Spoked Motorcycle Wheel Building

The Wheel

Before doing any wheelwork, note the position of the rim in relation to the hub. Look at your bike with the wheels still on the bike. Check maker's specifications if you have them. Note which way around the wheels and hubs are in relation to the bike. Mark the rims and hubs so you will know which is the left side and which is the right side. Some wheels are symnetrical, but it is still good to fit them back on the way they came off. There maybe some other unforeseen reason why at a later date you wish you knew which way the wheels originally were. Take notes, draw pictures, take photos. It may be weeks, months or years before you get it all back together. Measure the offset of the rim to various bits on your bike. Swing arm, forks, shocks etc.
Make notes. You can use this information to double check everything after final assembly. Take the wheels off the bike and measure rim offset in relation to the hub. Use a straight edge across the rim to measure to the datum on the hub or a straight edge across the hub to measure to the rim. Draw pictures of spoke patterns. Use a datum point like the face on the hub that the disc or sprocket sits against. If the hub is a brake drum hub, then use the edge of the brake drum opening. Take notes on how the wheel appears before you pull it apart. Note what you used for a datum surface. Match mark the parts as you disassemble them. Small centre punch marks are unnoticeable to anyone else but you. Make notes or drawings of where you match marked the parts. Draw colour schemes or pin striping details. This sort of preparation and detail will save you a lot of headaches later on.

The Hub:

Wire spoked wheels have a metal hub with wire spokes passing through holes either directly in the hub or flanges on the hub then running outwards radially or tangentially to the rim where they pass through holes drilled into the rim. Some hubs may not have flanges. Like the later Matchless or BMW. These hubs are drilled to allow straight pull spokes to go straight through the extreme ends of the hub. Flanges can be out at something like 45 degrees to the axle like on some Harley Davidson's and trail bikes or the flanges can be at right angles to the axle as on most bicycles and motorcycles. However no matter what the attaching point on the hub, the spokes must be made with a head angle and head length to suit that particular hub/flange design.

Rims:

Rims are usually a flat steel or aluminium strip rolled into shape with the ends butt welded together. Basically this flat strip has flanges rolled up on each side to keep the tyre on and a valley around the centre to give strength and rigidity to the rim and help ease the tyre onto and off the rim at tyre change time. The depth of this valley makes a huge difference to the ease of tyre changing. The deeper the valley, the easier it is to change a tyre. The cross sectional shape, made up of the rim flanges, the rim and the valley all work together to give the rim strength. Inside the rim should be clean and free from rust and corrosion. This should be checked and cleaned every tyre change. There should be a rubber rim band fitted in the valley covering the nipples to give protection to the tube. The quality of the rim is in the material used and the roundness, trueness and welding. Some poorer quality rims have a very obvious weld and a definite flat spot right on the weld where they haven't been properly re-rolled. A pain when it comes to truing up the wheel. Rims can be bought in various materials such as unpainted steel, chromed steel, aluminium alloy and stainless steel. Flat spots, buckles and twists may be able to be pulled out of bicycle rims by pulling with spoke tension however motorcycle rims are very much stronger and it's been my experience that trying to do this on a motorcycle rim is generally a waste of time. It may be possible to move the rim a small amount, but the payoff is over tensioning of some of the spokes, which results in uneven load

sharing by other spokes causing spokes to continually come loose or break. Take the wheel apart and get the rim re-rolled or simply replace the rim.

The rim valleys have dimples pressed into them for every spoke. On most wheels the dimples are offset off the centre line of the rim, half to one side, the other half to the other side. The dimples are equally spaced apart around the rim. The dimples are to recess the nipple and give a hemispherical surface so spoke holes can be drilled at the correct spoke angle to suit the hub. If these holes are not drilled at the correct angle, you will notice the spokes will be bowed when the wheel is assembled and tightened. These spokes will break in service. Make sure the hole angles are correct! Some rims have the spokes going to the hub flanges from holes drilled on the same side of the rim, some rims have the spokes going to the hub flanges from holes drilled on opposite sides of the rim. That is, from left side of rim to left hub flange, right side of rim to right hub flange. While others go from left side of rim to right hub flange, right side of rim to left hub flange. An example of the latter is the disc brake wheel on the front of a Norton Commando. All should be revealed on proper examination of the bits. If in doubt, look for maker's specs or look at other similar makes of bike.

