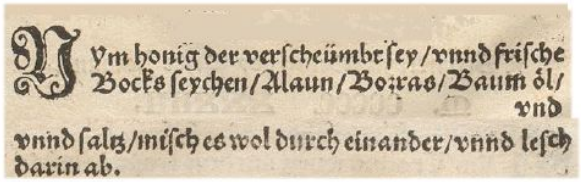
Myths and Bullshit Around Quenching

Hint: The juicy part will be at the end!

Recipes from "Stahel und Eyssen"

Advanced

The general literature about iron, steel and swords supplies a number of quaint if rather disgusting old recipes for making good quenching "juices". Here is one for a first taste treat:


Vm honig der verſcheümbt ſey / vnnd friſche Bocks ſeychen / Alaun / Boꝛras / Baum öl / vnd vnnd ſaltz / miſch es wol durch einander / vnnd leſch darin ab.

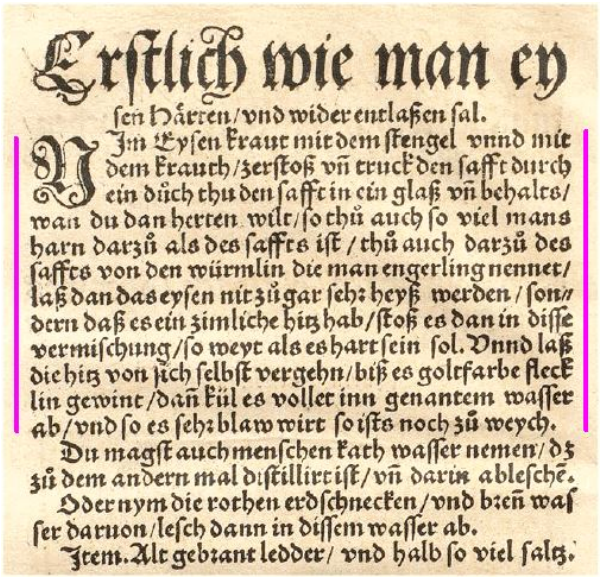
Vom Honig der verscheümbt sey / und frische Bocks seychen / Alaun / Borras / Baumöl / unnd Saltz / misch es wol durcheinander / und lesch darin ab

Take clarified honey, fresh urine of a he-goat, alum, borax, olive oil, and salt; mix everything well together and quench therein.

Source: "Stahel und Eyssen" (Steel and iron)

It looses a bit in the translation ("Bocks seychen" is rather more earthy than he-goat urine) but you get the drift.

This first recipe is from the book "Stahel und Eyssen" (Steel and Iron). It was printed 1534 in Mainz (where printing was invented by Gutenberg in 1450). This book is the only source for all those cute recipes that everybody likes to reproduce in the context of iron and steel history.
Let's have a few more:


Erſtlich wie man ey
ſen Härten / vnd wider entlaßen ſal.
Nim Eyſen kraut mit dem ſtengel vnnd mit dem krauth / zerſtoß vñ truck den ſafft durch ein düch thu den ſafft in ein glaß vñ behalts / wan du dan herten wilt / ſo thů auch ſo viel mans harn darzů als des ſaffts iſt / thů auch darzů des ſaffts von den würmlin die man engerling nennet / laß dan das eyſen nit zů gar ſeh: heyß werden / ſon- dern daß es ein zimliche hitz hab / ſtoß es dan in diſſe vermiſchung / ſo weyt als es hart ſein ſol. Vnnd laß die hitz von ſich ſelbſt vergehn / biß es golfarbe fleck lin gewint / dañ kül es voller inn genantem waſſer ab / vnd ſo es ſeh: blaw wirt ſo iſts noch zů weych.
Du magſt auch menſchen kath waſſer nemen / dz zů dem andern mal diſtillirt iſt / vñ darin ableſchē.
Oder nym die rothen erdſchnecken / vnd brēn waſ ſer darnon / leſch dann in diſſem waſſer ab.
Item. Alt gebrant ledder / vnd halb ſo viel ſaltz.

