

ENGINEERING REPORT

Subject: RG and Differential RG Study- Retest

Date: 9/24/15

Place: International Training & Research Center

Present: Dan Speranza

Purpose: Rerun the RG, differential RG study test to confirm results.

Summary: This was a retest of the RG differential RG study previously conducted to confirm the results. While the absolute values from some of the test results for (1) boards of hook, (2) total angle change and (3) breakpoint location changed, the general trend remained the same. But, some of the absolute values of the results might be more in line with bowlers' perceptions.

Data: The RG and differential RG study was to vary the RG and differential RG within the spec range and measure the difference using E.A.R.L. and BOLTS. Below are the RG and differential RG test parameters:

- RG- 2.48, 2.72, and 2.58 (center point)
- Differential RG- .005, .060 and .035 (center point)

Three response properties were measured:

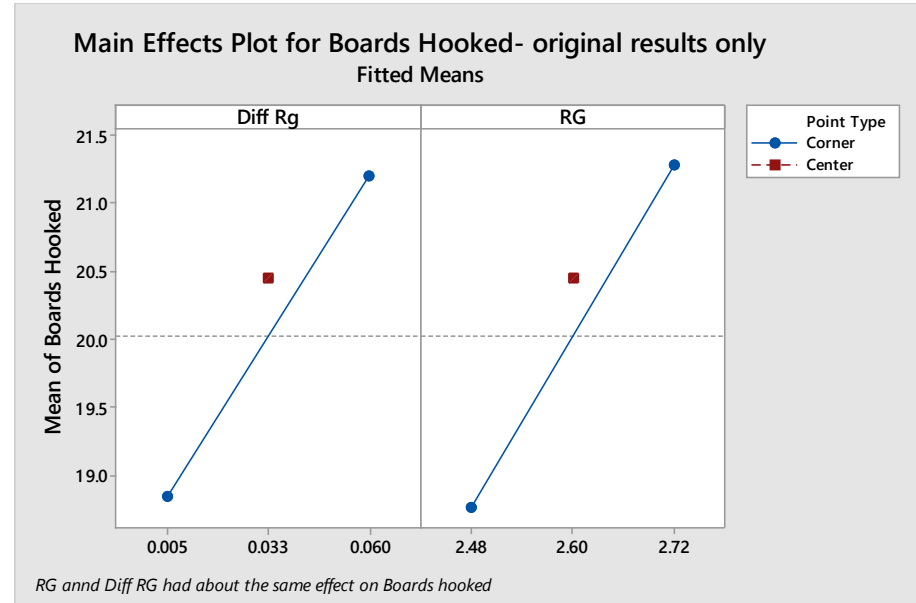
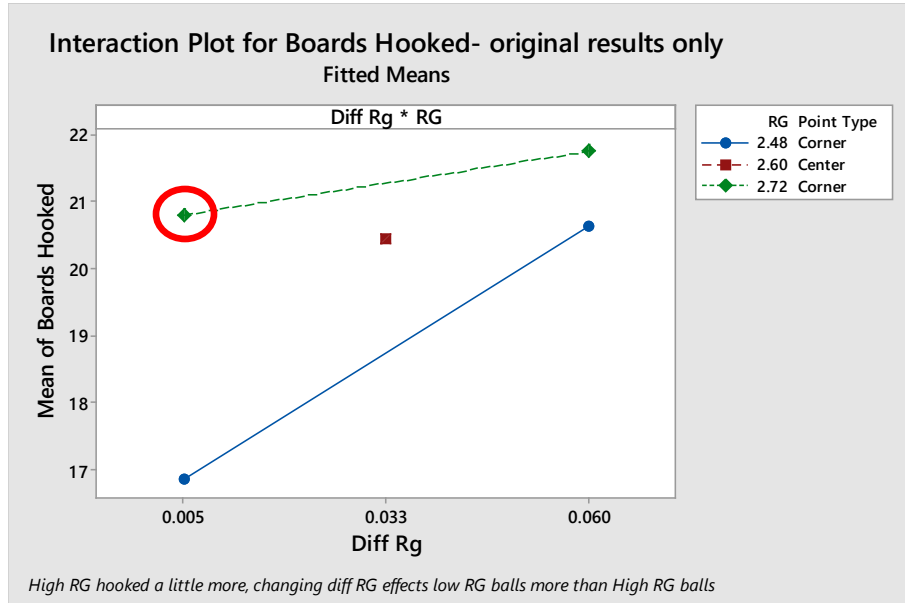
1. Boards of hook
2. Total angle change
3. Breakpoint distance down the lane

Below are graphs for:

- Original RG and differential RG study results (retest 3 below)
- The new retest results from this report (retest 4 below)
- The combined original and retest results