Rim orientation:

If you are building a wheel from scratch, you will have to lay the rim down on a bench and have a good look at it. The holes around the rim are drilled slightly offset to the centreline of the rim and should be drilled on such an angle so when fitted, the spoke will look directly at it's correct hole location in the hub flange.

Check that you have the rim the right way around to suit your hub. For asymmetrical hubs like Triumph conical hubs or hubs such as the front disc brake wheel on a Norton Commando that have a dramatic offset, you can get a good idea of which side of the rim will go to which side of the hub, by putting a couple of nipples through a couple of spoke holes, screwing spokes into them and holding the nipples firmly in the rim holes with finger pressure. The spokes will stick out at whatever angle the holes were drilled. You should be able to get an idea of hub flange position if the holes in the rim have been drilled at the correct angle, this should be indicated by the direction of the spoke and it should become obvious which way the rim should face for the spokes to connect up with the hub flanges when all is in the correct place.

You now need to look at the spoke holes adjacent to the valve hole. Basically, with the rim lying flat on a bench, valve hole to the top, every second hole should look up and every other hole should look down. Look at the two holes immediately each side of the valve hole and note which hole looks up and which hole looks down. Rims can be drilled either way, with the hole to the left or right of the valve hole being the hole that looks up. At the moment you are only interested in the hole that looks up. This will be your starting point for lacing the wheel. Remember this hole. You will need it later.

Spokes:

Spokes have a head on one end to stop them from being pulled through the hole in the hub flange and an adjustable threaded nipple on the other end that goes through the hole in the rim. Spokes can be straight pull-spokes such as on some BMW's and Matchless or the spokes will have a bend at the head so the spoke can go at an angle through the hub flange. The spokes need to have a head length to suit the hub flange thickness. They also could have a different head length depending if they are inside the flange or if they are outside the flange. The outside flange spokes have a longer distance to reach around to bring them into line with their corresponding rim hole. This means that for a symmetrical hub/rim assembly that has same diameter left and right hub flanges, there will be two different groups of spokes. One lot of spokes dimensioned for inside the

flange, and one lot of spokes dimensioned for outside the flange. The inside spokes may be shorter overall and have a shorter head length and an obtuse head angle, while the outside spokes may be longer overall and have a longer head length and a more acute head angle. If there is an offset between hub and rim, or the hub has unequal flange diameters, there will be a difference again between left and right inner and outer spokes. So there is a possibility that there could be four different spoke types for a particular wheel. Sometimes three different types, but mostly at least two different types. Be aware of this and make sure you have all the right spokes for the right wheel. Make sure you are familiar with which spokes go where at the time of lacing the wheel. Don't take it for granted that the spokes you have are the correct spokes.

Check your spokes against maker's specs if you can. Check your new spokes against the old ones if you are rebuilding a wheel with new spokes. Lay all the spokes out and put them into like groups. In a 40 hole rim there will always be look-alike groups of ten or multiples of ten. Compare, compare, compare. For example the Commando front disc wheel has ten outer left spokes, ten inner left spokes and twenty right hand spokes. Each group should be similar. You won't have 9 in one group and 11 in another, look again.

Spokes are usually cad plated steel. Stainless steel is a popular shiny material favoured by many for looks. Some people like to chrome spokes. Chroming can make the spoke material brittle. This is not such a good idea as spokes will 'work' in use and anything that works can suffer fatigue resulting in spoke breakage. Brittle spokes will not be as resistant to fatigue as standard spokes. The spoke nipple usually has a square on the shank to enable adjustment with a spoke wrench and a slot in the head for a screwdriver for faster running up or down. Sometimes the nipples have a dished washer under them. The threads on spokes are not normally cut with a die, but rolled into the spoke.

This is a more reliable method of thread creation on an item that is liable to suffer from fatigue. Rolling the threads into the material doesn't cut across the grain structures, but rolls the threads into the grain structure and is a stronger method of thread manufacture, it has less chance of developing a fatigue concentration point along the thread. The minor diameter of the thread on the spoke shank is the thinnest part of the spoke and the weakest link in the chain. Spokes will break at this point. Spokes will also break on the bend at the spoke head where the spoke goes through the hub flange. Some hub flanges have countersunk holes. This is not for the spoke head to sit in, like a counter sunk screw, but for the bend at the spoke head to sit in. If the bend sits against a square unchamfered edge of a drilled hole, the sharp square edge will work against the spoke and create a nick or fatigue point, which is usually where the spoke will break.

