CAD-CAM Technology: Transforming the Goldsmith's Workshop

Experiences and benefits of CAD-CAM by a jewellery manufacturer

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Introduction

This presentation has been intended as a complement to the papers by Ante Rem and Vendorafa presented at previous International Technology Symposia held here in Vicenza (see *Gold Technology* No 20, November 1996 and No 23, April 1998). Stilnovo Srl are the end users and we can bear direct witness to the considerations that led us to choose this CAD-CAM technology and to the results we obtained. When we started to use this technology, it was very innovative and risky.

Does new technology alter the process and degrade the final result?

About seven years ago, our first consideration was: *can the operations related with the manufacture of a jewellery item be split into two distinct parts?* It is a common opinion – frequently supported by good reasons – that jewellery production is a field between art and handicraft, a kind of "production space" ruled by creativity and manual learning, which has been handed down to posterity through the ages.

By definition, a jewellery piece is something precious and rare. The adjectives "precious" and "rare" already show the limits of the space we mentioned above. "Precious" not only denotes the raw material, but also the manual skill of the goldsmith who makes the object and the style refinement of the creative designer. In other words, it denotes excellence with regard to the jewellery quality and to the capability of man. Consequently, a jewellery piece will be rare, because the world reserves of precious metals are scarce and the humans endowed with such an admirable talent are also scarce.

Going away from this tradition means to do something revolutionary, that can be compared – if we put it in the right perspective – with the revolution that took place about one century ago with the advent of photography, in a world that up to then had only been painted by hand. What happens to an artistic masterpiece when it can be duplicated by means of technology? How much will its value be changed? (see W. Benjamin, "Das Kunstwerk in Zeitalter seiner technischen Reproduzierbarkeit" - "The work of art in the age of its technical reproducibility"). When transferred in the field of jewellery production, this question could become: 'what happens to the goldsmith's masterpiece or to the craftsman's work when it becomes industrialized and is manufactured with mass production technology?'

What is the true value of a jewellery piece that will be produced in the thousands? In other words, can we see as precious something that is no longer rare? The answer is definitely yes. Modern times have hidden this problem with the technique of marketing. The value of an object is measured from the desire it arouses and from the ability of the advertiser to suggest uniqueness and rarity both for the object and for the person who will wear it.

Consequently, jewellery manufacture can be industrialized, because this distortion will be concealed and separated from the object, whose "aura" will be recreated later, by the trade department of the company.

What opportunities can be offered by the choice of new technologies?

Our answer to this question induced us to borrow from industry the design technology and to maintain the traditional technology for the production operations. Obviously we approached CAD (Computer Aided Design)-CAM (Computer Aided Machining) technology.

Going from the excellent manual ability of the master model maker to the much more prosaic skill of the designer on computer brings three important advantages.

1) The special professional skill of an expert craftsman (the model maker is the typical goldsmith) is no longer required to realize the project: today, excellent craftsmen are a species on the verge of extinction. Therefore, we can turn to the much more common skilled draftsmen, who are trained in great number in specialization schools and dedicated master courses.
2) To draw a master model instead of making it means to compare two different kinds of approach to construction: the traditional way and the modern one. Frequently this comparison gives rise to an analysis of the production process that can help to rationalize it.
3) Moreover, the results obtained with CAD-CAM technology show a very high degree of precision that cannot be attained with manual work. So the subsequent step, i.e. production, will also benefit from it. In other words, the production work will be

easier to do and the factory manpower will need a lower level of training.

On the other hand, CAD-CAM technology also requires one to bear some burdens that cannot be defined as disadvantages, but represent a "cost" for the company. We can schematically classify these costs as follows:

1) To equip the company with a CAD-CAM system means to meet a considerable expense for equipment and training. In our case, our excellent model maker engaged himself in the task of learning. Maybe this is the optimum condition, because a single person will bring together the heritage of craftsman's excellent ability and the knowledge of new technology.
2) A complete reorganization of production methods and practices is necessary to obtain all the possible advantages from the decision to design with the new technology.

Now, it is worth a few more words on a more detailed examination of the problem, because the appropriateness of the choice strongly depends on the answer we give to the above points. First, we have the problem of cost. Therefore it is necessary to calculate the cost of the equipment, that currently starts from a minimum of 130,000.00 euros, depending on the kind of system we want to adopt. To this cost, that can be considered certain, further costs should be added, that refer to the implementation of the new system. These costs are difficult to anticipate.

I recommend to anybody wanting to venture on this road to consider firstly the human resources that are available in the company and who should be involved in the modernization process. The ideal person embodies the expert in jewellery design, i.e. the traditional model maker, and the expert in computer graphics. There is little probability that such a person will be available on the work market. So we could opt for the co-operation between an expert goldsmith coming from the factory and an expert in computer graphics. The expert goldsmith knows the style of the factory and is able to understand its guidelines correctly and the expert in computer graphics knows the rapid prototyping systems usually adopted in the mechanical industry. The evaluation of the required time and the inherent costs for the integration of these two kinds of professional ability should be a duty of the managing director of the company. For this evaluation, the specific features of the company should be taken into account and, unhappily, there is no available data to help us to solve this problem.

