Now that technology allows us to accurately measure the factors that affect ball reaction, differential ratio has emerged as a very significant force in determining the motion of a drilled bowling ball. The differential ratio of the drilled ball is the most significant factor that affects the shape of the ball’s motion.

Differential ratio is defined as the intermediate differential divided by the total differential. Before discussing the effect of differential ratio on ball reaction, let’s review the three phases of ball motion. The Ball Motion Task Force, which consisted of the USBC Equipment and Specifications Department and the ball manufacturers, used CATS to perform graphical analyses to accurately measure the resulting ball motion when a drilled ball was thrown by an automatic ball throwing machine on a lane with a 53 foot flat oil pattern.

The analyses showed the three phases of ball motion for each ball tested. The USBC received accolades from the scientific community in the form of an ASQ award for the detail and accuracy of this study. Congratulations to them for that. It’s a feather in the bowling industry’s cap. That award reinforces the credibility of the USBC study.

What is bowling ball motion, really?

It is now time to accurately explain bowling ball motion. A bowler imparts four forces to the ball at delivery. They are: 1) the initial ball speed; 2) the initial rev rate; 3) the initial axis tilt; and 4) the initial axis rotation. Those factors, plus the location of the PAP, are the only factors necessary to know for

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an automatic ball thrower to duplicate a bowler’s delivery during ball motion testing.

As the ball travels down the lane, it passes through three phases and two transitions.

1. the skid phase
2. the first transition from skid to hook
3. the hook phase
4. the second transition from hook to roll
5. the roll phase

The diagram of ball motion looks like this:

During the skid phase, the force from the ball speed exceeds the force from the rev rate. As the ball travels down the lane, the friction between the ball and the lane reduces the ball’s speed and increases the ball’s rev rate. When the forces from the ball speed and the rev rate become equal, the ball transitions (that’s the first transition) into the hook phase.

In the hook phase, the force from the ball’s rev rate exceeds the force from its speed. During the skid and hook phases, the ball’s axis rotation always exceeds its axis tilt. The ball will lose axis rotation faster than it loses axis tilt during the skid and hook phases.

When the axis rotation and axis tilt become equal, the ball will transition (the second transition) into the roll phase. Once the ball enters the roll phase, it will no longer hook and the axis rotation will always equal the axis tilt.

The axis rotation and axis tilt will decrease slowly as the ball travels down the lane during the roll phase. The bowling ball will reach its maximum rev rate at the second transition. The ball’s rev rate will always be less in the skid and hook phases than it is in the roll phase. That’s why a bowling ball always hits harder after it stops hooking (the roll phase) than it does when it is still hooking (the hook phase).

Once the ball reaches its entry angle at the second transition, that entry angle will remain the same until the ball hits the pins. This is a scientifically accurate description of bowling ball motion.

There is one more fact that must be mentioned before discussing all the factors that affect the shape of the drilled ball’s motion. To me, it is very obvious that we are only concerned with drilled bowling balls. No one cares how undrilled balls roll. It has been proven that all drilled bowling balls are asymmetrical, whether they are symmetrical or asymmetrical before drilling.

To be considered asymmetrical, a bowling ball must have a measurable intermediate differential and a Preferred Spin Axis (PSA). All drilled bowling balls have both those measurable properties. All this information was verified during the Ball Motion Study. In reality, the intermediate differential is the measure of a bowling ball’s degree of asymmetry.

**How is ball motion affected?**

Now, for the nitty gritty of this article. According to the study, ball motion is affected by coverstock, mass properties (ball dynamics), and static weight balance. The study proved that the most important factor in determining ball
motion is coverstock. Next in importance are the mass properties of the ball, followed by the least important factor, the ball’s static weight balance.

I will be expressing the mass properties in this article in terms of RG, total differential, and differential ratio. Remember, differential ratio is defined as the intermediate differential divided by the total differential. Diff ratio is expressed as a decimal. The larger the diff ratio, the more asymmetrical the bowling ball. Conversely, the smaller the diff ratio, the less asymmetrical the ball.

Coverstock aggressiveness (chemistry plus surface texture), RG, and total differential all have similar effects on a drilled ball’s motion. They all affect the location of the first transition on the lane to various degrees. In plain words, they determine how soon a ball starts up on a given lane condition. As the study showed, the coverstock of the ball has the most impact followed by the RG and the total differential of the ball. My latest research now shows that those factors have very little effect on the shape of the ball’s motion after the first transition.

The most important factor in determining the shape of a drilled ball’s motion is differential ratio. It will determine the length of the hook zone, which determines the location of the second transition on the lane, once the first transition has been determined by the ball’s coverstock, RG, and total differential.