What follows is the English Standard translation:
Take the stems and leaves of *vervain*, crush them, and press the juice through a cloth. Pour the juice into a glass vessel and lay it aside. When you wish to harden a piece of iron, add an equal amount of a man's urine and some of the juice obtained from the little worm known as *cockchafer grubs*. Do not let the iron become too hot but only moderately so; thrust it

into the mixture as far as it is to be hardened, Let the heat dissipate by itself until the iron shows gold-colored flecks. then cool it completely in the aforesaid water. If it becomes very blue, it is still too soft.

That is the first page of the book, starting with the headline "**Firstly, how iron is hardened and released again**" and then gets immediately down to business.
So what the hell is ***vervain*** ? Or ***cockchafer grubs***? The present German word for "vervain" is "Verbene" and that doesn't help all that much either. In the original, however, it is "Eysenkraut", **iron herb**. Other German names are "Eisenhart" (iron hard) and "Stahlkraut" (steel herb). Aha. Now we get an idea.
Here is vervain:

Vervain, Verbena, Verbenen, Eisenkraut
Probably a cultivated version; the Internet provides for many somewhat different kinds.

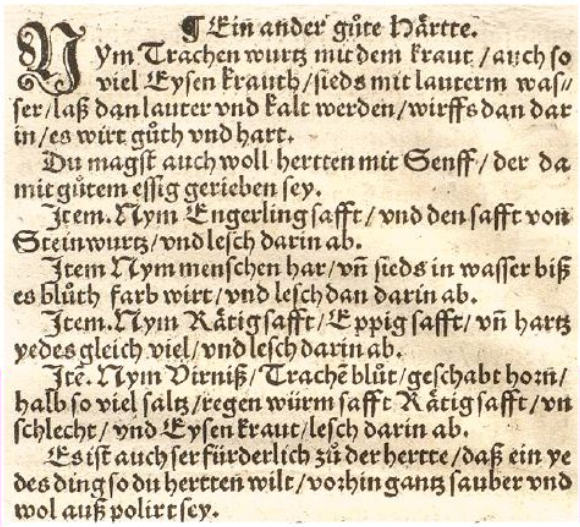
Source: Photographed in my neighborhood

Vervain, it appears, was one of the major "miracle plants" in many cultures from antiquity to modern times. Good for about anything from hardening steel to curing diseases or for cleaning things. As far down the time scale you care to look, vervain comes up in recipes for about everything. The ancient Egyptians seem to have used it, the Celts, and so on. You know it, if you know it at all (assuming that you are not overly given to esoteric stuff), as a some unobtrusive weed.
Now let's look at the *cockchafer grubs*. A cockchafer grub ("Engerling" in the original) was a very well know kind of "worm" (and there is no "little" in the original) before around 1930. Here it is:

Cockchafer grub (Engerling) and what it turns into:
May beetle (Maikaefer).

- Those things are big! And juicy. They used to be around by the billions, like crickets in biblical plagues, and constituted a big part of country life and lore in Europe. I have encountered huge swarms of the bugs when I was a kid. There are plenty of recipes for May-beetle soup in old cook books. It's supposed to be good.

One more recipe for hardening:



Ein ander gůte Härtte.

Nym Trachen wurtz mit dem kraut / auch so viel Eysen krauth / sieds mit lauterm wasser / laß dan lauter vnd kalt werden / wirffs dan darin / es wirt gůth vnd hart.

Du magst auch woll hertten mit Senff / der damit gůtem essig gerieben sey.

Item. Nym Engerling safft / vnd den safft von Steinwurtz / vnd lesch darin ab.

Item Nym menschen har / vñ sieds in wasser biß es blůth farb wirt / vnd lesch dan darin ab.

Item. Nym Rätig safft / Eppig safft / vñ hartz yedes gleich viel / vnd lesch darin ab.

Item. Nym Virniß / Trachē blůt / geschabt horn / halb so viel saltz / regen würm safft Rätig safft / vn schlecht / vnd Eysen kraut / lesch darin ab.

