FROM BRASS TO RECYCLABLE PLASTIC
– THE REINVENTION OF MUSICAL INSTRUMENTS

A quarter of a million brightly coloured trombones made of recyclable ABS plastic have been sold worldwide in the last few years. The pBone, weighing less than a kilogram and costing a tenth of its metal cousin, has driven a demand for a range of polymer-made instruments including a trumpet. Rachel Jones spoke to Warwick Music Group’s CEO, Steven Greenall, and Innovation Director, Chris Fower, about the engineering hurdles that were overcome to enable this success.

The pBone journey began with an experiment developed by an engineering design student, Hugh Rashleigh, at Loughborough University. An amateur trumpeter, he was inspired by a peer-reviewed PhD paper from the 1980s suggesting that the surface quality in brass instruments could be as influential as the metal itself for sound quality. Rashleigh made a prototype trombone for his undergraduate project that, through an introduction to Steven Greenall – a venture capitalist and entrepreneur with a degree in electrical engineering – formed the basis of the pBone.

Greenall was a trombone player and owner of the music publisher Warwick Music Limited. He was interested in widening access to music education and saw a strong market proposition in Rashleigh’s prototype. If a trombone of acrylonitrile butadiene styrene (ABS) plastic could retain a traditional instrument’s features while lessening cost, maintenance and propensity for damage then it would have strong business potential.

While the pBone was not intended for professional orchestras, it would have to be good enough to convince music teachers and get young people interested. Chris Fower, a professional trombonist and consultant involved in high-end trombone design, was brought in to help develop the project. Making a trombone from polymer would involve a matrix of design, engineering and manufacturing challenges.

LATERAL THINKING
Like trumpets, trombones produce sound by generating air vibrations in a tubular resonator. The slide itself comprises two parallel, stationary inner tubes and two movable outer tubes. “It’s the trombone’s weak spot, with two soft metals running over each other,” Fower explains. “If you bash it, it’s hard to repair – which can make the metal trombone a costly choice for children.” Rashleigh’s solution for the slide drew on fibreglass manufacturing methods. A non-metallic material could potentially make the slide lighter, stronger and bash-resistant, but it would need engineering to remain stiff, light and parallel. “A metre-long piece of tubing with a wall thickness of 0.5 millimetres, that needs to be turned completely straight and completely rigid, is hard to engineer out of anything,” says Fower. Experimenting with extruded plastics brought issues of longitudinal torsion and tolerancing into play.

To solve this, Rashleigh looked into the manufacture of fibreglass fishing rods. For these, a resin-impregnated glass cloth is wrapped over a cylindrical mandrel, rolled under high pressure and baked to melt the resin to a solid mass.
3D-printing demonstrated how areas of the prototype where the sound quality, especially in the overtones, was vital in helping improve the sound of the instrument. "It was quite a warm, dull, mellow alteration. The sound quality was extremely uneven. "We had areas of low definition where it was insecure and muffled. The polymer helped produce a solid material by heat or pressure without melting it to the point of liquefaction – and stereolithography, a form of 3D-printing. Another issue that was sorted out before production was bacterial growth. Brass trumpets contain raw nickel (a natural antimicrobial) but polymer-made instruments had antimicrobial additives incorporated.

By 2009, a manufacturing facility in China agreed to take on the instrument. The trio began moving to production, transferring printed shapes into engineering files, and creating tools. "We'd worked out where struts were going to go, shapes of turns, all of that," says Fower. The pilot's launch in late 2010 saw the first stock of 500 instruments sell out in 19 minutes. Since then, Warwick Music Group has sold more than 250,000 units worldwide, of 500 instruments, a new shipment of 2,500 is now in the pipeline. They were ready to address the engineers' greater challenges. One of the main obstacles lay around achieving acceptable tolerance (limits of variation) in piston valves. "The trumpet is half the length of a trombone, so the acoustic challenge was easier to deal with," notes Fower.