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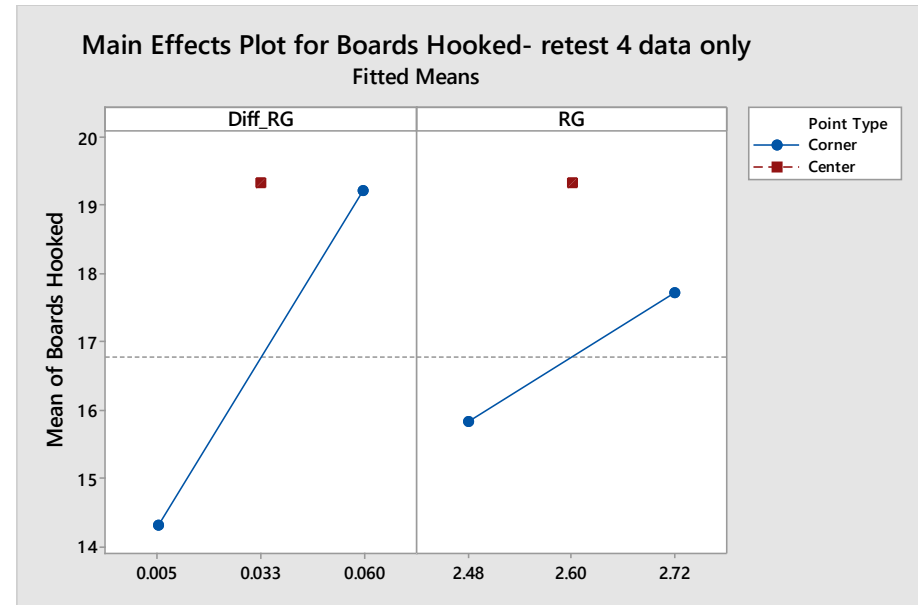
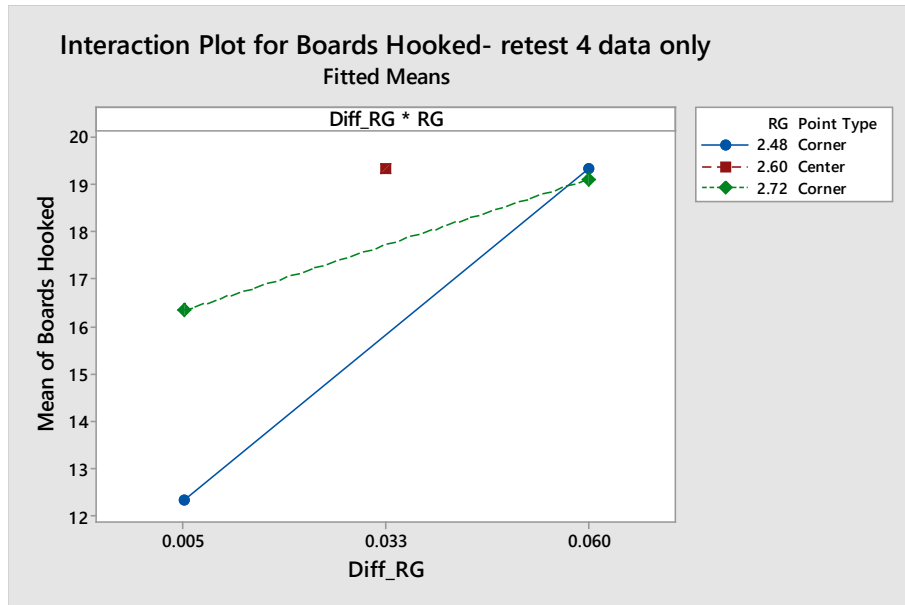
Original test was rerun because of the data point in the red circle. Difficult to accept, as a bowler, that a high RG ball with no flare could out hook a low RG, high differential RG ball. Basically, these results are showing that a ball with a three-piece core would out hook a high performance core with the same shell. Math calculations might support this conclusion, but bowlers perceptions do not.



Boards Hooked- Results from retesting the original RG and differential RG test

Below are the retest 4 results. The results have the same trends as the original results but the absolute value for the high RG balls dropped slightly. It now shows the high RG ball with low differential RG hooking less boards than the low RG, high differential RG ball. The main effects plot shows that the differential RG has a stronger impact on the boards of hook than the RG. Note that the center point (red data pt- 2.57 RG & .035 differential RG) hooked as many boards as any other test ball.

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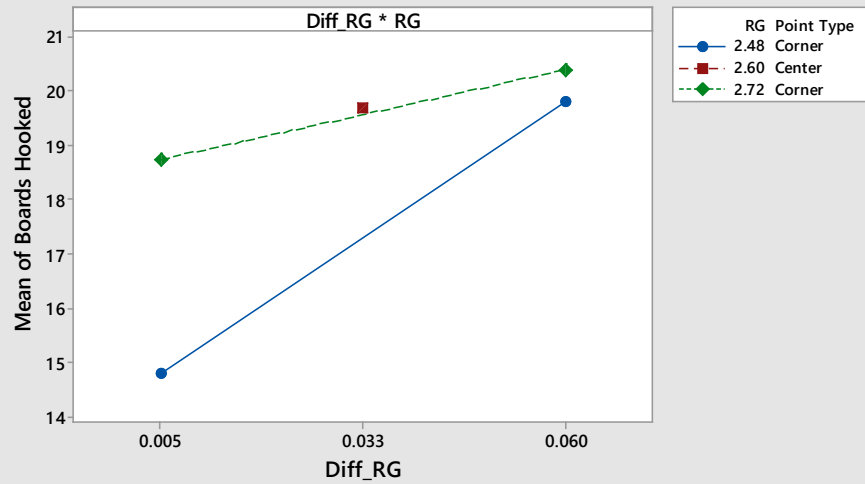
Boards Hooked- Combined original and retest results

Below are the combined results from the original test and the retest. The high differential RG balls hook more than the low differential RG balls (although the high RG, low differential ball is close to having the same boards of hook).

