How to calculate bag skirt patterns

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The bag skirt is a loop of material fitted to the Hovercraft that is inflated forming a tube around the machine, similar to the inner tube of a car tyre. This tube is inflated to a pressure slightly higher than the pressure in the plenum or air cushion, the volume beneath the machine.

The cross section of this bag is formed by two radii, the outer radius the part of the bag that is visible, and the inner radius which is exposed to the plenum.

The outer radius is determined from the ride height of the model, and the model base to deck dimension. The ride height is the distance between the base of the model and ground when hovering, usually between 1/8 and 1/10 the width of the model. Having calculated the ride height, add it to the base to deck dimension. The outer radius is this total divided by 2.

The inner radius is a function of the bag and plenum pressures, the graph shown in Fig 7 gives the relationship between, the ratio of the bag and plenum pressures, and the ratio of the outer and inner radii.

For the example calculations here, a ratio of 2:1 will be used, and the changeover point of the two radii is at an angle of 15 degrees in from the ground touch point. In this example the outer radius will be 50mm, so that with a ratio of 2:1, the inner radius will be 100mm.

The next requirement, is the angle of each segment. This is determined from the curve that the finished bag has to round, (a bit like an orange, if there are 20 segments then the angle of each segment is 18 degrees).

In this example a segment angle of 30 degrees will be used, 30 degrees divides into 90 degrees to give 3 segments for one corner, this works fine for corners with curves of 4 or 5 inches radius. However that’s not quite the full story, it actually requires two full segments and two half segments to make up the 90 degrees, this will be explained later when generating the end and the side panels.

There are a couple more requirements before calculations can be started,

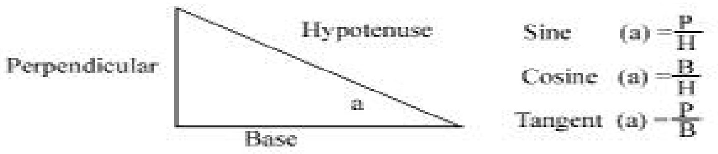
1) the attachment points, and
2) has to do with the practicalities when joining the panels. Sewing panels that terminate at a point can be a little cumbersome, it is much easier if the panels are truncated, i.e. they have a flat end.

For the purpose of these calculations, the inner attachment point will be at the same height as the centre of the outer curve, in this case 50mm from ground level, and the flat will be 10mm.

So a recap of the data : -

1) Outer radius R, 50mm
2) Inner radius R2, 100mm
3) Segment angle, 30 degrees
4) Change over point of the two radii, 15 degrees
5) Height of attachment point, 50mm.

Before starting the calculations it may be prudent to re-acquaint ourselves with the trigonometrical ratios, sine, cosine, and tangent, and the sum of the angles in a triangle is 180degs.



When referring to the figures the method for naming lines and angles is as follows, lines, curved or straight will use upper case letters, and angles will be in lower case letters, e.g. a line would be "A.B.C", and an angle would be "a.j.k ".

It is suggested that it would be helpful to take a look at the drawings before starting the calculations, familiarity with them will help when following the text.

The drawings Fig 1 and Fig 2

Because the second part of the calculation is rather cumbersome, that part will be scaled from the drawing, so make an accurate drawing of the skirt profile, as shown in Fig 1. Then draw Fig 2 below it.

1) Draw an arc radius "R", 50 mm in this case, from "A" at the top to "F" at the bottom, "F" is 15deg past the ground point.
2) Draw a line "M.K.F" from "F" through the centre of the arc, "K", at 15deg to the vertical "A.E" as shown in Fig 1. The centre of the inner arc must lie along this line in order that the two radii blend.
3) From point "F" mark the centre of the inner radius along this line "F.K.M", point "M", as the inner radius in this example is 100mm, its centre will fall on the outer arc at "M", now draw the inner arc from "F" to "J", its centre at "M".
4) Drawing Fig 2, start with a horizontal line "C.L" directly below Fig 1.
5) Now draw vertical lines from points "C" and "J" on Fig 1 to cross "C.L", this will be the plan view of the segment, see Fig 2. Positions around the skirt profile, Fig 1, can then be directly related to the segment.

One of the requirements for the pattern was that it should have a 10mm flat at the attachment point "J". Because of the truncation, it will be necessary to calculate where "L" is in relation to "J" on the line "C.L", "L" is the position where the segment would come to a point were it not truncated. Referring to Fig 2 it is the dimension of "J.L", and is half the length of the truncation, divided by the tangent of half the segment angle, the segment angle being 30deg in this example.

6) Length of "J.L" = 5 / tan 15 = 18.66mm. "L" is the centre point of the segment, analogous to the centre of rotation of the inner tube of a car tyre, and is positioned 18.66mm from "J".

7) Draw a line each side of “C.J”, from “L”, and at an angle equal to half the segment angle, 15degs for this example, as shown in Fig 2.

Corner patterns.

The next operation is to calculate the length of the pattern, it is the length of the outer arc plus the length of the inner arc.

1) The length of the outer arc “A.-E.F” is (180 +15)degs of a circle radius 50mm, which is “A.F” = 2 x pi x R x (“a.k.f’ / 360) = 170.17mm. “a.k.f’ is the angle of the outer arc.