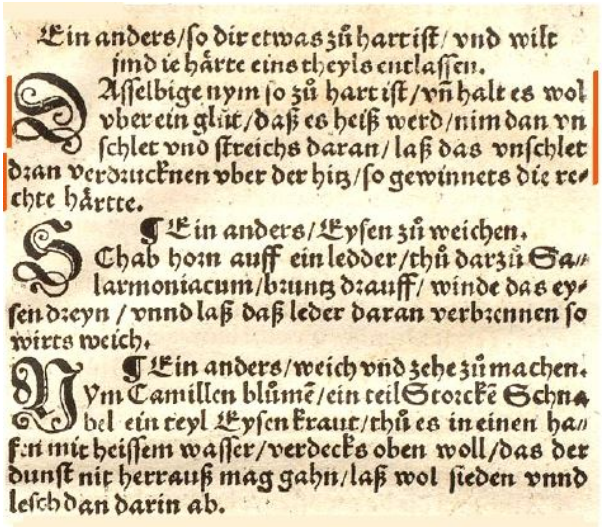
Es ist auch ser fürderlich zů der hertte / daß ein yedes ding so du hertten wilt / vorhin gantz sauber vnd wol auß polirt sey.

Standard translation the marked part:
Take varnish, *dragon's blood*, horn scrapings, half as much salt, juice made from earthworms, radish juice, tallow, and *vervain* and quench therein. It is also very advantageous in hardening if a piece that is to be hardened is first thoroughly cleaned and well polished.

Source: "Stahel und Eyssen" (Steel and iron)

Dragon's blood (Trache blut)? In the 16th century?
Just look at the beginning of this recipe (not contained in the translation). There you find "Trachen wurtz" or *dragon herb*. That gives a clue: Dragon's blood refers to a ground-up bright-red resin that was obtained from a number of distinct plants. It would have been a bit difficult to get the "real" stuff in the 16th century (or at any other time).
Note that a really useful advice is also given: Keep your steel clean!

There are plenty more recipes for hardening iron and steel but also quite a number for softening it. This probably implied to make a quenched steel less brittle; what we do in more modern times by a bit of tempering after the quench. Here is one:

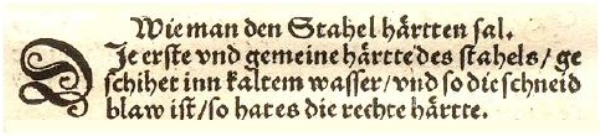

Ein anders/ſo dir etwas zů hart iſt/ vnd wilt
jmd ie härte eins theyls entlaſſen.
Aſſelbige nym ſo zů hart iſt/ vñ halt es wol
vber ein glůt/ daß es heiß werd/ nim dan vn
ſchlet vnd ſtreichs daran/ laß das vnſchlet
dran verdrucknen vber der hitz/ ſo gewinnets die re-
chte härtte.
Ein anders/ Eyſen zů weichen.
Chab horn auff ein ledder/ thů darzů Sa-
larmoniacum/ brunz drauff/ winde das ey-
ſen dreyn / vnnd laß daß leder daran verbrennen ſo
wirts weich.
Ein anders/ weich vnd zehe zů machen.
Vm Camillen blůmē/ ein teil Stoeckē Schna
bel ein teyl Eyſen kraut/ thů es in einen ha-
fen mit heiſſem waſſer/ verdecks oben woll/ das der
dunſt nit herrauß mag gahn/ laß wol ſieden vnnd
leſch dan darin ab.

I loosely translated the marked part for you:
If your iron is to hard / hold it over glowing coals / so it gets hot / Then take some tallow and paint it on / Let the tallow sizzle off in the heat / so you gain the right hardness

The rest (and many more recipes) give the by now usual mix of weird things.

