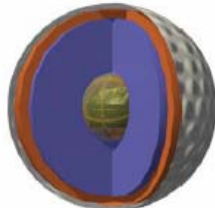


Case Study

HBL Ltd

Impact Analysis of a Golf Ball



HBL Ltd Company Profile

HBL Ltd was a small self-funded company set up by Iain McCreary and Rani Osnat, with intellectual property contributions from Qinetiq, and engineering support from Plextek Ltd. HBL's intent was to provide real time, three dimensional tracking of golf balls in flight, giving accurate

feedback on speed, spin, shot shape and curvature, in-air and on-ground distance, etc.. A variety of applications were then possible, ranging from real-time data overlays for television broadcast to letting enthusiasts compete head-to-head in real time against the like of Tiger Woods through their television and games consoles. The initial market was the driving range, where HBL's tracking technology was expected to more than double the revenue and triple profits of any driving range. In effect, HBL's goal was to digitise the game of golf.

Background

The first golf balls were wooden and used until the early 17th century, when the featherie ball was invented. The featherie ball consisted of cowhide bag stuffed with goose feathers. Due to its superior flight characteristics this type of ball was used for more than two centuries but was very expensive to make. It wasn't until the 20th century that multi-layer balls were developed.

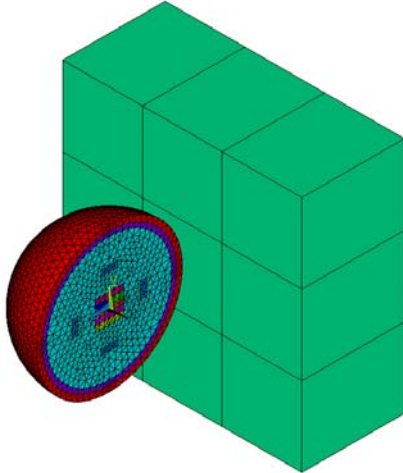
Today's golf balls are complex, layered engineering marvels that balance the needs of a high density core for speed/distance against softer outer layers for a "soft" feeling that offers higher spin and control. Inner layers tend to be made from polybutadiene rubbers, embedded with high strength, light weight stiffeners such as nickel alloys, titanium compounds or other hybrid materials. Balls consist of anywhere from two to four-layers, with an outer shell of softer, more pliable synthetics like surlyn or urethane blends.



HBL wanted to take golf balls one step further, but embedding tracking electronics. Several companies have already proven the usefulness of in-ball electronics, usually based on RFID tags either to find lost balls (e.g. Radar Golf Inc.) or to enable automatic scoring on specialised driving ranges (e.g. TopGolf Ltd.). However, as yet there are no in-ball or external radar/camera technologies that allow one to track a golf-ball in flight over full length driving ranges, let alone full sized course. HBL's would be the first to do this. Applications on the driving range would significantly increase the revenue and profits of driving ranges, and included both training programmes, games (bringing the golf-video game to the driving range), and custom club fitting for pro-shops. Looking forward, installation on full-courses would allow golfers to store and save their shots, not only for automatic scoring but also for customised 'virtual caddy' advice.

Analysis

HBL requested that **IDAC** predict the impacted behaviour of a golf ball containing a wide-band microwave transmitter unit. The impact analysis would be used to answer four sets of questions: 1.) How do golf balls behave under impact? 2.) Would the embedded electronics survive the swing, or would they shatter? 3.) How sensitive would the ball be to asymmetries within the core? 4.) Would a ball with an electronics core be too "hot" to win R&A/USGA certifications, and could we modulate the material properties of the surrounding layers to keep the ball within regulated specs? All of this was to be done using a relatively simple model of the in-ball electronics to gain a better understanding of how the golf ball changed in shape during and after the impact of a swung golf club. Three scenarios were analysed as follows:



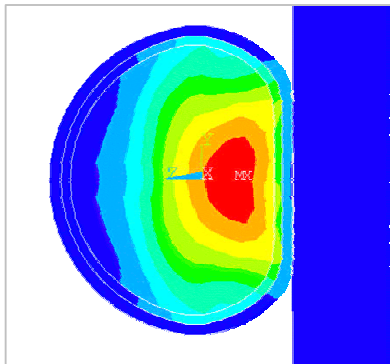
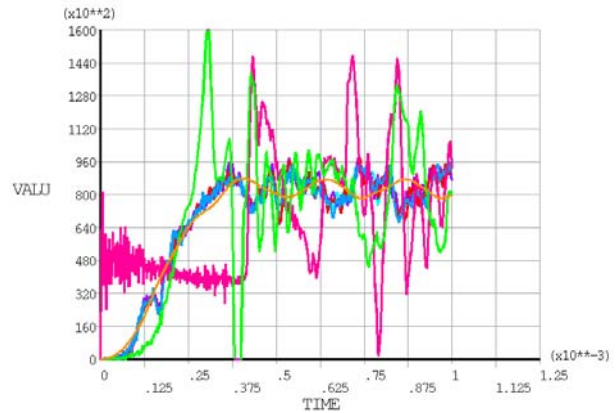
- Impact analysis of typical golf ball design without internal transmitter unit installed, struck Flat-On. To enable correlation.
- As above analysis with the internal transmitter unit installed, struck Flat-On.
- As above analysis, but struck 45° to Flat-On to maximise distorting stresses.

HBL were primarily interested in determining the stresses and strains that would be imposed on the internal components as the ball is struck. For example, the fragile clock circuits contain quartz crystals; a key concern was whether distortion or shock waves would shatter these components.

The dimensions of the geometry of the golf ball were supplied by HBL. The modelled golf ball consisted of three layers with an unprotected LTCC (Low Temperature Co-Fired Ceramic) core at the centre. The four layer LTCC ceramic core was not modelled in detail, instead being represented as a simple cube with one quarter of one layer having quartz crystal material properties. Six power cells were placed around the LTCC. All material properties of the LTCC core, inner layers and external skin, were supplied by HBL.

Due to the highly non-linear nature of this short time duration event (balls are compressed by 1/3 diameter in roughly 200 msec), IDAC decided to use the explicit dynamics solver ANSYS/LS-DYNA.

LS-DYNA elements SOLID168 and SOLID164 were used for the golf ball and golf club respectively, with the golf club being represented as a rigid body. The graphic above shows the distribution of the different materials within the model.



The plot to the left shows the deformed shape contour plot of the ball without the transmitter unit. This first phase of the analysis showed a good correlation between real life and the analysis.

The second and third phases of the analysis work confirmed that in some orientations, the proposed electronics were not robust enough to withstand the peak accelerations combined with the large deflections in an unprotected core. However, surrounding the LTCC ceramic core with a hard spherical shell would probably allow the electronics components to survive. The plot above (right) shows the peak accelerations experienced by the golf ball when struck at 45° to flat on.

Design Benefit

HBL used the findings to improve the design of the core of the golf ball.

Iain McCreary (iain@insightsri.com), then Managing Director of HBL says “IDAC gave us the confidence we needed to proceed. Before spending too much money, I wanted to know whether the electronics would survive [the impact]. Golf balls are compressed by 1/3 of their diameter and see peak instantaneous accelerations of almost 30,000 G. It was entirely possible that under these forces the layer ceramic core, the chipsets, or the small pieces of glass-like silicon used in the timing circuits would shatter. Although later designs pulled everything into a spherical polycarbonate core, these early tests were key to understanding whether we were heading down the right path in terms of materials.”