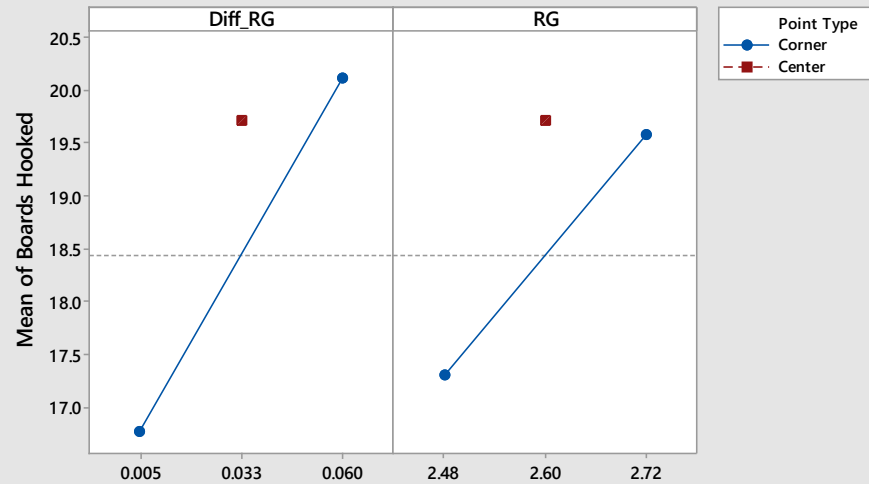
Differential RG has a greater change in the boards of hook with low RG balls than high RG balls, which is the same general conclusion as from the original test.

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Interaction Plot for Boards Hooked- retest 3 & 4 combined
Fitted Means



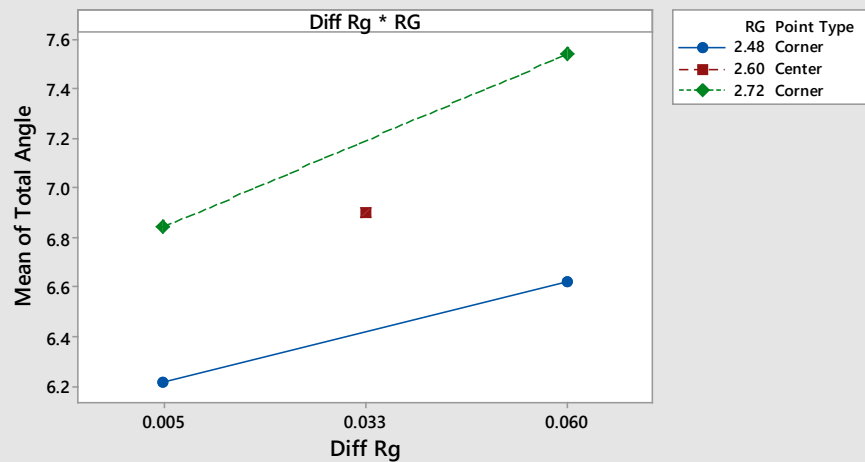
Main Effects Plot for Boards Hooked- retest 3 & 4 combined
Fitted Means



(2) Total Angle- Original test results

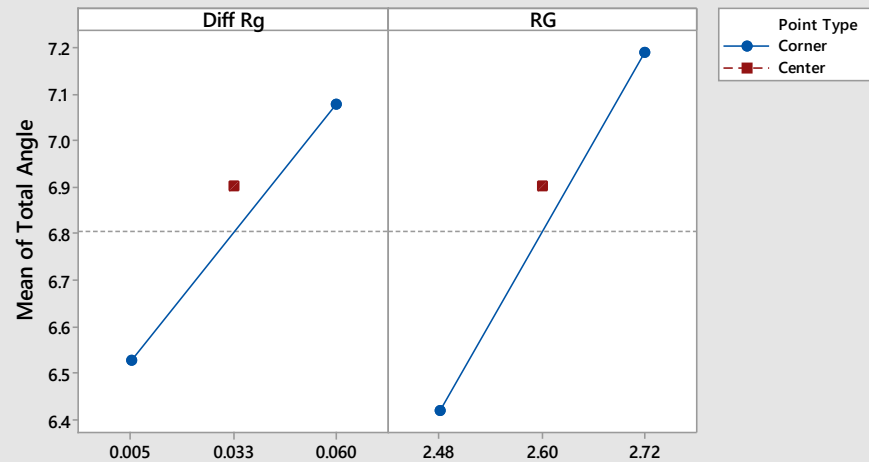
In the original test, the high RG always had more total angle change than the low RG ball with any differential RG. Therefore, main effected plot shows that RG had more effect on the total angle change than differential RG.

