Here's angle on frame geometry

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Racing bicycle design

Continuing my series on racing bicycle design, this month I will discuss the seat and head frame angles. I'll start with the seat angle and how it affects your riding position.

English framebuilders always talk of the seat angle, which is the angle formed by the intersection of the top tube and the seat tube, whereas framebuilders in other European countries talk of the distance of the seat lug behind the bottom bracket. Both amount to the same thing, but I prefer to talk of angles. Then if we say a seat angle is 73 degrees, that angle remains the same whatever the frame size. But if we talk of the distance of the seat lug behind the bottom bracket, then even if the angle remains constant the distance increases as the frames get bigger, giving us many different measurements to memorize for just one angle.

I often hear people say things like, "73 degrees parallel is best for the road," and then add something like, "If it's good enough for Eddy Merckx it should be good enough for anyone." Well, fine...if you are built like Eddy Merckx, about six feet tall with long legs and a short body. If so, you are one one of the lucky ones who can get on most any stock racing frame and feel comfortable.

However, the shorter rider will want a frame with a steeper seat angle. With shorter thighs it is necessary to sit farther forward to get the knee directly over the pedals when thrusting downward. Also, a steeper seat angle allows for a shorter top tube, ensuring that a small rider's arms are not stretched out too far in front.

Riding the Tip

How often do you see riders sitting on the front tip of their saddles when making a maximum effort? This is because the body takes up a "natural" position where it can do the job most efficiently; that is, with the arms in direct opposition to the legs.

If, for example, you ride the pursuit on the track and for the duration of the race are on the tip of the saddle, surely it makes sense to have a frame with a steepened seat angle so the saddle is forward. Beside being uncomfortable, sitting on the tip has the effect of making the saddle too low, creating an inefficient position.

To explain further this business of getting the arms in opposition to the legs, imagine rowing a boat. You sit with your legs out in front of you, thrusting in opposition to the pull of your arms. You would not sit with your legs thrusting vertically downward and your arms pulling horizontally, because apart from needing a very deep boat this would be inefficient.

Cycling is not unlike rowing, except that it is the arms which remain stationary and the legs which thrust. So if the arms are pulling horizontally as the legs move vertically, it is inefficient and backache will probably occur.

Arm Position Important

The trouble is that many cyclists do not realize how much work their arms and upper bodies are doing. Look at photos of top riders and see the location and definition of muscle on their arms, shoulders and backs. Most did not get this way from weight training in the off season. In fact, you can learn a lot from studying photos of riders, especially good side-on shots. See how a line from the shoulder to the hands corresponds to a line from the hip to the foot as the leg thrusts downward.

As I said earlier, a 73 degree seat angle is ideal for the taller rider using a frame of 23 inches or bigger. Generally speaking, I steepen the seat angle by one degree for every inch reduction in frame size, thus a 22-inch frame will have a 74 degree seat angle, 21-inch will have 75 degrees, 20-inch and under will have 76 degrees.

What if a rider has a very long or very short thigh length—should the seat angle be altered from the above? Not necessarily.

Seat angle can be linked with leg length and therefore frame size, rather than thigh length. The reason for this is shown in Figure 1. Two riders, A and B, have identical leg length and therefore use the same size frame. One rider has a longer thigh than the other (it follows that his lower leg is shorter) but the diagram shows that there is very little difference in the position of each rider's knee over the pedal on the downward stroke.

Top Tube Length

As for top tube lengths, frames in the middle size range are built "square." That is, the top tube when measured center to center is the same length as the seat tube (frame size).

Large frames have top tubes shorter than seat tubes; conversely, very small frames have top tubes longer than seat tubes. This has to be done to keep the overall wheelbase within reasonable limits, but works out very well in other regards. Because the very tall person has long legs in relation to his body length, the rider of a 24-inch frame does not need a 24-inch top tube (something in the region of 22.5 inches would probably be ideal). In fact, I would go as far as to say that no frame over 21 inches should have a top tube longer than its seat tube.

The key to getting an efficient position is the short top tube, allowing the rider to keep his hands as close to the body and legs as is practical, bearing in mind comfort and bike control. A good aerodynamic position is achieved by having the handlebars low in relation to the saddle, which stresses the importance of not having a frame which is too big.

Beware of Tradition

I said at the end of last month's article that, "Tradition has done much to hamper progress." Tradition has it that the seat angle is shallower than the head angle. Of course, this results in the seat tube "leaning" backwards and the head tube forwards, making for a long top tube.

About three years ago I received an order from Vancouver B.C., Canada, for six track frames. The design requested was for 73 degree seat angles and 75 degree head angles on sizes that ranged from 22 to 24 inches with top tubes of 23 to 24 inches. I suspected that the frame sizes were too big for the individual customers, but I could not verify this as I did not have their personal measurements. Ultimately I refused to build the frames to these specifications, as I knew they would be totally unsuitable.

I later received a telephone call from one of the customers, who insisted that the specifications were right, having been designed by the coach. I tried to explain that they were some 20 years out of date, but it was not easy to make my point of view understood via a transatlantic telephone line and the order was cancelled. I could, of course, have taken their money and built the frames to their specifications, but I felt my reputation as a framebuilder was worth more. If any of these customers read these articles I hope they will now understand my actions.

Head Angle and Steering

Later in this series I will summarize the various angles and tube lengths in the form of a table. But now I will move on to the head angle, which does not directly affect the rider's position but nevertheless is very important to handling, cornering, and how the bike feels when ridden.

For road frames I generally make the head angle 73 degrees with a fork rake of 1.25 inches. This is constant throughout the range of sizes, because this combination gives ideal handling characteristics for general road work. Some framebuilders argue that the head angle should vary with the size of the frame, but I feel that they are probably doing this to shorten the wheelbase rather than add anything to the bike's handling.

Look at Figure 2. You will see that a line drawn through the center of the head tube meets the ground at a point B, which is in front of point A, the point where the wheel contacts the ground. The difference between A and B is known as the "trail."

The trail is essential because it provides a caster action which keeps the bicycle going in a straight line as well as self steering, allowing the machine to be steered by leaning into corners. When the rider leans to the left the head tube moves to the left, and so does the wheel at point B. The tire on the road at point A acts as a pivot and so the wheel turns to the left. When the rider moves himself upright the bicycle straightens, assisted by the caster action.

On 'Trail' to Handling

You can see from Figure 2 that a steeper head angle means less trail because point B moves closer to point A. By the same rule, a longer fork rake also means less trail. So the worst possible combination is a steep head angle and a long fork rake, which results in little or no trail. You could even get to the stage where point A is in front of point B, causing a "positive" trail which would be unridable—when you leaned to the left the bike would steer to the right!

(Incidentally, this is why motor pace or stayer bicycles have the forks turned the "wrong way." A very steep head angle is necessary to get the cyclist close behind the motorcycle, and the forks have to be raked backwards to keep a "negative" trail.)

Getting back to the road racing cycle, correct trail gives "oversteer" which means the bicycle takes a corner right. Not enough trail means "understeer" which causes you to corner wide, losing time and possibly ending up on the wrong side of the road facing oncoming traffic. Too much trail means the bicycle feels unstable when you are out of the saddle. So we have to compromise and I find that a 73 degree head angle and 1.25 inch fork rake gives just the right trail. The slight oversteer counteracts the centrifugal force when cornering and allows the rider to keep a good line.