Asymmetry becomes more and more usual

By Michel LECOQ
lecoq.michel@skynet.be

Introduction

A short time ago I have raised the attention from Roni Horowitz on an article about asymmetry in the Japanese longbow and he commented this article in his newsletter "ASIT technique for a week Issue 161." Then I received email from Ellen Domb to send her some more comments for the TRIZ-journal.

Here is the reference of the article

The asymmetrical Japanese Longbow
http://www.netwiz.net/~eclay/translat/kyudo.htm

and here are the comments from Roni :

> " In contrast to all other bows in medieval times, the Japanese long bow had an asymmetrical structure in which the "knocking point" was approximately 1/3 of the way up from the bottom limb and not in the center (as is the case with all other developments of the bow – you can see a picture in the link above).
>
> There's been an ongoing debate for many years as to why the bow was asymmetrical. One theory claimed that the bow had a short bottom limb to allow the archer to maneuver his bow to the left and right of the horse so that his aim was not restricted. If the bow had a long bottom limb, the horse's neck may restrict the rider's aim.
>
> A second theory maintained that in many cases the Japanese style of hunting involved lying in wait. The hunters did not chase their prey. As they lay in wait, the hunters would often sit concealed by trees and bushes. In this position a bow with a short bottom limb allowed them to shoot while sitting or kneeling.
>
> Yet a third theory resorted to the materials from which the bow is constructed, stating that bamboo, like most plants, is stronger at the bottom than at the top. This forced the bow makers to make the bows asymmetrical in order to compensate for the imbalance.
>
> The above-mentioned article claims that all these explanations are incorrect and that the actual reason for the transition to an asymmetrical structure is that the asymmetrical shape allows for the optimal angle between the arm and the wrist for a strong grip -a grip that would enable the "projection" of energy and power
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> Whatever the correct explanation, the very fact that we regard an asymmetrical shape as being so unusual explains why a tool such as ASIT, that reminds us to look for asymmetrical structures in any situation, is so important. "

The assumption that the bow has a short bottom limb to allow the movement to the left and right of the horse reminds me that this was the main reason why the American Indians were

defeated in their battles against the white man as soon as Colonel Samuel Colt (1814 – 1862) produced his revolver called the "Peacemaker" The Indians could only shoot on the side with their bows, and could not resist to a front attack. The use of a revolver allowed a front attack because the "Peacemaker" could be used above the horse head.
The word "Peacemaker" seems strange here but English people use it in this sense. When the duke of Cumberland defeated the Scots (supporters of Bonnie Prince Charles) in Culloden in 1746, and after killing a large part of the population and sending another part as slaves to the American colonies, somebody made the comment: "Cumberland made a desert and called it peace"

About bows

The article had just showed me a nice application of asymmetry, but I see also that the modern bows are now more and more asymmetrical in many of their aspects (one of my neighbor is in an archery club).

But first let introduce the bow and its physical functioning.

An excellent reference for this is the work of Professor James Edward Gordon (1913-1998) who taught Materials Technology at the University of Reading. In his book "***Structures***" he presents the bow as follows:

> The bow is one of the most effective ways of storing the energy of human muscles and releasing it to propel a missile weapon. The English longbow, which did so much execution at Crecy (1346) and Agincourt (1415), was nearly always made from yew. Because yew timber has not much commercial value nowadays, little scientific work was done on it until recently. However, my colleague Dr Henry Blyth, who is doing research on ancient weapons, has ascertained that yew (Taxus baccara) has a fine-scale morphology which is rather different from other timbers and seems to be peculiarly adapted for storing strain energy. Thus yew probably really is better than other woods for making bows.
> Contrary to popular relief, English longbows were not, as a rule, made from English yew-trees, whether grown in churchyards or elsewhere. Most English bows were made from Spanish yew and it was legally compulsory to import consignments of Spanish bow-staves with each shipment of Spanish wine. In fact the yew-tree grows well, not only in Spain, but all over the Mediterranean area. In spite of this, one seldom hears of the use of yew bows in Spain or in the Mediterranean countries, either during the Middle Ages or in antiquity. Their use was almost confined to England and France and, to some extent, Germany. English depredations generally stopped somewhere around Burgundy and hardly ever spread south of the Alps or the Pyrenees.
> Although these facts seem surprising at first sight, Henry Blyth points out that, because of its rather special constitution, the mechanical properties of yew deteriorate more rapidly with increasing temperature than do those of other timbers. A yew bow cannot be used reliably above 35° C. As a weapon it is therefore pretty well confined to cool climates and is unsuitable for use in the Mediterranean summer. Thus, although yew wood was used for arrows, it was seldom used for bows in Mediterranean countries.
> For this reason what was called a 'composite' bow was developed in these countries. Such bows had a core of wood which, being near the middle of the thickness of the bow, was only lightly stressed. To this core was glued a tension surface made from dried tendon and a compression face made from horn Both these materials are even better at storing energy than yew. Furthermore they retain their mechanical properties better than yew in hot weather. After all, an animal normally operates at about 37° C. In practice, tendon does not deteriorate appreciably below about 55° C. As against this, dried tendon slackens and behaves badly in damp weather.