You may ask, “Exactly how does this affect a drilled bowling ball’s motion?” The diff ratio affects the ability of lane friction to steer the ball and pin carry. WOW! Those are the two most important factors in scoring!

Diff ratio affects both the bowler’s margin for error on any given lane condition and the bowler’s strike percentage. That seems very important to me. It doesn’t mean that we always want the maximum diff ratio possible. On flatter oil patterns where there is less friction on the lane to steer the ball, larger diff ratios are very beneficial. For bowlers who are speed dominant or have less hand, larger diff ratios are also very beneficial. On oil patterns with bigger crosswise blends (much more oil in the center of the lane compared to the outside boards of the lane like typical house shots), smaller diff ratios are preferred. Smaller diff ratios are usually preferred by bowlers who are rev dominant or have more hand.

The diff ratio of a drilled bowling ball is determined by the design of the ball and the drilling technique used. The drilling technique consists of the layout and the balance hole location and size (if one is used). In my experience, the layout created by the drilling technique is about 40 percent of ball reaction while the balance hole location and size are 60 percent of the reaction. I have also observed that a ball’s designed reaction may be reduced by as much as 29 percent or increased by as much as 55 percent by the drilling technique used on that ball. Again, WOW!

**So what?**

Now we get to the real purpose of this article: how you use this knowledge of differential ratio to benefit your bowling. Knowledge of diff ratio has two benefits. Choosing the correct ball to drill and then choosing the correct drilling technique for that ball provides the bowler with the best possible drilled ball for the conditions for which the ball is being drilled.

The first decision to be made is to choose the ball that will provide the ball motion desired. Then the drilling technique has to be chosen to lock in the desired reaction. The drilling technique consists of the layout and the balance hole location and size (if a balance hole is desired).

Obviously, the coverstock is a major factor in choosing the right ball. After deciding on a cover, the next decision to be made concerns a symmetrical or asymmetrical ball. Symmetrical balls yield drilled balls with smaller differential ratios. This will produce a drilled ball with a smoother, more controllable motion when compared to an undrilled asymmetrical ball.
Varying degrees of longer transitioning (longer hook zone) ball motion can be obtained by choosing to drill a symmetrical ball. The degree of control and continuation that the drilled ball will have depends on the exact ball chosen. You’ll need to rely on a knowledgeable ball driller to help you make that decision.

Asymmetrical balls yield drilled balls with more defined, more angular breakpoints. These balls can create more area at the breakpoint and will respond to friction at the breakpoint faster. Again, there are a wide variety of ball motions available from asymmetrical balls by choosing different covers and balls with different diff ratios, total diffs, and RGs.

Finally, the drilling technique for the drilled ball must be chosen to guarantee the exact ball reaction for that bowler. Drilling techniques will result in the drilled ball having a wide range of diff ratios and total diffs. I refer back to a previous statement made in this article. A designed ball’s reaction may be reduced by as much as 29 percent or increased by as much as 55 percent by the drilling technique used on that ball. That fact should emphasize the importance of choosing the correct drilling technique.

Detailed information on drilling techniques may be obtained by reading the technical articles listed on the home page at www.morichbowling.com. Discussions or questions about all technical issues can be handled by logging on to www.forum.bowlingchat.net and getting involved there. Technical bowling subjects are discussed on ‘bowlingchat’ daily.

Examples of the diff ratios and diffs can be achieved by choosing different drilling techniques.

Looking at the charts of the two different layouts, you can see how much difference there is in diff ratios and diffs between the two layouts with different balance hole locations. I chose to use the MoRich RipR for these charts because I have all the information on this ball available to me. The specifications for an undrilled RipR are: diff ratio of .25, intermediate diff of .013 inches, and total diff of .042 inches.

Notice that by changing the chosen drilling technique, we can end up with drilled balls with diff ratios from .21 to .60, intermediate diffs from .008 inches to .037 inches, and total diffs from .037 inches to .061 inches. I hate to repeat myself, but WOW!

By understanding the importance of differential ratio to the resulting reaction of a drilled ball, bowlers have a much better chance of getting the ball reaction they desire out of a new ball. Good decisions in choosing the correct ball and the correct drilling technique make it much easier for bowlers to enjoy their new ball and make sure they are getting the desired results from that ball. Knowing how much these decisions play in the resulting ball reaction is why I say, “Once an oil pattern is applied to the lanes, the decisions made by the ball driller are the single most important factor in how much a bowler enjoys bowling on that lane condition.” Make good decisions and enjoy!