The Impact of Rapid Product Development Processes on the Jewellery and Artifacts Sector

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History and Context

The Jewellery sector is a vast industry — from the top end, where single pieces can be sold for hundreds of thousands of pounds to the lower end of the market where hundreds of thousands of pieces can be mass produced and sold for a few pounds each. Regardless of consumer spending power however, jewellery is universally used to make a statement by the wearer and the appeal of jewellery is global.

The knowledge and expertise required for the design and manufacture of jewellery is extensive and includes, but is not limited to fabrication, mould-making, casting, electroplating, forging, silver/gold smithing, stone-cutting, engraving and polishing. Each of these disciplines has evolved over many years and each requires technical experience and in-depth knowledge when applied to jewellery manufacture — as an example the origins of investment casting can be traced back 4000 years or more.

The RPD Effect

A fact that cannot be denied, however, is the influence that rapid product development (RPD) processes have had on the jewellery sector and how jewellery is made. The way that jewellery can be designed to the way that it can be produced, whether in single, low or high volumes, has changed dramatically in recent decades. Long-established methods of jewellery design and manufacture are still embraced today by traditional jewellers who utilise age-old skills to create and produce bespoke pieces of art. However, the 3D digital revolution and the emergence of advanced manufacturing technologies now means that jewellers across the board have a much wider range of tools at their disposal for creating new and innovative jewellery designs.

The manufacture of jewellery has typically involved a number of key steps, namely:

- creating the design
- creating a primary model of the design (traditionally by hand crafting or CNC)
- creating a pattern
- producing a silver master
- creating a silicon/rubber mould for wax injection of mass produced pieces
- casting / production of final pieces & finishing.

3D CAD software has had a significant affect on jewellery design — with the ability to create complex geometries that previously were not possible. Furthermore, the advent and subsequent developments and refinements of additive fabrication (AF) processes, that can build the 3D designs directly from the CAD models have driven opportunities much further than could have been envisaged even twenty years ago. The ability of some of the advanced AF platforms to build in metals has seen the emergence of some jewellery collections that are directly manufactured in this way. There are still some limitations in this area for mass uptake, specifically the range of materials available, but early adopters are inspiring continued growth and development.

More commonly, AF is being used in rapid prototyping and rapid tooling applications to produce jewellery models as the precursor to investment casting or die casting — creating the primary model or a direct wax pattern from which to achieve a rubber or silicon mould. These applications have seen massive developments in many areas of the jewellery sector, eliminating some of the time-consuming steps of the traditional process.

For jewellery applications the additive processes that produce parts with the tightest tolerances and highest resolutions have driven deepest into this sector. The processes that have had notable success within the jewellery market are the DMLS (direct metal laser sintering) process from EOS, specifically for direct applications; the Perfactory process from Envisiontec; the SLA process from 3D Systems; and Solidscape's range of additive machines utilising wax materials.

Vacuum Casting is another process that features heavily in the manufacture of jewellery, and offers a valid alternative to additive methods of producing models and patterns.

Perfactory Jewellery

The developments and improvements with AF processes have unquestionably had a profound impact on jewellery manufacture. It has long been reported that using AF offers certain advantages over traditional production methods, one of the key advantages being the ability to design and build parts with ‘complexity built in’. Considering the traditional first step in the manufacture of jewellery — creating a primary model — AF offers the opportunity to produce more elaborate and intricate pieces that would not be possible if hand crafting the piece or utilising CNC methods (see figures 1 and 2).

Envisiontec is one company that has worked closely with its many clients in the jewellery sector to further refine its Perfactory process for jewellery applications. The company manufactures and markets a full range of 3D printing machines for a broad spectrum of industrial sectors. However, the Perfactory Desktop and Mini Multi-Lens machines in particular have both proved successful for jewellery applications running highly detailed filigree and accurate settings to produce models in precision and castable materials. The throughput of the machine has also proven to be exceptionally well suited for jewellery manufacture applications. As an example, a set of 15 rings can be produced in a castable material within five hours, with a printing resolution of 15 microns.

The latest addition to the Perfactory range is the Aureus; this machine was specifically developed by Envisiontec for the jewellery market and was introduced at the recent Baselworld 2009 exhibition — a large and important event for the watch and jewellery industry — which takes place annually in Switzerland. The machine has had an unprecedented response since its launch, capturing the attention of many small to medium sized jewellers as a result of the fact that the machine is able to produce between 25 and 50 rings per day in either resin or wax materials, which can dramatically reduce the lead times associated with traditional methods of manufacture as outlined above, by eliminating one or more of steps in the process. Moreover, with accuracy capabilities of 43 microns and a build envelope of 60 x 45 x 100 mm, orders for this machine are well ahead of expectations and jewellery manufactured using this process is now hitting the market.

Case Study
Timothy Roe Fine Jewellery, based in Chichester, West Sussex, is a retail jewellers with a very capable manufacturing facility. The company's premises houses design and manufacturing equipment, which includes a 3D CAD design suite, a rapid prototyping (RP) machine and casting hardware. This affords Timothy Roe Fine Jewellery the ability to design and produce custom jewellery for its clients in a range of precious metals - including platinum and palladium (see figure 3).

By using 3D CAD and RP the business has been transformed, allowing it to make almost anything its customers ask for. The company started using CAD/CAM software about four years ago after visiting an industry exhibition at the NEC (Brimingham, UK) and was impressed with the easy and interactive interface provided by the 3D design software package from Vision Numeric. The company's initial foray into creating designs with this software resulted in the designs being sent to RP bureaux in London and Birmingham. As the company became more proficient with the software, more applications for its use became apparent. This resulted in the decision to buy an RP machine, largely because the costs associated with paying the bureaux each month was increasing rapidly.