Composite bows of this kind were used both in Turkey and elsewhere down to comparatively recent times. Lord Aberdeen (1784-1860), traveling to the Congress of Vienna in 1813, wrote of the use of Tartar troops, armed with what seem to have been composite bows, against the armies of Napoleon which were retreating through eastern Europe. There is a good deal of evidence that composite bows were better in many respects than the English longbow. However, whereas the longbow was essentially a cheap and simple weapon to manufacture, the composite bow was a much more sophisticated affair, and presumably expensive. Greek bows were composite bows, and the bow of Odysseus, like that of Philoctetes, seems to have been a pretty special job.

Which brings us back to the unfortunate Penelope and the task she set her suitors of stringing the bow of Odysseus. As we all know, this turned out to be beyond the strength of any of them, even the technically-minded Eurymachus: . And now Eurymachus was handling the bow, warming it on this side and on that before the heat of the fire; yet even so he could not string it, and in his great heart he groaned mightily.' But after all, why bother? Why didn't the suitors, or Odysseus, or anybody else, just use a longer string?

The answer to this is "for a very good scientific reason" - which is as follows. The energy which a man can put into a bow is limited by the characteristics of the human body. In practice, one can draw an arrow back about 0,6 meters (24 inches), and even a strong man cannot pull on the string with a force of more than about 350 Newton (80 lb.). It follows that the available muscular energy must be around 0.6 meter x 350 Newton, or about 210 Joules. This is the most that is available, and we want to store as much of it as possible as strain energy in the bow.

If we suppose that the bow is initially virtually unstressed and that the string is almost slack to begin with, then the archer starts to draw his arrow with a pull which is initially nearly zero, and he only works up to his greatest pull when the string reaches its maximum extension. This is expressed diagrammatically in Figure 2. In such a case, the energy put into the bow is the area of the triangle ABC, which cannot be more than half of the available energy, ie. 105 Joules.

In practice the measured energy that was stored in an English longbow was a little less than this figure. However, Homer specifically says that the bow of Odysseus was palintonos, that is, "bent or stretched backwards". In other words the bow was initially bent in the opposite or 'wrong' direction, so that considerable force had to be applied to it before it could be strung.

When the bow is strung in this way the archer is no longer starting to draw the bow from an initial condition of zero stress and strain; and, by intelligent design, it is now possible to arrange for the force-extension diagram to look something like Figure 4.

* Figures 2 and 4 are, of course, schematic. Generally the force-draw diagram will not be a straight line; but the same principle applies.