Interaction Plot for Total Angle- Original Results Only
Fitted Means



High RG had more angle change with any diff RG value

Main Effects Plot for Total Angle- Original Results Only
Fitted Means

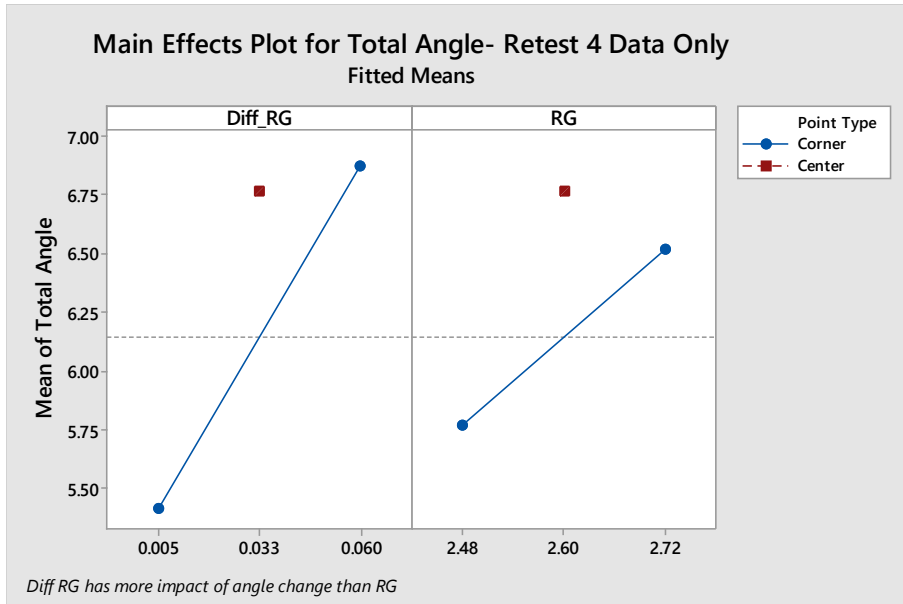


RG had more effect on angle change than Diff RG

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Total Angle- Retest 4 results

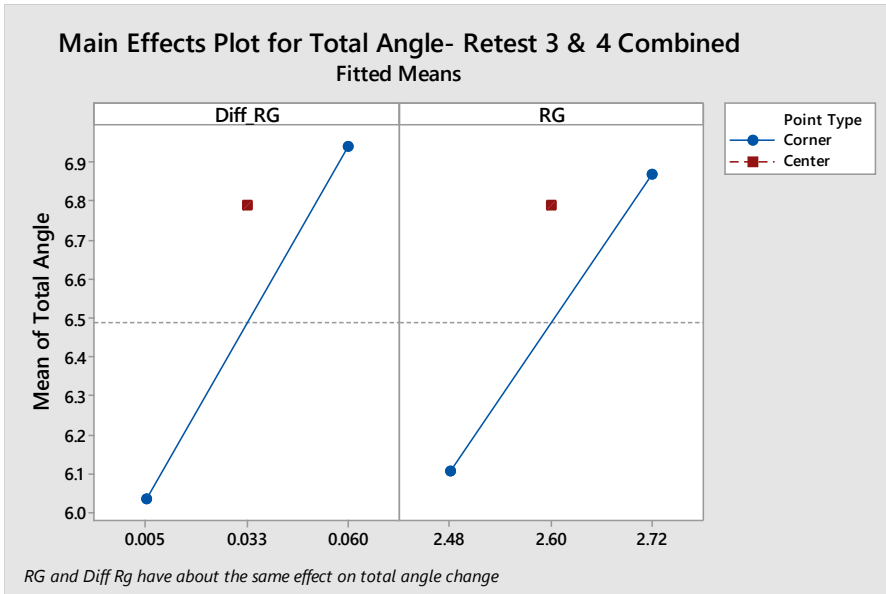
In the retest, differential RG had more influence on the total angle change than RG.



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Total Angle- Combine Original and retest 4 results