Now a question comes up: People might have been superstitious, ignorant and stupid during most of the human history on this planet. But certainly not all people at all times, as these recipes seem to indicate?
Well, no they weren't. If you consult all of the book, you realize:

1. It is *not* just about "Stahel und Eyssen (Steel and Iron). Those are just the first three words of its 86 words title! It also covers how to solder metals, to get stains out of clothing, dye wool an so on. It just reports what people have done and do.
2. It gives you also the no-nonsense recipes. Here is the first recipe given for hardening steel:



How one should harden steel.
The first and common hardening of steel / is done in cold water / and as soon as the cutting edge is blue / it has the right hardness.

What more do you want?

I think it is quite telling that the the first chapter has the headline: "Firstly, how iron is hardened and released again" while the second chapter opens with: "Following now the pieces how one should harden steel". The author, like everybody else, knew the difference between iron and steel. Iron was the stuff that we now call wrought iron or low carbon steel; i.e. the stuff that does not form martensite and thus cannot be quench hardened. It also might have contained phosphorous steel that can't be quench hardened either. Steel ("Stahel") in contrast is whatever responds to quenching, i.e. medium carbon steel.
It follows that all the concotions for hardening *iron* are not so much recipes for quenching "juices" but describe carbon and / or nitrogen sources for case hardening by "carbonizing" the surface.near regions. In some descriptions (in particular older ones, see below) the (solid or pasty) mixtures are used by heating the iron in the stuff, as required for effect. Of course, some confusion with quenching is to be expected and thus recipes for liquids in which to quench iron are found, too.

The whole book should be seen like a modern 500 page "Of health and beauty" book. On the first page it says: Eat healthily, exercise, don't get overweight, and wash yourself regularly with water and soap. On the remaining 499 pages it states (in spirit but not in the exact words following): In addition, you also could buy and apply the products and procedures detailed in what follows; the more exotic and expensive the better (for the seller). It will help some, provided that you always follow the advice on page 1.

Was there anything good about all the stuff you pitch into water for proper quenching of steel? As far as the hardening of *iron* is concerned, some recipes are not really about quenching but about getting some carbon / nitrogen into the outer skin of the soft wrought iron as outlined above. For that you need all this biology as a carbon / nitrogen source, water certainly would not do any good.
As far as martensite production in carbon steel by quenching is concerned, whatever you add to water tends to decrease its thermal conductivity a bit, making quenching a little slower and the blade a little less harder but also less brittle. So yes, if everything else is just right, pissing into your quenching fluid might do a bit of good.
There might have been other fringe benefits, however. Your customer was probably willing to pay more for a blade that had been made with the help of extremely fancy stuff. In particular if there were convincing explanations. Clear water running forcefully down a ravine cannot but impart more "force" to a blade than murky water from some boring lake. It's called "**sympathetic magic**" and that works up to this very day (for whoever sells it). Quenching in expensive and magic stuff just must be better than doing it in cheap stuff. That is an easy claim to make if there is no way of a quantitative comparison. Nobody then could measure hardness in a quantitative way, so claiming that my sword is harder than yours was without much risk. In contrast, claims to who has the longest are open to measurements. I just read in a newspaper that Lana Turner has rated Ronald Reagan's sword lengths "40 minutes" while J. F .Kennedy just got a humble "4 minutes". S. Freud would have understood.

The "Stahel und Eyssen" book from 1534 is not the only medieval reference to quenching. There is also "De diversis artibus" (about various arts), written around 1100 - 1125 by one **Theophilus Presbyter**. probably a pseudonym for Rogerus von Helmarshausen, a benedictine monk who also was a well-traveled gold smith. The book or better books (not completely preserved) deal with gold smithing, painting, casting bells etc. and contain detailed recipes for making, e.g., files, piercers and gravers.
Here is one for gravers; pointy tools for engraving:

Fit ferrum ex calibe puro, longitudine maioris digiti, et grossum ut festuca, in medio vero grossius, et est quadrum. Una cauda ponitur in manubrium, et in altera summitate limatur una costa, quae est superior, usque ad inferiorem, sed inferior est longior, quae limata gracilis est in cuspide; quod calidum temperatur in aqua. Ad hanc speciem fiunt plures maiores et mmores.