However, many wheels have only countersunk holes on the outside of the flanges. This is probably because the outside spokes have the sharpest bends in them, the spoke bend sitting hard in against the relief given by the hub flange hole countersinkings. The inner spokes, because of their direction inward toward the rim, start to leave the side of the hub flange hole as soon as the spoke exits the hole. Spokes can be the same thickness along their full length or they can be waisted toward the head end. Spokes are described in the following way as is in the factory Norton Commando manual. Rear outer: 6.093 in long: 8/10 SWG: 90 degree head: offset length .531 in. This gives the length of the spoke, the gauge at the narrow end and the gauge at the waisted end, spoke head angle and spoke head length.

Tensioning a spoke is usually done by feel or by ear. Typically a wheel is tuned like a piano, meaning the spokes are struck gently with another metal object like the spoke wrench, listening for the pitch or note given by the spoke. The spoke should have a nice "ding" sound, not a dull "thud" or sharp "ping". A spoke that touches another spoke will not ring clearly, by bearing a litte weight on the other spoke you can get it out of the way in order to listen to the "ping". There are torque figures and spoke torque wrenches, but these are not often used. It is easy to get false readings on the torque wrench unless all the spoke nipples are in excellent order. The slightest sticking of a

nipple could give a false reading. The best, quickest and most accurate method is the tuning method. Just to give an idea, the torque figure listed in a Honda Gold Wing manual for spoke adjustment is 17-38 in/lbs (2 - 4.5 Nm) The spoke and nipple threads should be coated in an anti seize compound to help with tensioning and later adjustment or disassembly. The threaded end of the spoke gets all the weather, goes through all the puddles and needs lots of looking after. Be careful tensioning spokes on a brake drum. Over tensioning can pull the drum out of round. Check the drum for trueness after you have finished building the wheel.

Only cut out the old spokes if the nipples are frozen solid. Pulling the spokes out will give the first timer a chance to get familiar with the spoke pattern. Also gives some time to look over everything and put some thought into the job. If the spokes are in reasonable condition, they can be used again. If replacing the spokes with new ones, the old ones can always be kept as spares. If you know they are the right spokes as per maker's specs, then they should be kept as samples. The new ones you get may not be right! Don't destroy things unless you have too. Mixing spokes of different gauge can give problems in tensioning and load sharing. Thicker spokes will share the load easier than thinner ones. Loose or broken spokes may result in this practice.

There are several different methods or patterns of spoking that can be used on spoked wheels. Eg., Radial, Crows Foot and Cross or Tangential spoking. Most motorcycle wheels use the Cross or Tangential pattern of spoking, where pairs of spokes form a series of crosses around each side of the wheel. In this pattern the spokes come on a tangent from the hub to the rim. This pattern is stronger and much more rigid than the other two patterns and is able to transmit torque which is the forces of power delivery and braking from the hub to the rim/tyre/road much more effectively without danger of the hub twisting out of the spokes/rim. It is also better able to transmit the impact forces of the wheel striking bumps in the road, back to the suspension. The loads are carried through a larger number of spokes than the other patterns.

Wheels with the Cross or Tangential spoke pattern will always have an even number of spokes. For example, most British wheels use 40 spokes. They use the Tangential pattern of spoking. Japanese maker's also use the Tangential pattern, but mostly choose to use 36 spokes. Once again, an even number. Crows Foot pattern uses a combination of Tangential spoking and Radial spoking. The cross pattern is used, but there is one radial spoke going straight from hub to rim, right through the middle of the cross. This pattern uses groups of three spokes and so will have an odd number of holes around rim and hub. If you find a rim at a swap meet with an odd number of holes, this is most likely why. So check the number of holes in your rim.

Dimples are pressed around the valley of the rim equal distances apart, but every second hole will be off centre to one side, the other holes will be off centre to the other side of the rim. To drill the holes in the dimples for the spokes the correct angle must be used. It is very important that this angle is calculated and drilled correctly because it will determine if the nipple will sit true and straight and be absolutely in line with it's corresponding hole in the hub flange when all is together and tightened up. These holes will not necessarily have the same angles for left and right side of the wheel as the hub may not be central inside the rim, or the hub may have different diameter flanges as is the case with Triumph conical hubs and most early hubs that did not have a full width brake drum. So it's very important to have a rim with the spoke holes drilled at the correct angle and it is very important to know which way around the rim goes in relation to the hub so the right spoke angles match up with the corresponding hub flange diameter.