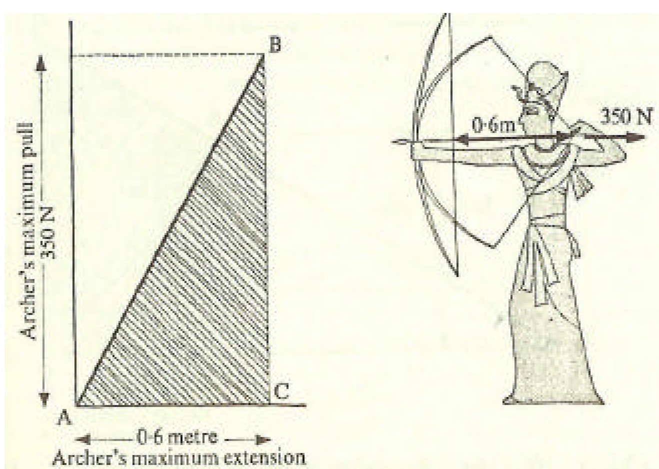

Figure 2. Energy stored in bow = t x 0,6 x 350 = 105 Joules.*

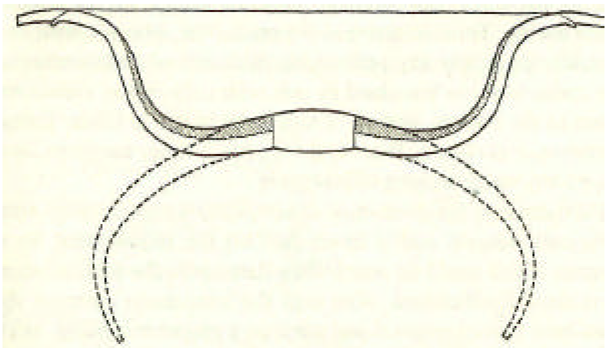

Figure 3. Composite bow, unstrung and strung.

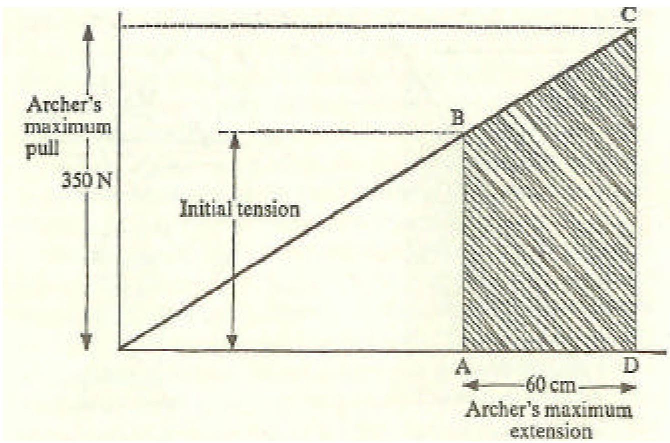

Fig 4 Why a bow is "stretched backwards" Energy stored in bow is now area ABCD = around 170 Joules

The area ABCD under such a diagram is now a very much higher fraction of the total available energy and might perhaps reach about 80 per cent of it. So it is possible that about 170 Joules of energy can now be stored in the bow, as against only about 105 Joules for the bow that is not palintonos. This is clearly a great improvemen1 for the archer - quite apart from any advantage it might have had for Penelope.

In fact all bows are more or less pre-stressed, in the sense that some kind of effort is needed to string them. However, since the longbow is a 'self-bow', that is to say, it is made from a stave that has been split from a log of timber and is therefore initially nearly straight, the effect in this case was small. It is much easier to arrange for the best initial shape with a composite bow, and these had usually a very characteristic form, from which we get the shape of a' Cupid's bow' (Figure 3).

Because the strain energy storage of horn and tendon, as materials, is better than that of yew, a composite bow can be made shorter and lighter than a wooden one. This is why we talk of a wooden bow as a 'long' bow. The composite bow could be made small enough to be used on horseback, as was indeed done by the Parthians and the Tartars. The Parthian bow was handy enough for the cavalrymen to be able to shoot backwards, as they retreated, at their Roman pursuers; from this we get the phrase 'a Parthian shot'.

According to this text the English longbow already made use of some kind of asymmetry by being used by people living in a cold climate although it grew in warm climates.

The Mediterranean composite recurve bow makes already a large use of asymmetry in the type and place of material.

The longbow is not an evolution of the composite bow.

And now to the modern compound bow

Today three type of bows are used in modern archery:

- The longbow
- The recurve bow
- The compound bow

The asymmetric Japanese longbow seems to be unknown from the Olympic competition.

