What are “aspect ratio” and “condensed design” all about?

In weaving the weft yarns are usually thicker and spaced more widely apart than the warp yarns.

One reason is that the warp must be bent back and forth under tension as each shed is created, thus it needs to be flexible, while the weft is inserted straight into the open shed, hence does not need flexibility.

When the woven fabric is removed from the loom it is no longer under tension lengthwise from the warp nor widthwise from the temples and reed, so it relaxes into a final smaller size. A thin weft will be more easily deflected by the weaves, thus will cause the fabric’s width to shrink more than it would if fatter stiffer wefts were used. Lengthwise shrinkage (along the warp) is easy to compensate by adding a few more picks. Widthwise shrinkage can only be compensated by widening the loom, hence is less tolerable.

Finally, the amount of “yardage” woven per hour depends on the picks per minute the loom or weaver can insert times the spacing of each weft inserted - fatter more widely spaced weft yarns mean more yards per hour.

For these and other reasons, weft spacings are often 2 to 3 times wider than warp spacings.

The warp and weft form a grid with the warp vertical and the wefts horizontal. Since the spacings are different the grid will define rectangles rather than squares.

The **Aspect Ratio** of a fabric is
height of rectangles / width of rectangles
or
warps per inch / wefts per inch
also called
Ends per inch / Picks per inch (EPI/PPI)

A typical upholstery fabric might be set for 172 Ends/Inch and 56 Picks/inch, so its Aspect Ratio on the loom would be:
On the loom Aspect Ratio = 172 / 56 = 3.07

As mentioned above, the fabric shrinks as soon as it is removed from the loom. Further shrinkage occurs during the “finishing” of the fabric when it is washed, brushed, tumble dried, or subjected to other processes to prepare it for sale. In almost all cases the shrinkage increases the yarn density by differing amounts in the warp and weft directions thus changing the Aspect Ratio.

For example, if the upholstery fabric above shrank by 10% across the weft and 6% along the warp, the “finished” product would consist of
Finished EPI = 172 / 0.90 = 191.1 (Ends per Inch, increased by 10%)
Finished PPI = 56 / 0.94 = 59.6 (Picks per Inch, increased by 6%)
Finished Aspect Ratio = 191.1 / 59.6 = 3.21

The “on the loom” values are set by the reed you use and the pick wheel which sets the fabric advance per weft insertion. They are easy to calculate, but of limited use.

The “finished” values can only be determined accurately by weaving representative samples on the loom, subjecting them to the full finishing process, and then measuring the result. More work, but very important because they determine what the customer sees. For example, if you need to weave a “25 inch long towel”, you must know the finished PPI to know how many picks (weft insertions) will be required to meet the specification.

The test samples must be woven under the same conditions as will be used for the final product. Changes in warp tension settings, in yarn materials or sizes, in weave families used, or in finishing processes will result in changes in shrinkage and can invalidate your test.

The importance of finished EPI and PPI values is obvious - they determine the dimensions of the finished product and whether or not it meets specifications.

Why does the Aspect Ratio matter? Because it determines the shape of your design.

Suppose you want to weave a circle that is 50 wefts tall. If you design it to also be 50 warp ends wide, it will weave as a tall ellipse if the aspect ratio is greater than 1, as it almost always is. To have it actually come out as a true circle in the upholstery example above, you would have to design the circle as 160 Ends wide by 50 Picks high.

The formulas for equal lengths in the warp and weft directions are:
 # of Warp Ends = # of Weft Picks X Aspect Ratio
 # of Weft Picks = # of Warp Ends / Aspect Ratio

Since the important thing is the shape as seen by the ultimate buyer, you should be using the Finished Aspect Ratio, not the “on-the-loom” value.

For example, using our upholstery example:
 to weave a 50 Weft tall circle requires 50 X 3.21 = 160 warp ends
or
 to weave a 160 Warp wide circle requires 160 / 3.21 = 50 weft picks
whereas
 to weave a 50 Warp wide circle requires 50 / 3.21 = 16 weft picks

The Aspect Ratio is used by JacqCAD to display your design as it will appear in the final fabric; it does so by showing each thread crossing as a “rectangular pixel”. When you are making important aesthetic decisions about shapes in the design it is important that you see the shapes as they will actually be woven; this requires that you set the correct Aspect Ratio. When you draw a circle or square, JacqCAD uses the Aspect Ratio you have specified to scale the circle or square correctly; such circles or squares will only by truly circular or square in the fabric if you have specified the right Aspect Ratio.

To summarize, the EPI (Ends per Inch) and PPI (Picks per Inch) determine the size of your product while the Aspect Ratio determines the shape of the figures in your design.

The importance of the Condensed Design

To this point we have been discussing an “aspect ratio” calculated directly from the density of warp and weft yarns. This assumes that we are designing using one pixel for every thread crossing. In fact, this is more the exception than the rule.

Most textile design work is done on what we call a “**condensed design**” which contains a reduced number of pixels, each of which represents several thread crossings.

We would be designing at full scale - 1 design pixel for each thread crossing - only for certain simple constructions. For example, when we are weaving a black warp against a white weft every yarn crossing is independent and we are free to choose, yarn crossing by yarn crossing, whether the weft or the warp will be on the surface.

However the situation is different if we are weaving a “pick and pick” fabric in which two wefts of contrasting color are alternated. The surface design is created by bringing one of the two wefts to the surface while simultaneously burying the other weft underneath and out of sight. In this construction we must control both wefts in order to create a single point in the design - in other words the two wefts are inter-dependent and must be designed as a single unit. Our “condensed design” would be 1/2 the height of the final fabric, i.e., condensed 2:1 in the vertical direction, with each design pixel representing a ***pair*** of wefts.