Lacing up a Wheel

Step One: Place the hub on a bench top in front of you or hold the hub in one hand flanges horizontal. Remembering that you could have four different sets of spokes, decide which spokes are for INSIDE the top flange as the hub appears in front of you. Holding the correct spokes in the other hand, start sticking a spoke down every other hole around the top flange. These spokes will be inside spokes.

IMPORTANT BIT: Now is when you check which holes lead and which holes follow. Still with the hub in front of you the same as when you started. Do not turn it over. Look straight down over the hub. Look straight vertically past a spoke hole on the top flange that you have just put a spoke into. Looking down onto the bottom flange, you will notice the holes in the bottom flange are not directly under the holes in the top flange. They are midway between them. Now remember back to when you looked at the holes in the rim each side of the valve. If your rim had the looking up spoke hole to the left of the valve hole in the rim, go to the next hole in the bottom hub flange immediately counter clockwise back from a hole in the top flange that you have just put a spoke into and with the correct spokes for OUTSIDE the bottom flange, start here and stick a spoke through every other hole around the bottom flange. OR if your rim had the looking up spoke hole to the right of the valve hole in the rim, go to the next hole in the bottom hub flange immediately clockwise back from a hole in the top flange that you have just put a spoke into and with the correct spokes for OUTSIDE the bottom flange, start here and stick a spoke through every other hole around the bottom flange. This bit can be quite tricky if you have hub flanges of very different diameters. You may have to go over it a couple of times to make sure you have the spokes in the correct holes. Now you should still have the hub in front of you with flanges still horizontal and twenty or so spokes hanging straight down.

Step two: Still with the hub in front of you the same as when you started, sweep all the spokes back around both flanges so they are in two bundles (top and bottom) Hold them so they don't fall out and turn the hub over. Repeat step one with the rest of the spokes, making sure you have the correct spokes in the correct flanges. Go around the top flange first, sticking the INSIDE spokes down through the flange from the outside, then around the bottom flange, sticking the OUTSIDE spokes down through the bottom flange from the inside, ending up in the correct direction (inner or outer) phew! Now you should have a hub with 40 or so spokes in it. Looking down onto the hub you should have every other hole alternating between a spoke head and a spoke shaft on each side of both hub flanges.

Step Three With the hub laying on a bench top and all spokes extended outwards radially, sweep all the spokes around so they are bundled together in one spot. Place the wheel rim over the hub, roughly in it's position valve hole to the top or furthest away from you. If your re-using your old rim, lay the rim over the hub keeping the same direction of rotation as it was before you pulled the wheel apart. Look up your notes, drawings and photos if you have to. If it's a new wheel build, make sure the rim is around the right way for the spoke angles in the rim holes matching up to whatever hub you have. Offset or unequal hub flange diameters. (You can establish this by checking spoke angles as per the rim orientation paragraph above.) Take any head up spoke from the top flange (spoke head up means the spoke head is facing upwards, with the spoke inside the flange) and put it in the first looking up hole adjacent to the valve hole. Remember, you established this earlier on, so you should be right now!! Use anti seize on the threads. Thread a nipple only four turns on each spoke as you lace it into the rim.

Step Four: Count off five spoke holes to the right, including the hole you spoked in step three. This must also be a looking up hole. Into this put the next head up spoke to the right of the one you spoked in step three. Continue this sequence until you have laced up all the head-up (inside) spokes in the top hub flange. The wheel will now have ten spokes in holes with three spoke holes between each spoke. The centre of the three empty holes will be a looking up hole, the other two, looking down holes.

Step Five: This is a critical step, so take it slowly and repeat it if you don't get it at first. Take the partially spoked rim and hub, and, keeping the same side up, rotate the rim so the spokes are at an acute angle. Because of the spoke angles drilled in the rim, it will be immediately obvious if you go in the wrong direction. Depending on how the rim has been drilled (angle of the holes in the rim) rotate the rim left or right. Hold the hub as you rotate the rim.

Step Six: Another critical step. Take any head down (outside) spoke from the top hub flange (The wheel should not have been turned over!!!) and going in the opposite direction from the spokes laced so far, cross over the top of the other spokes and stick it in the remaining looking up hole. Thread a nipple on it four turns. This spoke should have gone into the middle remaining hole. Continue lacing all the head down (outside) spokes in the top flange. When you are finished there will be twenty spokes in groups of twos.