However, we can give information on the organizations supplying training programs similar to the above described requirements. For example, the Politecnico of Torino (Technical University of Turin), Italy, Alessandria Section, has organized two different programs, one for the graduates of high school and another for the holders of a university degree. These programs aim to introduce the attendees to the world of jewellery production, and jewellery design problems are carefully analysed. For example, the attendees of the Master Courses on Jewellery Engineering are able to communicate with jewellery factories because they have already studied the production process, from casting to quality control, and frequently they have already seen it, during the training stage in the factory. A professional training of this type greatly facilitates the implementation of the new system. In Milano, Italy too, both the Politecnico and the European Institute for Design offer interesting possibilities.

The second item of our schematic outline asks an important question of us: are we ready to reconsider the whole production process, in order to adapt it to the requirements of the new approach to model making? I do not fear to be opposed when I say that this investment will bring benefits only if we are ready for this reconsideration. Therefore, once more the expert manager should consider the human resources available in the company and evaluate their attitude towards change and continuous training. Eventually, the inclination to a modern approach to work problems will be the most useful indication of the actual cost to be sustained to get the best results.

Comparison between traditional and "modern" approach to design. An example: the CUBE LINE of Gucci

As an example, we will engage in a kind of exercise: we will deal with the design and production of a jewellery collection that, because of the problems it enables us to discuss, will help us to understand requirements and benefits of the new technology: the CUBEs of Gucci.

Figure 1 - Artist's drawing that gives indications of the size of the centre stone. Also the general slope of the sides and the described details are visible

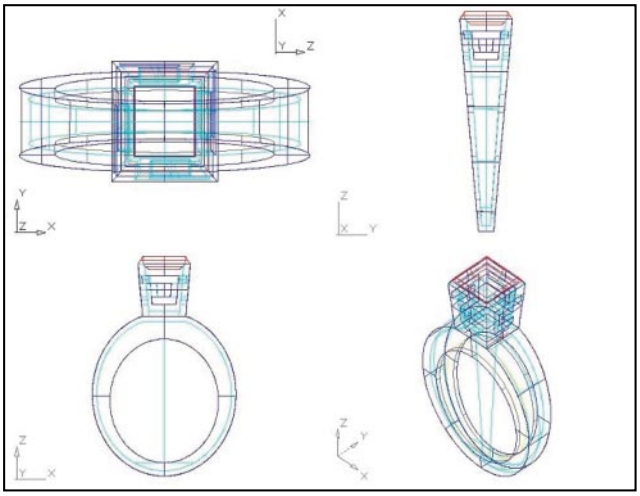

Figure 2 - "Translation" of the artist's drawing into a working drawing

Figure 3 - Rendering of the piece

Let's see Figure 1, representing the artist's drawing. Up to now, nearly all creative artists make pencil drawings and the "translation" is up to the technician, Figure 2.

A] Traditional method for making the master model

The maker of the master model must face the specific difficulties of this ring, Figure 3, which can arise mainly from:

1) The rigorously geometric shape of the piece; it does not contain curved surfaces, but only flat surfaces and sharp edges (fretwork, inner cavity of the shank, etc.).
2) Repetition of the fretwork in the ring's head: even small differences of size and shape will not be tolerated, even by the inexperienced eye.
3) The need to respect the slope of the sides of the ring (shank and head) and harmonize it with the perfectly square form of the head. The head should have perfectly square corners but its walls are not perpendicular to the contacting surface of the shank.
4) Very high precision of the fitting between head and shank, because of the aforementioned reasons.
5) In our exercise, we consider a piece marketed by Gucci, a very big company, that produces very large amounts of high quality jewellery. In this case, as also happens for other prestigious companies, the strict quality control and the large number of pieces to be produced, make it economically profitable to design not only the standard size piece, but also the master models for the most common finger sizes. Making the different models by hand means to meet the same difficulties each time, and to multiply the problems. Moreover, as the difference in comparison with the mean size increased, it is necessary to change the angle between the flat sides, to keep constant the proportions of size and shape.

To overcome these problems, the traditional model maker can rely on his traditional tools: the raw material - wax or nickel silver or something else - will be shaped with the file, the hacksaw, the compass and not much more.

Everybody can easy realize that:

- the model maker should master a lot of manual skill;
- the end result will never reach the high precision level guaranteed by machining, even if the operator is highly experienced;
- the time required for making the model is very long and is multiplied many times when models of different size are required.