The popular “tap” constructions represent an extreme case. A common construction might weave 6 warp colors against 3 wefts. The wefts usually consist of a “light” weft, a “dark” weft, and a “binder” weft - the latter being quite thin and is used to bind the warps into the surface.

To create a single “point” of the design one selects one (or more) of the 6 warps to lie on the surface backed by either the light or dark weft. For example, one might bring the red warp to the surface over the light weft to create a light red spot (or the red warp over the dark weft to create a dark red spot). The unused warps and the unused weft are used to weave the underlying structural fabric while the binder weft interlaces with the surface warp to bind it to the fabric.

The crucial point is that all 6 warps and the 3 binders - a total of 18 yarn crossings - must be coordinated as a single unit in order to create a single spot of color in the fabric. This unit is represented by a single pixel in the condensed design.

In this case our condensed design would be condensed 6:1 in the horizontal and 3:1 in the vertical.

For example, assume that we are weaving 1200 warp ends against 900 wefts. The size of our condensed design would be:
 case 1: 1200/1 x 900/1 = 1200 x 900 for black warp against white weft fabric
 case 2: 1200/1 x 900/2 = 1200 x 450 for “pick & pick” using 2 weft colors
 case 3: 1200/6 x 900/3 = 200 x 300 for a 6 color tap construction

Further assume that the yarn densities were 180 EPI (warp Ends/inch) and 90 PPI (weft Picks/inch) - an aspect ratio of 2.0 at the loom.

The condensation changes the aspect ratio - if we have condensed 2:1 in the vertical then there will be 1/2 as many “pixels” as wefts, 45/inch instead of 90/inch.

For the above examples the condensed "pixel" densities and aspect ratios will be:

case 1: simple black warp against white weft,	180/1 x 90/1 =	180 x 90 = 2.0
case 2: "pick & pick" using 2 weft colors	180/1 x 90/2 =	180 x 45 = 4.0
case 3: 6 color tap construction	180/6 x 90/3 =	30 x 30 = 1.0

It is crucial to design in the correct condensed size. In order for a tap fabric to "work", each unit of 6 warps X 3 wefts must be fully coordinated to provide the surface appearance while simultaneously creating a sound underlying support fabric. Designing at double the density, in other words having 2 design pixels representing a single 6 x 3 unit, will inevitably create defects in the fabric.

Setting the Aspect Ratio in JacqCAD allows you to view the design shapes as they will be woven. This is primarily important for helping you to make valid aesthetic decisions based on what you see on the display. It also comes into play when you constrain the oval or rectangle tools to create circles or squares - JacqCAD uses the Aspect Ratio you have specified to calculate the correct ratio of width to height.

Bringing it all together:

1) Each construction has specific horizontal and vertical condensation factors.
Some common examples include:
H x V : construction
1 x 1 : black warp against white weft
2 x 1 : two warp colors against single weft
1 x 2 : "pick & pick" playing 2 wefts against each other
1 x 3 : "pick, pick & pick" playing 3 wefts against each other
2 x 2 : "2 layer" afghan - 2 warp colors against 2 weft colors
2 x 3 : "2 1/2 D afghan" - 2 warp colors against 3 weft colors
6 x 3 : 6-color "tap" fabric - 6 warp colors, 3 wefts

2) It is crucial to design at the correct condensations - otherwise fabric defects are sure to occur.

3) It is important/helpful to design at the correct Aspect Ratio - so that the design's appearance is as you intended, and so that "circles" and "squares" are in fact circular rather than oval and square rather than rectangular.

4) the Aspect Ratio should match the finished fabric, i.e., off the loom and after all finishing processes are completed. Best practice is to weave a sample which uses the same construction, remove it from the loom, run it through the complete finishing process, and then measure and calculate the actual yarn densities.

5) the Aspect ratio must take into account the condensation factors.
given f_EPI, f_PPI = measured post-finishing Ends/inch and Picks/inch
given E_cond, P_cond = appropriate condensation factors for Ends and Picks
actual "pixel" density of condensed design =
c_EPI = f_EPI / E_cond   condensed horizontal pixels per inch
c_PPI = f_PPI / P_cond   condensed vertical pixels per inch
c_AR = c_EPI / c_PPI   aspect ratio to use in condensed design

Example:
loom set for 180 EPI and 90 PPI

measured off-loom finished sample shows:
finished width / on-loom width = 51” / 54” = 0.94 (= 6% shrinkage)
finished length / on-loom length = 33” / 37” = 0.89 (= 11% shrinkage)

calculated finished densities:
f_EPI = 180 / 0.94 = 191 finished Ends/inch
f_PPI = 90 / 0.80 = 112 finished Picks/inch

condensation:
fabric is 6-color tap, so 6:1 horizontal & 3:1 vertical condensations
c_EPI = f_EPI / E_cond = 191 / 6 = 31.8 condensed horizontal pixels/inch
c_PPI = f_PPI / P_cond = 112 / 3 = 37.3 condensed vertical pixels/inch

condensed Aspect Ratio:
c_AR = c_EPI / c_PPI = 31.8 / 37.3 = 0.85

calculating the size of the condensed design:

size of woven design (yarns):
9720 warp ends (54” at 180 EPI on loom)
3330 picks (37” at 90 PPI on loom)

condensation 6:1 horizontal (ends) X 3:1 vertical (picks):
9720 / 6 = 1620 design pixels wide
3330 / 3 = 1110 design pixels tall

so, the condensed design should be:

1620 wide X 1110 tall, set for 0.85 Aspect Ratio

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