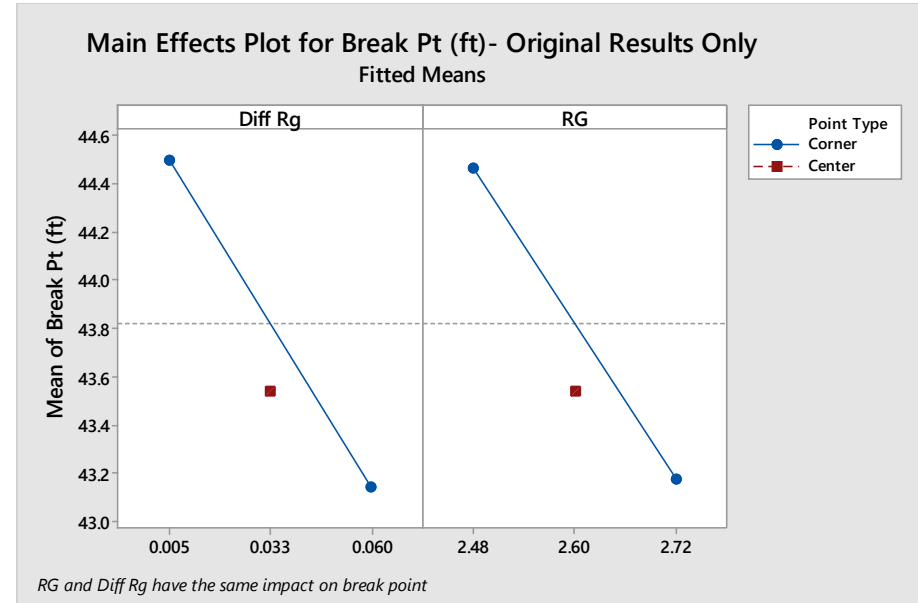
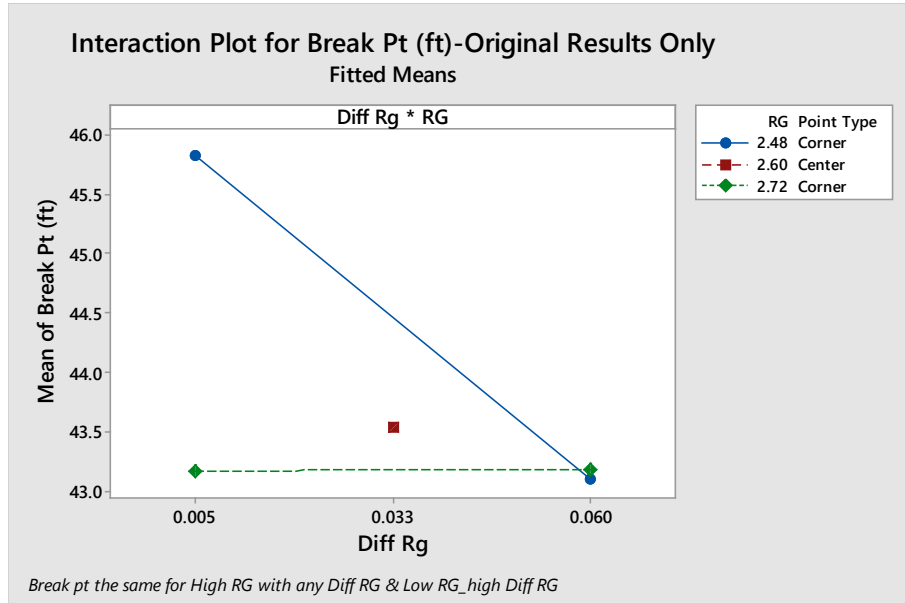
In the combined test of all the data collected (below), the differential RG and RG have about the same effect on the total angle change.



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Breakpoint Distance- Original test results

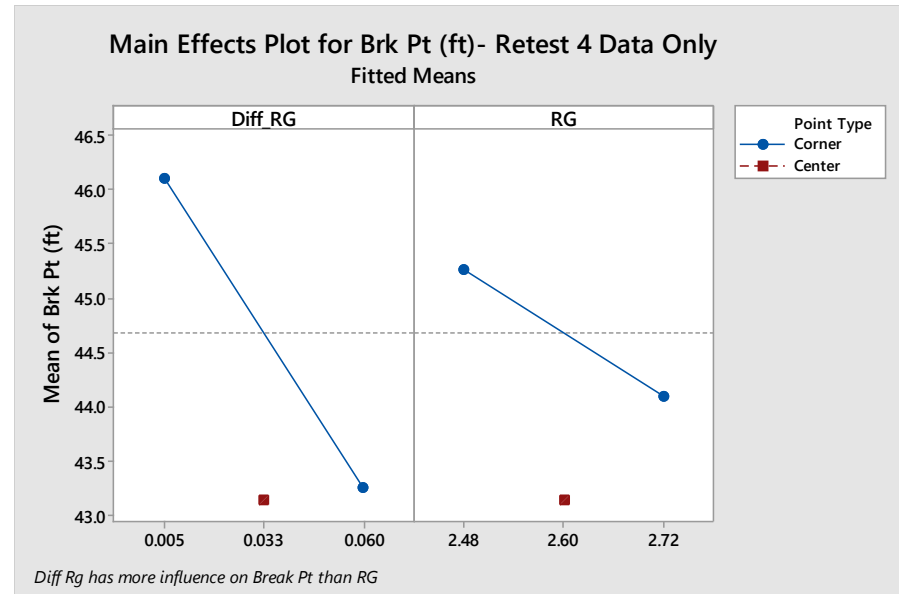
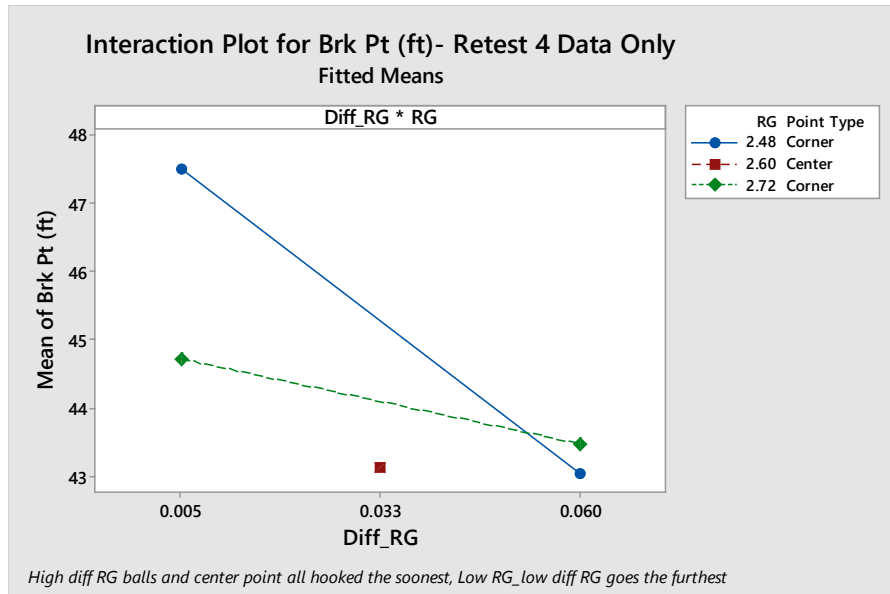
In the original test (below), the high RG ball with varying differential RG, along with, the low RG, high differential RG ball all had the earliest breakpoint (approximately 43 feet).