B] Making the master model through a CAD-CAM system

To make a good drawing means to create with CAD a design suitable for the CAM that will transform it into a shape. Therefore, the draftsman should approach his work with the aim of finding the best way to utilize the machining centre, taking into account its specific features, Figures 4 and 5. If he is able to perform this task knowledgeably, with the use of the new systems, the features before defined as object related problems, will simply become characteristics of the object.

With a CAD system, to draw curved lines instead of straight lines makes no difference and to repeat the fretwork means only to "rotate" it. Finally, and this gives the most important economic advantage, joints and finger sizes can be designed at the outset: on the basis of maximum and minimum diameter, the slope of the sides of the ring and the shank thickness after sizing can easily be determined. With the traditional way of model making, the thickness of the shank after sizing is a result, an end point, after making the copies of the ring for the different sizes. To design it in advance helps to avoid the risk of failing to achieve the correct realization of a ring, e.g. of size 60, because the shank becomes too thin, as a result of the angle between the side surfaces, Figure 6.

The replication of the master model for the different finger sizes becomes simplified: to change proportions or dimensions is mere mental work: first the software and then the machine will carry out the required work perfectly.

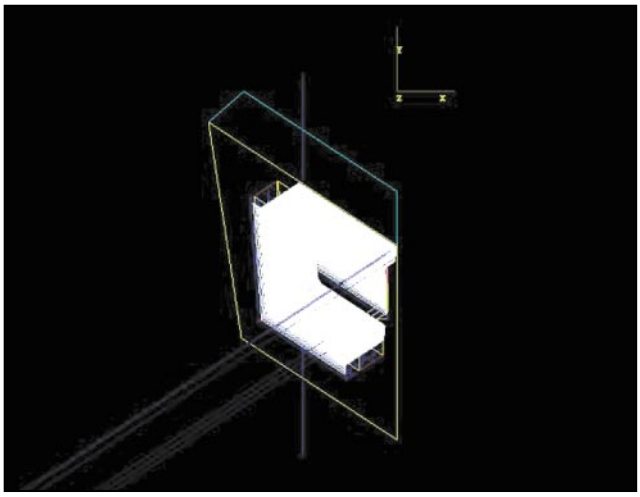

Figure 4 - A step of CAM

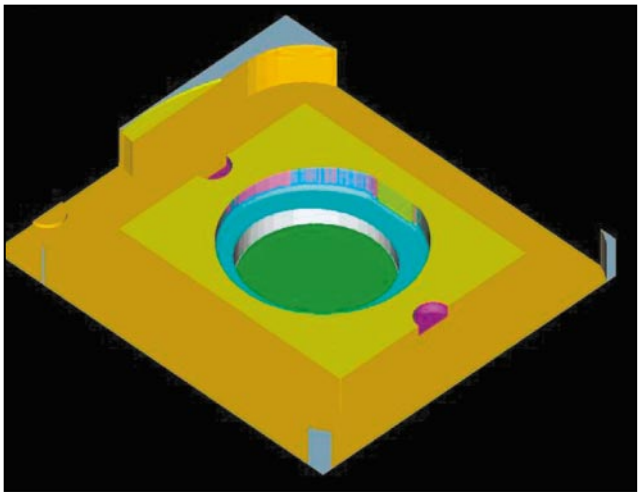

Figure 5 - Another step of CAM

We have described the advantages given by making the master model with the new technology, but nearly all these advantages can be nullified by a production process that cannot be adapted to the new requirements. We will save time in model making, but we will get a poor quality product, if we cannot obtain suitable moulds for the production of wax patterns, that duplicate perfectly the machined master model. We should remember that the introduction of the new technology upsets the way of envisaging the production process: formerly the manufacture of the object derived from the work of all the operators and only the task of "making adjustments, adaptations and corrections" was left to the goldsmith. Now the perfection of the master model manufactured with the CAD-CAM system gives the whole workforce devoted to the artisanal process of assembling and finishing the following rule: to do as little as possible. Because of space limits, in this presentation we will extend our process analysis only up to the production of wax patterns.

From this point of view, the rubber moulds for the injection of wax patterns must guarantee a perfect duplication of the master model, without deformation problems caused by the extraction of the wax pattern, or flashes or other defects. In this case only, will it be possible "to do as little as possible". Presently, CAD-CAM technology can also help to design and to produce the tools needed to achieve the required result: to make mould cutting easy, so the wax does not show defects requiring correction.