Step Seven: This is a most critical step. Turn the wheel over. Now, all the unlaced spokes will be in the top flange. Straighten spokes out and sweep them all out of the way. Things should look like they will now fall into place as these remaining spokes will only go into their rightful holes. Start with the head up (inside spokes) spokes on the now top hub flange. They will only go into one set of holes. Stick them in their holes and thread their nipples on four turns. Next do all the head down spokes crossing them over the outside of the spokes you have already laced and thread their nipples on four turns. While motorcycle spokes cross other spokes one, two or three times, they shouldn't weave in and out of one another like on bicycles. Bicycles spokes are much longer and thinner.

How to True a wheel:

Step One: Put your wheel into your jig. Your jig can be a pretty flash purpose made professional expensive things or can be a simple homemade stand. Something like an old swing arm clamped vertically in a vice will do. You don't need to use the wheel's own axle if it doesn't fit the jig. Any round bar that fits will do. The wheel rotates on the bearings, not the axle. It is handy to have some spacers each side of the wheel to stop it moving side to side while tightening or loosening spokes. Nuts and washers will do. You will need some form of pointer to check radial and axial runout. A black felt tipped pen is a good idea as well. Use a dial gauge only to check your final alignment. Get a comfy stool like a bar stool and sit it in front of the jig, have a cuppa handy and start work.

Step Two: Using a screwdriver and starting at the valve hole go around the wheel and screw all the nipples down so the last spoke thread just disappears under the nipple and stop. Adjust radial runout first. Side to side wobble comes last. Once the wheel is more or less within 6mm or so radial runout, start on sideways runout. Get this down to about 6mm as well. Check radial again. Don't tighten the spokes!

Step Three: Now we must look at rim off set. You'll find that if the spokes are original parts, or they have been correctly made by aftermarket people, the rim should have come somewhere near it's correct position. Go back to your notes or manufacturers specifications and see what the rim offset should be. Using the same method of measuring as you did before you stripped the wheel measure the offset of the rim as it is now and make a decision on which way it should go to be correct. Now tighten up whichever side spokes need tightening to move the rim in the desired direction. Don't do any spokes up too tight. Move your rim into position with the spokes not very much more than finger tight. Once the rim is in it's correct position, get out the felt pen and true the rim again. Holding the pen firmly against your jig, rotate the wheel and move the pen tip toward the rim. As the rim rotates the runout will contact the tip leaving a long black mark around the rim. This gives a clear indication of which way and where the rim needs to be adjusted. Adjust the spokes, wipe off the black mark and do it again. Check offset, check radial runout, then check axil runout

Do this enough times until you are happy with your work, then gradually go around tightening the spokes. They don't need to be death tight. There are lots of them and they all need to share the work equally. As you rotate the wheel strike the spokes lightly with you spanner. They should start to give a nice crisp 'ding' not a dull 'thud' or an over tightened 'ping'. Get a soft-faced mallet and go around the wheel and give every spoke a light wack. This will settle the spokes, one might have been tightened up with a slight bow in it. A gentle knock with the hammer will spring it into line and

it will now probably have a dull thud to it when struck with your tuning spanner. By now the wheel should be pretty close to being right. Keep checking offset, checking radial runout, and checking axil runout

Time for a cuppa or a beer. Come back later after the nerves have settled, run around it with the tuning spanner, ding, ding, dong, ding and give it that final touch…….. Should be pretty right after all that.

Finishing

If your keen enough, you can now check your work with a dial gauge. Most motorcycle manuals specify a maximum runout figure of 2mm or .080 in. You should easily get a new rim well under 1mm or .040 in. An old re-laced rim would still come somewhere near 1 mm or .040 in unless it had a bit of a woof in it. Put the rim band on, fit your tyre and make sure the bead sits down properly and you have correct air pressure. Put the fully assembled wheel back up in your jig and give it a slow spin and see how it goes for balance. Static balancing a wheel is another easy job that makes a lot of difference to the performance of the bike. You can buy proper wheel weights that either stick onto the rim or clamp around the spoke. You can cut strips of lead and wrap them around the spokes or cut strips of lead and stick them to the rim with silicon.

Spin the wheel slowly and wait for it to come to rest. Mark the top of the tyre with chalk. Spin the wheel slowly again and see if it stops in the same place. Add some lead weight to the top of the wheel by wrapping it around a spoke or by taping it to the rim. Spin the wheel again. Repeat this and add or subtract weights until the wheel takes a long time to stop turning and will stop in any position. Fix the lead weights properly to the rim. If you wrap strips of lead around the spokes, wrap electricians tape or similar around the windings. Stick the strips to the rims with silicon and tape over the weights until the silicon has set. Fit wheel to bike.

All there is to it really…….