The initial costing based on the number of waxes being built together with postage and packing resulted in the company being able to forecast that the capital expenditure needed for the machine could be repaid within 42 months. However, the company soon realised that the lower costs of the waxes opened up even more possibilities as it was now possible to produce items that were previously unviable. Shanks and collets that had previously been ordered in could now be made economically and due to improved design, they would fit seamlessly together without the need for tweaking and re-shaping. The company was delighted when the first RP machine was paid for in eighteen months when offset against the money saved in not sending off the files to third parties.

Timothy Roe Fine Jewellery has since added a casting workshop to its facilities with the ability to cast more than twenty models per week. The six goldsmiths and two setters are extremely busy keeping up with the demand for stock and customers' commissions. Recently the company has added a Perfactory desktop machine to its armoury and with its impressive build speeds and smooth surface, this machine is helping to further reduce production times and has also given some capacity for building models for other CAD users.

Electroplating

Electroplating is a process that has long been used in the jewellery industry for a number of reasons, including altering the appearance of items for a more uniform colour or achieving different colours and for improving surface finish by hiding imperfections. Traditionally the electroplating process involves metal coating a base metal object with a superior metal — for example plating gold onto a copper or silver item.

Developments in the electroplating process however, now mean that it is possible to plate metal, including precious metals such as silver and gold, onto a base ***plastic*** object. The Metalise it ... process from 3DDC has seen widespread interest emanating from the jewellery sector in the UK and further afield and is a significant growth area for the process. The implications of this capability for jewellery applications is proving to be huge, particularly when used in conjunction with 3D parts and models created directly on the plastic AF platforms as described above (see figures 4 and 5).

A New Approach
The manufacture of jewellery is, of itself, an intricate and fascinating discipline, however, like any other type of manufacturer, jewellers must market and sell their products. The display and marketing of jewellery can prove to be a complex, expensive and time-consuming business on its own. Whether at industry shows, in single or multiple shop locations or on the road, there is a real security risk around jewellery displays, particularly those with high value. The ability to produce exact, inexpensive replicas of finished pieces in gold, silver, platinum etc, can eradicate a number of security risks.

Example 1: Looking to the recent Baselworld show, once again, the security logistics for safeguarding each stand's exhibits was time-consuming and cost intensive each day of the show — requiring the lengthy services of a security firm. If the value of the exhibits were greatly reduced, without diminishing the quality of the finished product, exhibitors would be able to transport the exhibits to and from their stands themselves.

Example 2: For any jewellery retail outlet, stringent security measures and steep insurance premiums could be reduced, if not negated, by using precise electroplated plastic replica jewellery in their displays. The real pieces, while on-site for serious buyers, can remain locked in a safe.

Case Study
Another application for which the ability to closely replicate the original artefact has proved of significant value can be demonstrated by the following case study from the Jewellery Industry Innovation Centre (JIIC).

The JIIC was recently commissioned by Birmingham Museums and Art Galleries to make a set of reproduction candlesticks based on an original design by Matthew Boulton (1728–1809) as a part of the celebrations of his life, work and legacy during the up coming bicentenary of his death.

As an entrepreneur and major industrialist during his lifetime, Matthew Boulton's legacy was vast and he is remembered as a leading light across many industrial sectors. Boulton's heritage extends across the development and production of the UK's coinage system and the emergence of the steam engine. However, Boulton was also instrumental in establishing The Bimingham Assay Office, which greatly influenced the expansion of the jewellery and silver trades in Birmingham, a city that to this day remains at the centre of jewellery production in Britain.

The Birmingham Museums and Art Galleries were keen that the reproduction candlesticks should reflect 'today's technology' as there is little doubt that an innovative manufacturer like Boulton, were he around today, would be embracing all of the new technology tools that are available for design and manufacture. The Metalise it ... process would have been of particular interest to Boulton, as he was a primary force behind the widespread use of what is known as Sheffield plate — a significant technological development in silver plating, developed by Thomas Bolsover.

The JIIC was given access to one of the museum's Boulton candlesticks, however a stipulation of this access was that noone was allowed to touch or scan it, which posed an initial problem. However, a member of the JIIC team on this project took a number of digital photographs and some approximate measurements. Using this data the candlestick was then recreated in 3D CAD and then built in sections using both Objet's Polyjet 3D process and 3D Systems' Invision HR machine. The models were subsequently cleaned up and given to 3DDC to be nickel plated. The results were very impressive indeed (see figures 6–8).

Frank Cooper of the JIIC commented on the project, he said, "We were extremely pleased with how the candlesticks look — they are even better than we had anticipated, producing a very realistic rendering of a patina candlestick. And because they are replicas visitors to the museum for the Boulton exhibition will be able to touch and interact with these models. Following this successful project, we will certainly be looking at exploring ways of developing and using this plating technology adaptively in both the jewellery and silversmithing industries."

Conclusion

The jewellery industry is a fascinating market to examine, with the associated aspirational qualities it evokes, but beyond that, in design and engineering terms it generates new and exciting challenges for rapid product

development technologies and processes. There will never be a ‘one solution fits all’ due to the nature of the sector and the breadth of the spectrum from the lower end of the market to the higher end. However, the opportunities afforded to companies by utilising new technologies such as those offered by Envisiontec and 3DDC are great these companies are reaping great rewards.

For further information on the Metalise it ... process from 3DDC, visit www.3ddc.eu.
For more information on the Aureus Machine and Perfactory Desktop machine, visit www.envisiontec.com.

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