial part of sound production. Someone with a heavy bow arm won’t be able to play with gut strings as you need to let the sound of the strings develop by themselves. Someone with a light bow and gentle bow stroke will find an instrument with a high pressure set-up unplayable. This musician will experience the instrument’s sound as too dry and hard.

Our role as violin maker is to first find the best balance for each instrument and then adapt it to the needs of the player.

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