The tool is made from massive steel. (...) The tip of the tool is heated so it glows and is hardened in water.

Nothing wrong with that. More interesting is the hardening of files. Files, according to Theophilus, were made from massive steel but also from (soft) iron.

Cumque ex omni parte incisae fuerint, fac temperamentum earum hoc modo. Combure cornu bovis in igne et rade, atque misce ei tertiam partem salis, et tere fortiter. Deinde mitte limam in ignem, et cum canduerit, salies illam confectionem super eam ex omni parte, apertisque carbonibus valde ardentibus cum festinatione sufflabis per omnia sic ut temperamentum non cadat, et statim eiciens extingue aequaliter in aqua, et inde eiciens siccabis modice super ignem. Hoc modo temperabis omnes quae sunt ex calibe.
After structuring the surface on both sides, harden as follows. Burn horn of oxen in a fire. Scrape it, add a third part of salt and pulverize the mixture thoroughly. Put the file into the fire. When it glows paste on the mixture on all sides and surround the piece with bright burning coals. Blow immediately over everything taking care that the hardening mixture does not come off. Quench uniformly in water immediately after taking out. Take out and dry the piece lightly over the fire. In this way harden all the files made from steel.

Nothing wrong with that either, First carbonize the ridges of the file, than quench harden and temper a bit at lower temperature. There are more and similar recipes like this, and then there is the juicy one that made it into quenching folklore up to this day:

Fit etiam aliud temperamentum ferramentorum, quibus vitrum inciditur et molliores lapides, hoc modo. Tolle hyrcum triennem etliga eum intus tribus diebus sine cibo; quarta da ei filicem comedere et nihil aluid. Quem cum duobus diebus comederit, sequenti nocte cooperi eum in dolio inferius perforato, sub quibus foraminibus pone aluid vas integrum, in quo colligas urinam eius. Qua duabus vel tribus noetibus tali modo sufficienter collecta, emine hyrcum, et in ipsa urina ferramenta tua tempera. In urina etiam rufi pueri parvuli temperantur ferramenta durius quam in aqua simplici.
There is also, for tools to cut glass with, a different way for hardening. Take a three year old he-goat, and keep him tied up three days without food. On the fourth day feed him ferns and nothing else. After he ate that for two days put him into a barrel with a perforated bottom during the following night, and put a vessel below that barrel in which you collect his urine. If you collected enough during two or three nights, release the goat and harden your tool in the urine. You can also harden these tools in the urine of a red-haired boy; they will get harder than in mere water.

With regards from Baphomet, Mephistopheles, or whatever name you prefer for the horned and red-haired one who walks on goat's feed. A little magic can never hurt, even if it is thinly disguised black magic.

All in all, the medieval smiths knew a few things that worked. Then they knew a lot of things that neither worked nor did much damage for the iron / steel - but could do a lot of good for the smith's purse!

Serious Stuff

Did some ancient smiths, presumably in the "East", **quench their red-hot blades in the body of a live person**? This is a question that exercises several Internet forums quite a bit. A lot of people have run across indirect reports of this inhuman technique and became upset. Nobody, it seems, knows the text to that claim.
Here it is:

> Then let the master workman, having cold-hammered the blade to a smooth and thin edge, thrust it into the fire of the cedarwood charcoal, in and out, while reciting the prayer to the God Balhal until the steel be of the color of the red of the rising sun when he comes up over the desert towards the East, and then with a quick motion pass the same from the heel thereof to the point, six times through the most fleshy portion of the slave's' back an thighs, when it shall have become the purple of the king. Then, if with one swing and one stroke of the right arm of the master workman it severs the head of the slave from his body, and display not nick nor crack along its edge, and the blade may be bent around the body of a man and break not, it shall be accepted as perfect weapon, sacred to the service of the God Balhal, and the owner thereof may thrust it into a scabbard of asses' skin, brazen with brass, and hung to a girdle of camel's wool dyed in royal purple.
>
> Source: I got it from the book of **Stephen Sass** [2)].