Break Point - Retest 4 results

During the retest (below), the break point was always further down the lane for balls with small differential RG. differential RG had more influence on the breakpoint distance than the RG. The center point has an early breakpoint matching the balls with high differential RG.

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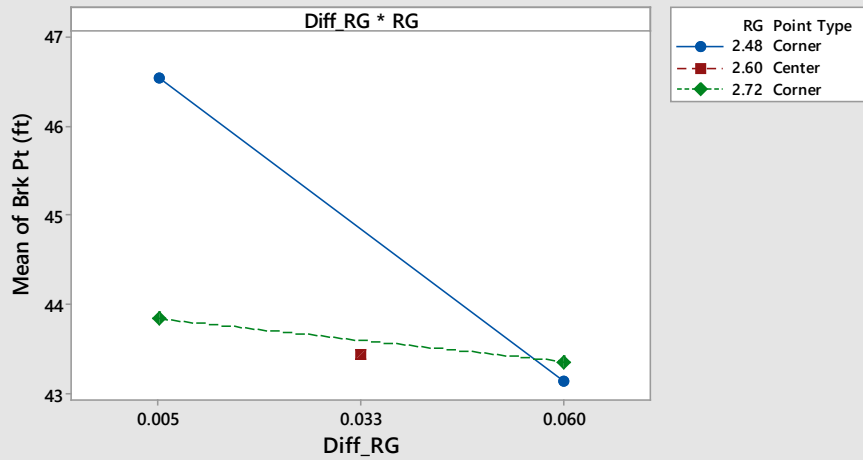


Breakpoint - Combine Original and retest 4 results

In the combined data analysis, the break point is soonest for the balls with the high differential RG. The breakpoint does not change very much for the high RG balls when the differential RG is varied. The differential RG changes the breakpoint more than the RG. The center point also had an early breakpoint.

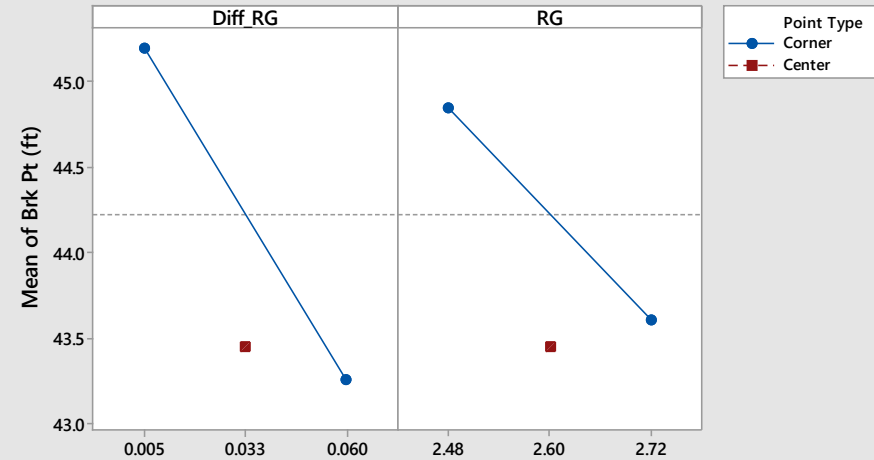
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Interaction Plot for Brk Pt (ft)- Retest 3 & 4 Combined
Fitted Means