The modern trumpet valve, invented in the early 19th century, allows players to control the passage of breath, recouting air through additional tubing, altering the pitch. As with the trombone, there have been a few innovations. The pair set themselves the target of replacing the metal valve system with one made entirely of plastic. "It was like making a combustion engine – in plastic," says Greenall. Their original design scheme, making the system using only ABS injection moulding, proved unworkable. "If a valve block is cut at 20 degrees and a piston at 25 degrees, they won't fit together, or there'll be big holes." The solution was to move everything into a temperature-controlled environment to sit for 48 hours before being machined. Even then, machining plastic was not simple. "A compression wave follows the cut and pushes material outward of the way," says Greenall. "It's difficult to get it thin."

Unlike handbrass,不便 brass piston systems, the pTrumpet's mass-produced "lapping" – the manual process of honing brass, improving an instrument's tonal quality – was especially hard to replicate. "In brass, you make inner and outer parts then hand-tap one of those two components until they fit," explains Fower. "The more expensive a brass trumpet, the more hand-lapping." In polymer, success rested on good choices of material and precision in mass manufacturing. This involved keeping close to suppliers to learn what was possible and make the process fully repeatable. "We pushed the weak spots around until we found a workable balance of tolerance and repeatability." The valve production is very repeatable now, and produces a surprisingly playable result.

With no competitors or researchers to inform the work, Fower and Greenall made only a few thousand trumpets that weren't good enough" before getting it right. Fower gives the example of a valve leakage from a prototype valve block. "Let's say it gave a leak 2 litres a minute at five bar [unit of pressure]. We'd design the rest of the instrument around that, but when we got into manufacturing and it leaked at 10 litres a minute, the adjustments went out of the window. We didn't know what real leakage was until we made it in a factory.

As with the pTrumpet, tiny changes had large impacts. "Making a thousand of exactly the same thing, such as pistons, meant we got better and better at making them." Mass manufacturing offered enormous benefits, bringing the pTrumpet to children who could not otherwise afford to play, but "when you mass manufacture in plastics, it's hard to get a perfect prototype and build it. Instead, we had to learn how to build it by building it.

Launched in September 2014, the pTrumpet weighed just 500 grams, and was an immediate hit. "It looks and sounds like brass at half the price," said The Spectator. "Its universal valves (replaceable in any holes) and ability to operate without lubrication, it was a game-changer for music teachers teaching large groups.

A HYBRID TRUMPET

The pTrumpet's all-plastic system did not totally overcome the lack of compression. Escaping air makes tonal quality less focused, and can negatively affect intonation and timbre. Since the base sound quality of polymer-made instruments leans toward being warmer and less focused than brass, this leakage is particularly difficult to carry. Yet making plastic to the tolerance of 0.0001 millimetres – possible with brass – was impractical commercially.

The limitations of a polymer-only solution drove Greenall and Fower to work on a hybrid: the pHyTech. They aimed to retain the pTrumpet's lightweight robustness while improving playability and sound quality by adding metal where polymers "couldn't cut it at price point." Fower adds. "We'd become experts in the limits of where plastics technology could take us within reasonable budgets, so we began to think about different choices of material to create enhanced resonance."

With valves again being the main challenge. Using metal to achieve airtightness would
The pTrumpet hyTech’s body is made from ABS plastic making it extremely light. The hybrid has metal for the valve block, valves, leadpipe and mouthpiece, which increases its durability and enhances resonance © Warwick Music Group

It launched the hyTech in 2019 and now has eight instruments in its portfolio, including a pre-brass starter (pBuzz) that retails at just £15. Principal markets are currently the US, Europe and Japan and further instruments are being developed with another patent soon to be filed.

With few competitors, what has been the secret to its success? “We came in from the musical angle,” says Fower. “An engineer can say ‘I’ve created the perfect trumpet’ but everything comes down to the sound. We had a deep understanding of why we were making this product, and we combined this with innovative thinking about materials and consultation with suppliers to transmit the ‘why’. By bringing artists and engineers together, we made sure the conversation went straight and productively down the line.”

Listen to the hyTech at: https://pbone.co.uk/product/hytech/