The 3 different type of bows used presently are shown in
http://student.ulb.ac.be/~flouwers/sport_carte.html

A picture of an Olympic bow with all accessories can be seen in
http://www.almeria2005.es/HTML/ESP/CaminoA2005/EventosDeportivos/2003/TiroConArco/ET_ArcoOlimpico.htm

A picture of a compound bow with all accessories can be seen in
http://www.almeria2005.es/HTML/ESP/CaminoA2005/EventosDeportivos/2003/TiroConArco/ET_ArcoCompuesto.htm

The compound bow was invented in 1969 and it makes use of asymmetry in every of its parts.
The grip is asymmetric to meet the same requirements than the Japanese longbow (meet the angle between arm and the wrist. The grip is also asymmetric in a vertical plane: it is slightly turned to the right (for a right hand). The biggest advantage of the compound bow is that it can store much more energy for the same effort due to the use of eccentric (asymmetrical) pulleys or cams having a multiplication effect of more than 2 to 3. The string is attached on each side to a cable going thru the pulley to the other side of the bow. The point where the arrow touches the string is not exactly in the middle to compensate the aiming errors.

To read how it was invented, see :
The compound bow (25 years after Allen's patent)
http://www.student.utwente.nl/~sagi/artikel/compound/compound.html

To understand the physics of it, see:
Archer's Compound Bow (smart use of non linearity)
http://physics.mercer.edu/petepag/combow.html

To have an idea how to tune it, see :
Various options and how to tune a compound bow
http://membres.lycos.fr/webarc/compound.htm?

To understand the archery vocabulary go to a dictionary like :

Definition of words used in Archery
http://en.wikipedia.org/wiki/Archery
Compound bow
http://en.wikipedia.org/wiki/Compound_bow

Note :

To store a maximum of energy (by having very stiff limbs), the crossbow was invented around 400 BC. Its missile can generally penetrate any practical thickness of body armor.
But it cannot match the rate of shooting (up to 15 arrows per minute) of a hand-bow. Therefore, we left it out of our comparison.

Conclusions

What has all this to do with TRIZ?

Where would you place the bow on an S-curve ?

For the purpose of war, other weapons replaced the bow. It is on the descending part of the S-curve. It is still used for hunting (and I am sure that to hunt a lion or a bear with this weapon, one should go very close to the animal giving him so some fair chances to win.)

It is also used for sport. (Olympic) It is then close to the top of the curve. So it is on different places on the S-curve depending upon its use.

Can we say that the bow has followed some Law Of Technical System Evolution?
Beside the fact that the modern bow make more usage of asymmetry and that we think more asymmetry could be a trend of evolution, we do not have the feeling that some laws of evolution are applicable here. The inventor of the eccentric pulley was looking to a way to increase a force and not to asymmetrize something.

That means that TRIZ is not presently a "theory" or that Laws Of Technical System Evolution are not "laws" or that some parts of TRIZ are presented as "theories" or "laws" when they are not. For more about this, please read the article from G. L. Filkovsky :
http://www3.sympatico.ca/karasik/GF_LOTSE_concept_testing.html

Last comment

A theory explains what causes what, and why, and under what circumstances.

A theory is useful if it has predictive power.

However even if they do not show all the attributes of a theory, I find TRIZ and also the "Law Of Technical System Evolution" useful, because they trigger creative ideas when using them as they are today.

"Everything a manager does is based upon a theory in his(her) head – a believe that if he does this, than that will happen" (Clayton M. Christensen in "The Innovator's Solution")

My personnel idea is that TRIZ is a theory telling that when using some methods (like ARIZ) and some knowledge of principles and tools in a certain way, then we will obtain good ideas of solutions to the problem, even better ideas than could be obtained without. And TRIZ has a lot of tools like contradiction matrix or Laws Of Technical System Evolution that are analog to "check-lists" for triggering ideas even if these "check-lists" have no prediction power for the particular problem.

I have no clear idea on how to bring TRIZ closer to being a "theory." It would be useful that some academics do some research in these questions.

One way to start is to apply the scientific process of theory building:

- Making assumptions
- Observing the experiments that should confirm the assumption
- In case of non-confirmation, understand the circumstances and change the assumptions.

Presently, TRIZ is too much like management books claiming you should do something and showing 10 examples where that had success. But there is always another book telling you should do the contrary and showing also 10 success stories.