I have involuntarily helped to spread this gruesome tale because I translated and used it in one of my hard-core Science hyperscripts in a "on the side" module" [4)]. Here it is:

> Dann stößt der Meisterschmied, nachdem er der Klinge durch Hämmern eine scharfe und gerade Schneide verliehen hat, das Schwert in ein Feuer von Zedernholzkohle, hinein und wieder heraus, während er das Gebet zu Baal rezitiert, bis der Stahl die rote Farbe der aufgehenden Sonne angenommen hat, so wie sie bei Sonnenaufgang über der Wüste gen Osten erscheint, um dann mit einer schnellen Bewegung den Stahl von der Spitze bis zum Haft sechsmal durch die fleischreichsten Teile des Rückens und der Oberschenkel eines Sklaven zu stoßen, bis die Farbe dem königlichen Purpur gleicht. Dann, falls das Schwert mit einem Streich und einem Schlag des rechten Armes des Meisters den Kopf des Sklavens ohne Scharte oder Riß vom Rumpf getrennt hat, und die Klinge um den Körper eines Mannes gebogen werden kann ohne sich zu verbiegen, mag das Schwert als perfekt gelten und dem Dienste des Gottes Baal geweiht werden.
>
> Source: Translated from the original in the book of Stephen Sass [2)]..

- In his book Stephe Sass put this quote into the context of wootz blade forging. So where did Steve get this atrocious tale from? He quotes a book from one J. G. Thompson[5)] as the source. The Internet seems to know nothing about Thompson and his book. I'm sure, however, that Steve Sass had access to it; the library of Cornell University (where Steve works) is famous for its huge collection. I'm equally sure that Thompson has his quote from somewhere else. Maybe in time the original source of this quote will be unraveled but I expect that nothing definite will be found. (Turns out I'm wrong; read on).
  Meanwhile everybody seems to have run across this "rumor" either by hearsay or by written reference to it. All the BS that was published around the secrets of the damascene / wootz blade, e.g. in the august New York Times[3)], seems to be especially fertile ground.

Since we have no unassailable records, we have to use ratiocination. The first question in this context then would be: Where those ancient (oriental) smiths cold-blooded enough to kill a human if his blood made for better blades?
The answer to that question is very likely a resounding YES! People were killed for smaller potential gains without much qualms. In particular slaves but also siblings, wifes, and you or me.
The second question than must be: Did killing a human by plunging a red-hot blade through his body really make for better blades? Better than just plunging it into anything not alive?
The answer to that is a definite NO! It is easy to see why:

- I have discussed what you can do with quenching, what you cannot do, and what can go wrong in some detail in the backbone. So let me just give the essence of the argumentation here:

  - Only the starting temperature and cooling rate matters for a "quenchable" steel, i.e. a steel with neither too much nor too little carbon. Whatever a human body can do, some liquid in a barrel can do better.
  - Nothing remotely important is transferred from the quenching liquid to the blade during quenching. Forget about nitrogen / carbon incorporation. What little there might be makes no difference to what already must be in a quenchable blade to start with.
  - Wootz blades must be kept below the austenite - ferrite transition temperature at at all times during forging and finishing. Quenching from that low a temperature does not have any effect. Moreover, wootz blades are extremely high in carbon and thus already hard enough. Wootz quenching thus makes no sense at all.