Before the length of the inner arc can be calculated, it is necessary to calculate the angle “f.m.j”, to do this first calculate the length of “M.MM”.

2) “M.MM” is 50 (“M.K “) x sine75 (90-15) = 48.3mm,
3) Then calculate “m.j.k”, sine “m.j.k” = 48.3 (“M.MM”) / 100 (“M.J”) = 0.483.The angle whose sine is 0.483 is 28.9degs.
4) Now calculate “f.m.j”, “f.m.j” = 180 – 105 (“m.k.j”) – 28.9 (“m.j.k”) =46.1degs.
5) The length of the inner arc “F.G.H.J” is then 2 x 100 (“J.M”) x 3.147 x (46.1 / 360) = 80.46mm (arc “F.J”).
6) The total length of the pattern “A” to “J” will be 170.17 + 80.46 = 250.63mm.

Now calculate the length of arc of a number of points around the outer arc, “A.—.F”, starting from “A”. For this example 45deg increment’s have been chosen, except for “E.F”, which is a 15deg step. For larger skirts a greater number of points, smaller angular increments, would be better. Make a note of the following dimensions “A.B” “A.C” etc, they will be needed to plot the end and side pattern curves.

7) Length of arc “A.B” = 2 x pi x R x (“a.k.b” / 360) = 39.27mm. For 45degs.
8) Length of arc “A.C” = 2 x pi x R x (“a.k.c” / 360) = 78.54mm. For 90degs.
9) Length of arc “A.D” = 2 x pi x R x (“a.k.d” / 360) = 117.81mm. For 135degs
10) Length of arc “A.E” = 2 x pi x R x (“a.k.e” / 360) = 157.1mm. For 180degs.
11) Length of arc “A.F” = 2 x pi x R x (“a.k.f’ / 360) = 170.17mm. For 195degs.

Now calculate the length of arc of a number of points around the inner radius, “F.J”, starting from “F”. For this radius 15deg increments have been chosen, (except for “H.J”).

12) Length of arc “F.G” = 2 x pi x R2 x (“f.m.g” / 360) = 26.18mm. For 15degs.
13) Length of arc “F.H” = 2 x pi x R2 x (“f.m.h” / 360) = 52.36mm. For 30degs.
14) Length of arc “F.J” = 2 x pi x R2 x (“f.m.j” / 360) = 80.46mm. For 46.1degs, the attachment point.
15) Referring to Fig 3, draw a line 250.63mm long, label one end “A” and “J” at the other, this line represents the length of the pattern, excluding any requirement for the end fixings.
16) Starting from “A”, the points “B” to “H” can be positioned along this line, then at each position draw a line at 90degs, to “A.J” extending both sides.

The next step is to measure the co-ordinates from Fig 2 for each position, “A” to “J”, and then plot them at their relevant position on Fig 3, this will give the shape of the segment pattern, when the points are joined.

There are two ways to accomplish this, either by measuring each position, or by transferring the dimension using a compass, the compass is probably the quickest method. Make a note of the following dimensions “A.A1” “A.A2” etc, they will be needed to plot the end and side pattern curves.

17) Measure “A.A1” on Fig 2, transfer this dimension to “A.A1” on Fig 3, now measure “A.A2” on Fig 2 and transfer it’s dimension to “A.A2” on Fig 3, as this pattern is symmetrical check that these two dimensions have the same value.
18) Next on the outer arc is “B”, Fig 1, repeat the procedure with “B.B1” and “B.B2”, measure the dimension on Fig 2, then transfer the value to position “B” on Fig 3. Repeat the procedure for position “C”, with values for “C.C1” and “C.C2”.
19) The next position round the outer curve is “D”, “D” is directly below “B”, so the values will be the same as for “B”, “D.D1” = “B.B1” and “D.D2” = “B.B2”.
20) The next point “E”, the ground point, is directly below “A”, so the values will be the same as for “A”, “E.E1” = “A.A1” and “E.E2” = “A.A2”.
21) Repeat the procedure for the inner curve points, “F”, “G”, and “H”.
22) At position “J”, the decision was made to truncate the segment with a 10mm flat, so the dimension for “J.J1” and “J.J2” = 5mm, each being half of the 10mm.
23) Join the points with a smooth curve, use French curves, a flexible rule or the like. This is the shape of the segment pattern.
24) Allowances must now be added for the stitching, and fixing to the machine, this has been indicated by the black line around the pattern, the segment pattern is in blue.

End and side patterns.

Now only the end and side patterns are required to complete the skirt, to generate these patterns the dimensions for the width and length of the machine will be needed. Both use the same curve as the corner pattern at each side of the pattern, with a rectangular section in between, see Fig 4, this is where the two half corner patterns mentioned earlier come in, one end and one side.

For this example, a model 400mm wide by 800mm long is chosen, Fig 6 shows the complete layout of the skirt. Fig 5 shows the front Port corner, with the two half patterns. Fig 4 shows the pattern for the end and side segments, the only difference between them being the width of the rectangle. The points “X”, “Y” and “Z” Fig 6, are the same centre of the segment referred to as “L” in Fig 1, these points have been renamed to avoid confusion when referring to the position of point “L” in Fig 5 and Fig 6.