Moreover CAD-CAM helps us when the mould shrinkage is different from that anticipated. It is well known that attempting an exact evaluation of mould shrinkage is not realistic, because too many variables need to be considered. Therefore, a constant shrinkage factor is used and later, if necessary, the dimensions of the master model are adjusted, after experimental trials. If, for example, it was necessary to increase the size of the model, the traditional model maker dipped it in a plating bath. In this way all dimensions of the model were increased. But we know that generally mould shrinkage is not uniformly distributed and frequently we need to increase the thickness in some areas only. With the traditional method, some parts could be insulated before dipping in the plating bath and after plating a smoothing operation was required. If the whole model was plated, it was necessary to remove the excess plated metal. With the new technology we can modify only the part of the model that should be enlarged. Then we make a new prototype, which perfectly compensates the mould shrinkage we observed experimentally. You can easily realize the benefits we obtain in work time and in accuracy of the model.

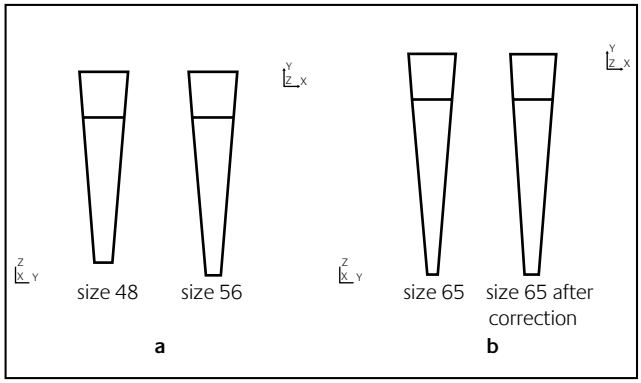

Figure 6 - a) Difference between size 48 and size 56: it can be seen that the width of the shank after sizing is no longer sufficient to guarantee wear resistance
b) Correction: the correct size is determined at the outset

Conclusions

The advantages of CAD-CAM over the traditional approach can be summarised in the following table :

Old	New
The model maker interprets the artist's drawing and makes a model. Only on the real object, even if in the unfinished condition, he will be able to observe: • volumes • visual appearance And calculate: • Weight • Range of finger sizes (for a ring) • Right and left pieces (for earrings) • Repetition of patterns (e.g. fretwork in the CUBE ring) • Enlargement or reduction of some parts.	The work perspective changes completely: what before was the end result is now a part of the initial study. The object is submitted to a scrutiny of the form. The results can be simulated by stating the size parameters: • by scaling up and down • with mirror reflection • by verifying weight accurately. When the CNC machine starts machining the metal, the model maker begins the final check of a practically completed work.

These new developments lessen that magic aura pertaining to past time jewellery pieces, but this is the way progress goes on. The main objective of this paper is to arouse a spark of interest for the new developments in sceptical people. So my own experience will gain a value going beyond my business.

I would like to conclude with a reflection of Paul Valery. I will commit to his authoritativeness the task of letting the reader reflect: "...the astonishing increase of our means, their ductility and precision, the ideas and habits they bear with, will bring imminent and deep changes in the ancient industry of beautiful things. In all kinds of art there is a material part that can no longer be considered and treated as it was in the past times and can no longer escape the effects of modern knowledge and power..... We can expect that such important new developments will fully transform the technology of the arts. They will even influence the very mechanism of invention, even up to a wonderful change of the concept of Art."(La conquête de l'ubiquité - The conquest of ubiquity).

It was 1934, and Valery referred to the impact new technologies will have on modern art. At the present time in 2002, we can apply the reflection of Valery to the field of jewellery. We can feel ourselves to be not "less artists", but simply more modern ones, able to delegate the machine to do the manual operations of minor importance and devote ourselves to the fundamental value of aesthetic and technological creativity.

World Gold Council Website: Finding technical information

There is a large amount of technical information on gold available on the World Gold Council's website, www.gold.org This is constantly being updated and improved in content.

General information is to be found in the 'Discover' section. Look at the menu and select the 'Knowledge' domain.

Jewellery information can be found in the 'Value' section, under the 'Jewellery' domain, although the jewellery magazine, "Inspirations" can also be found in the 'Enrich' section

Jewellery technology information can also be found in the Jewellery domain, under the 'Technology' sub-domain. There is a menu of items giving basic information on a number of topics. Here, you will also find current and archived volumes of *Gold Technology* in both English and Italian versions. It is planned to put the complete set of back issues of *Gold Technology* on this site later.

Other technical information can be found in the 'Value' section under the 'Science and industry' domain. The site contains information on the industrial applications of gold (latest developments, electronics, dental, biomedical, catalysis, decorative and other interesting applications). There is also information on the properties of gold and details of World Gold Council's GROW programme of support for research, development and feasibility studies leading to new applications of gold. In the coming months, further details of the proposed international conference on New Industrial Applications of Gold – Gold 2003, will be available via the website. Access to current and archived volumes of *Gold Bulletin*, as well as the gold catalysis newsletter, *CatGold News*, will be found here too.

For **Jewellery Technology**, remember: Click mouse on 'Value' section to reveal menu; click again on 'Jewellery' and then click again on 'Technology' to reveal technology menu! It is easy!


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