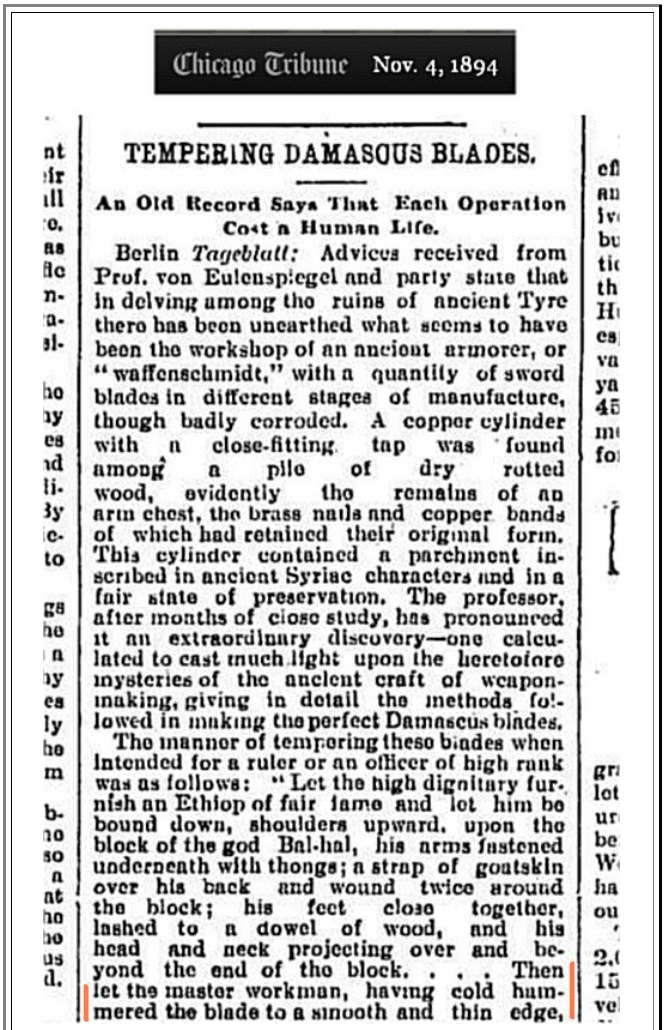
  So quenching any steel in a human body is not a particularly good practice, and quenching wootz steel is counterproductive in any way of doing it.

The next question thus is: OK. Killing a slave by quenching makes no sense at all. We know that *now*. But did the ancient guys also know that *then*?
I doesn't matter, after all, what we *know,*, it only matters what blade makers and their customers *believed*. Nobody could assess the exact hardness of a blade in a quantitative way in old times and it was impossible to be sure if your slave-quenched blade was better or not compared to a normally quenched one. It was a matter of believe. People believe strange things after all, for example that a BMW is better than a Mercedes.
Answering that question is impossible. My feeling is that here or there some rich idiot who could afford one of these extremely expensive swords would be capable of believing the tale. So one cannot rule out that some smith followed the procedure on occasion.
That, however, triggers the next question: Is it *technically* possible to quench a sword, however badly, as described?
The answer is: NO! The "fleshy parts" are just not large enough. Cooling rates would be quite different in different parts of the sword and that is very bad. And only the first thrust would have any effect anyway.
The final question is: Does the tale contain internal inconsistencies? The answer is a resounding: YES, it does! Let's see what there is:

1. " ... having cold-hammered the blade to a smooth and thin edge, thrust it into the fire of the cedarwood charcoal ... the color of the red of the rising sun..." The cold-hammering indicates a wootz blade and no smith who made one by knowing the "secret" of cold-hammering would ever heat it up again!
2. "... while reciting the prayer to the God Balhal..." A wootz blade smith would most certainly not have prayed to the God Balhal, probably good old Baal.
3. "... it severs the head of the slave from his body...". You can't decapitate a person with a freshly quenched blade. It is not sharp (if you sharpen it before quenching the edge will burn off) and it has no handle.
4. "... display not nick nor crack along its edge, and the blade may be **bent around the body** of a man and break not...". Nice performance but not particular impressive, and most certainly *not* the properties you need to do quenching for.

- In other words: The whole thing is a joke!

Aren't' you impressed by my powers of ratiocination? I certainly am. Because it turns out, I was right. *After* I have come to the conclusion above, I found what appears to be the original source[6)] of the English version of the tale:



Chicago Tribune Nov. 4, 1894

TEMPERING DAMASCUS BLADES.

An Old Record Says That Each Operation Cost a Human Life.