Earliest break pt with high RG ball with any diff RG & low RG_high diff RG

Main Effects Plot for Brk Pt (ft)- Retest 3 & 4 Combined
Fitted Means

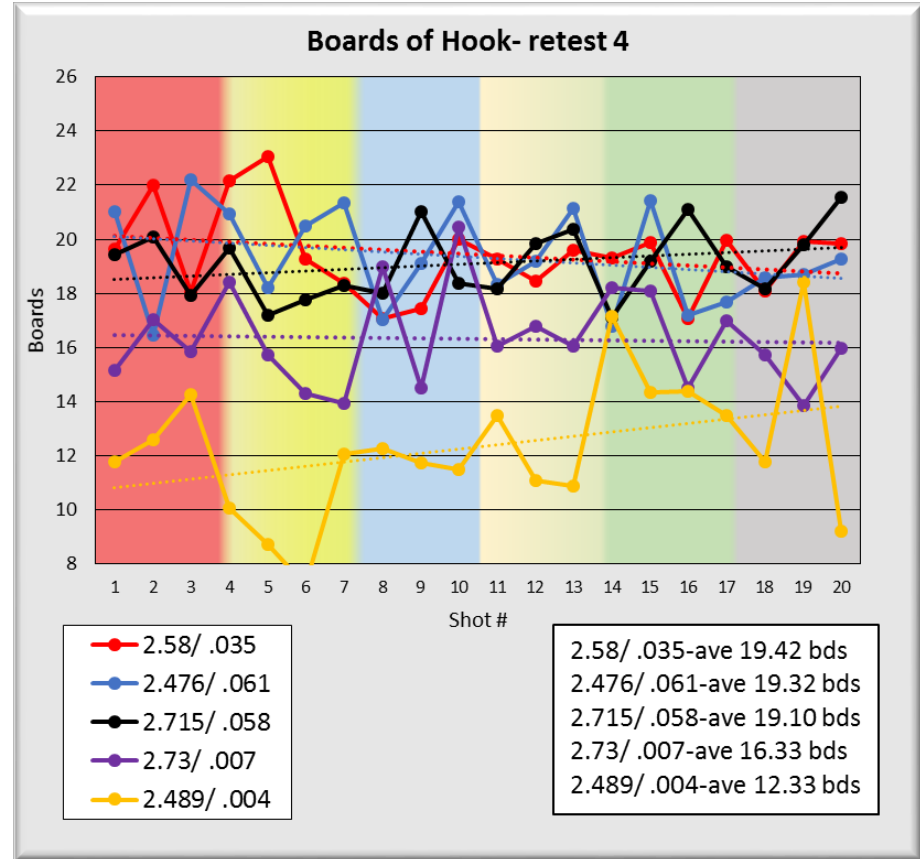
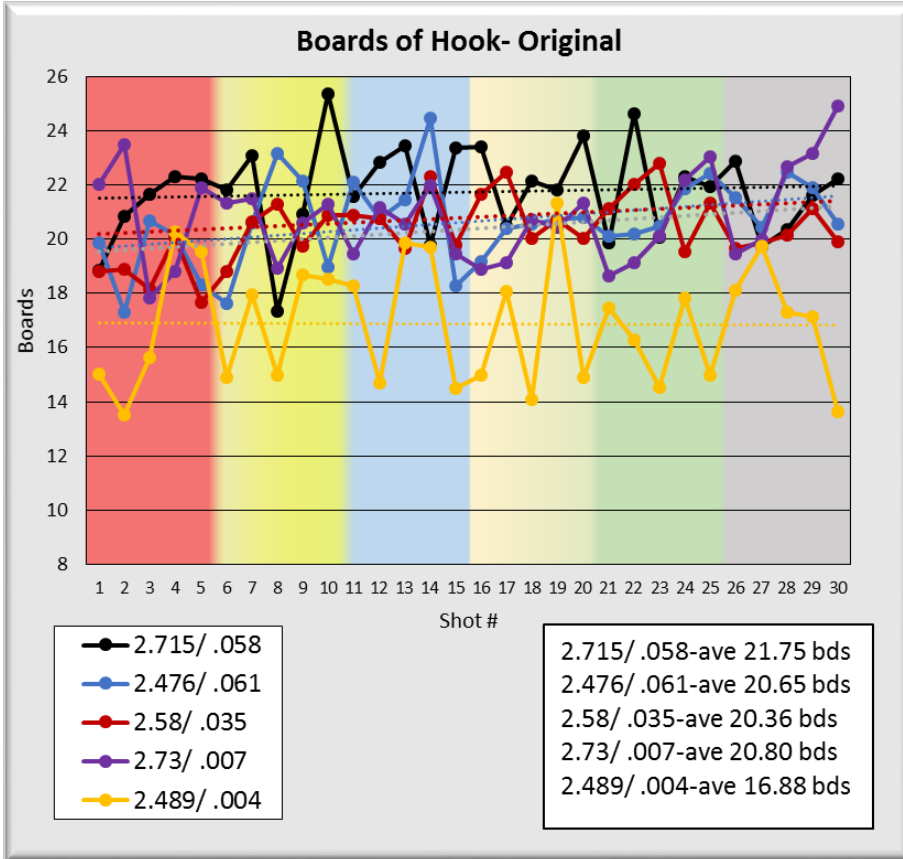