The ground contact point should be slightly to the inside of the outer edge of the model, and never outside the edge, for the sake of stability. In this example the ground contact point is positioned 10mm in from the edge of the model.

In order to produce a pattern for end or side segments it is necessary to calculate the distance between “Y” and “Z” for the end pattern, and “X” and “Y” for the side pattern, refer to Fig 6, and to do this it necessary to calculate “K.J”, see Fig 1. First calculate “MM.J” then “MM.K” and subtract to give “K.J”.

1) “MM.J” = “J.M” x cosine “m.j.mm” = 100 x cosine 28.9 = 87.54.
2) “MM.K” = “K.M” x cosine “m.k.mm” = 50 x cosine 75 = 12.94.
3) “K.J” =87.54 – 12.94 = 74.6
4) “Y.Z” = width of m/c 400 – (2 x 10) – (2 x 74.6) – (2 x 18.66) = 193.48mm

5) “X.Y” = length of m/c 800 – (2 x 10) – (2 x 74.6) – (2 x 18.66) = 593.48mm
6) To generate the end segment pattern, refer to Fig 4, first draw a rectangle 193.48mm by 250.63mm, the 250.63mm is the pattern length previously calculated for the corner pattern. Now use the same dimensions (co-ordinates) that were used to plot the corner pattern curve to generate the curve at each end of this, the end pattern, “A.A1” at point “A” etc, one side of the rectangle “A.A2” at point “A” etc, the other side of the rectangle.
7) The side segment pattern follows the same procedure as for the end pattern except that the starting rectangle will be 593.48mm by 250.63.
8) Having generated the patterns, allowances must now be added for the stitching, and fixing to the machine, make the same allowances as used for the corner pattern, this has been indicated by the black line around the pattern, the segment pattern is in blue.

One further point regarding the side patterns, they may be rather wide for the skirt material, it is permissible to cut the pattern, but remember to add the allowance for sewing to each part.

Base width, length and fixing

The base width and length depends on the method used to attach the skirt, two arrangements will be discussed.

The first method uses a clamp arrangement, where by the skirt is trapped between the base and a batten then secured with small screws. In this case the skirt pattern would need to be extended by an amount a few millimetres greater than the width of the batten. The base width would need to be the sum of “J.Y” + “Z.J” + the distance between “Y” and “Z”, and is, 18.66 + 193.48 +18.66 = 230.8mm. The length of the base would be 18.66 + 593.48 + 18.66 = 630.8mm, see Fig 6.

The second method uses a waterproof tape to hold the skirt to the base. In this case the extra material added to the pattern in the above method is not necessary, but an extra 10mm added all around the base does help when attaching the skirt. The width of the base would then be as above plus twice 10mm, 230.8 + (2 x 10) = 250.8, and the length would be 630.8 + (2 x 10) = 650.8mm. This is the method used by the author very successfully.

Deck fixing

Several methods have been used successfully,

1) a batten and clamp arrangement,
2) a contact adhesive such as “Evo-stik”,
3) double sided tape, and
4) Velcro.

Skirt material

One material used to make skirts is the material used to make kites, often called rip stop. It is a treated cloth and fairly lightweight. The other material used is tent liner, it is a little heavier than rip stop but much more durable.

The Calculator (notes)

A calculator has been generated using Microsoft Excel to automate the calculations, it does however require the information outlined in the sections “Corner patterns” on page 3, and “End and Side patterns” on page 4. These sections explain how the patterns are drawn.

The calculator has been designed to calculate bag skirt patterns, primarily for rectangular shaped Hovercraft, like the Griffon machines, 2000 TDX, etc. With a little ingenuity patterns for other machines, like the Bell SK5 for example, can be generated.

For those modellers new to model Hovercraft, some explanation on using the calculator may be required, in the main, where to obtain some data, and what values to use for other data. First, only cells in the spreadsheet that are coloured can be edited, those in green are fairly self explanatory, the others need a little more explanation.

Refer to page 1 of these notes to calculate a value for the outer radius, other information can be found under the appropriate heading.

Cells that are yellow, the plenum and bag pressures, start by weighing the model, in pounds for this calculator, then measure the plenum area, in square feet. The plenum pressure is the weight divided by the area, and will be in lb./sq.ft, to convert to inches of water dived by 5.17. The bag pressure is higher than the plenum pressure, and is usually in the range 1.2 to 1.8 times the plenum pressure.

The cell coloured blue, the ratio of the inner radius to the outer radius, its value is obtained from the graph Fig 7, and is a function of the bag and plenum pressures. If there is insufficient data for the bag and/or plenum pressures a good starting point would be to use a value of 3 in this cell.

A value of 3 is in the middle of practical working range, and is a more realistic value than that of 2, the value used for convenience in most documents for the calculations, the first section of this document being no exception.

One final point, should any of the calculations be a negative value, check that the input data is feasible. Segments with small angles and too much truncation will give negative values for the pattern rectangle width.