Berlin *Tageblatt:* Advices received from Prof. von Eulenspiegel and party state that in delving among the ruins of ancient Tyre there has been unearthed what seems to have been the workshop of an ancient armorer, or "waffenschmidt," with a quantity of sword blades in different stages of manufacture, though badly corroded. A copper cylinder with a close-fitting tap was found among a pile of dry rotted wood, evidently the remains of an arm chest, the brass nails and copper bands of which had retained their original form. This cylinder contained a parchment inscribed in ancient Syriac characters and in a fair state of preservation. The professor, after months of close study, has pronounced it an extraordinary discovery—one calculated to cast much light upon the heretofore mysteries of the ancient craft of weapon-making, giving in detail the methods followed in making the perfect Damascus blades.

The manner of tempering these blades when intended for a ruler or an officer of high rank was as follows: "Let the high dignitary furnish an Ethiop of fair fame and let him be bound down, shoulders upward, upon the block of the god Bal-hal, his arms fastened underneath with thongs; a strap of goatskin over his back and wound twice around the block; his feet close together, lashed to a dowel of wood, and his head and neck projecting over and beyond the end of the block. . . . Then let the master workman, having cold hammered the blade to a smooth and thin edge,

Source: Cicago Tribune from Nov. 4, 1894 [6)]
Internet. The marked text is the beginning of the text above.

Full text

- Aha! A discovery made by Prof von **Eulenspiegel**! That sounds rather good - except if you know, *like every German*, that "Eulenspiegel" is never the name of a person but a synonym for a trickster, somebody who plays you for a sucker.
  Moreover, a copper cylinder was found that contained the ancient smiths' secret in writing! That must be the *only* copper cylinder used for keeping writings that was ever found in antiquity. Moreover once more, it contains writings from the the *only* ancient smith known to humankind who was capable of writing. Yes, indeed!

So some evil German at the end of the 19th century invented the story and spread it, disguised as archaeological discovery? Not so. Every German reading the Berliner Tageblatt around 1894 would have immediately realized that the article was a joke or a satirical comment to the craze about "damascene steel" that exercised scientists and "damascene steel" aficionados mightily in these times.
I would not be surprised eiher if it turns out that the article was originally published on April 1st.

- How this kind of urban mythe spreda from the initial Chicago Tribune article can be read in a short article from **Stephan C. Alter** from 2017, entitled: "On Slaves and Silk Hankies. Seeking Truth in Damascus Steel".

I sincerely apologize for having helped to promote this slanderous bullshit in the past!

[1] The 1524 book "**Stahel und Eyssen**, künstlich weych und hart zu machen, schrifft und bildwerck darinn zu etzen: Gold unnd silberfarben, auff ein yedes metal mancherley weyse zu machen. Auch mancherley lötung zu stahel, eysen und messing, kalt und warm ; Schmaltz flecken, öl flecken, oder was es nur für flecken seind, auss Gewandt, Sammat, Seyden, Güldinen stücken, Cleydern etc. leychtlich mitt wassern oder laugen, darzu bereyt, on schaden zu vertreiben: eins yeglichen gewandts verlorn farb wider zu bringen. Auch garn, Leynwath, Holtz, Beyn etc. Mancherley farben zu ferben.
Getruckt zu Meintz [Mainz] bey Peter Jordan, 1534.

[2] Stephen Sass: "he Substance of Civilization: Materials and Human History from the Stone Age to the Age of Silicon", Arcade Books;

[3] WALTER SULLIVAN: "THE MYSTERY OF DAMASCUS STEEL APPEARS SOLVED" Published: September 29, 1981 in The New York Times

[4] H. Föll: "Einführung in die Materialwissenschaft I"
http://www.tf.uni-kiel.de/matwis/amat/mw1_ge/index.html; advanced module t4_1_3 "Mythen der Schmiede"

[5] J. G. Thompson: "Mining and Metallurgy"
New York, American Institute of Mining and Metallurgical Engineers publication, May 1940.

[6] http://archives.chicagotribune.com/1894/11/04/page/26/article/tempering-damascus-blades