Diff RG has more influence on break pt than RG

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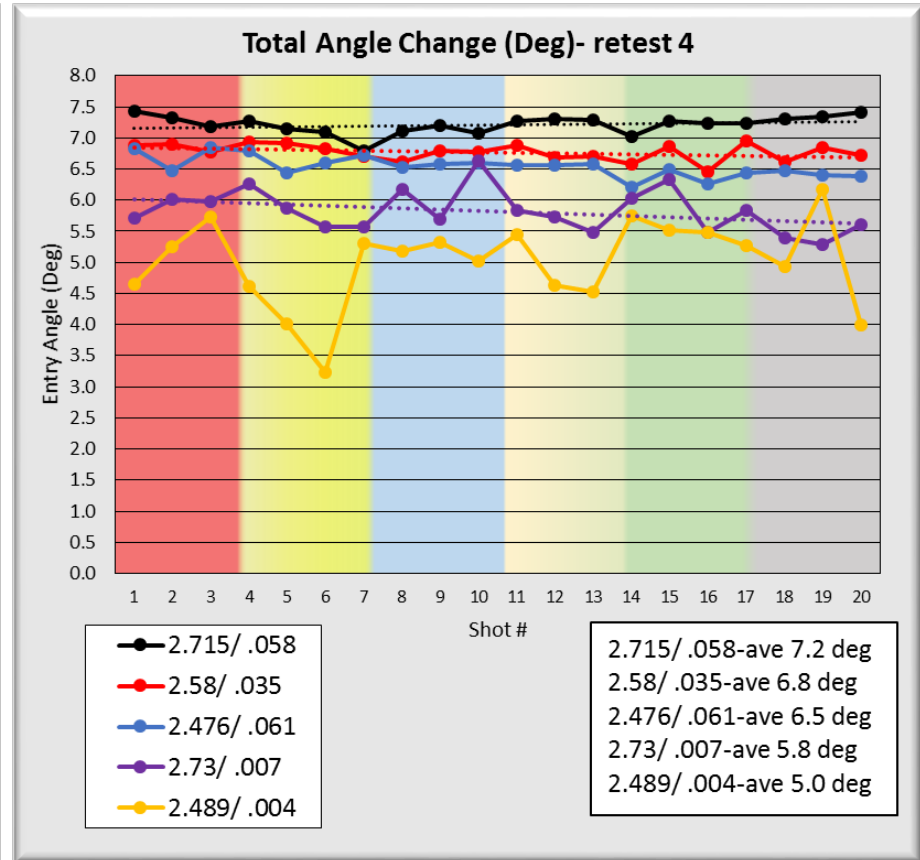
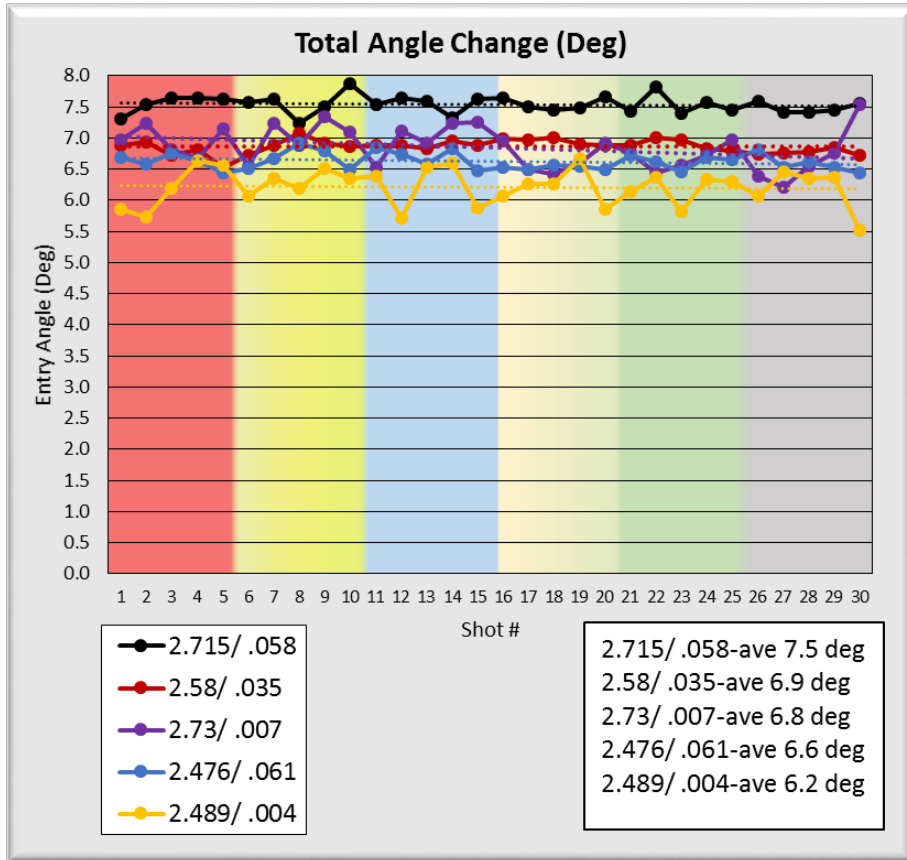
The graphs below show all the individual data points. They support all the conclusion from above.

Below are the boards of hook for the original test and the retest 4. The gold line graph (2.489_.004) hooks the least in both cases. In the original test all the other test balls had similar boards of hook with the black line (2.715_.058) appearing to be a little more boards of hook for many of the test runs. In the retest, the purple line graph (2.73_.007) hooks second least. Therefore, the low differential RG balls hooked less boards during the retest. The other three test balls are similar in boards hooked, which is supported by the average boards hooked in the text box.



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Below are the graphs for the Total Angle change from the original test and the retest 4. During the retest, there is clear separation between each test group. The higher differential RG balls had more total angle change, and the low differential RG had less total angle change.



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Break point distance graphs are below. The gold line graphs (2.489_.004) has the latest breakpoint during both test. During the original test, all the other test balls have about the same breakpoint distance (43.1-43.6 feet). During the retest the purple line (2.73_.007) had a later breakpoint (44.7 feet) compared to all the rest (43.0-43.5 feet).

