The role of CAD/CAM in the modern jewellery business

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Introduction

Today I will explain how production techniques developed in fields quite different from goldsmithing can be adapted perfectly to jewellery manufacture. In this presentation, the following topics are discussed:

- what is CAD/CAM
- what opportunities this new technology can offer to jewellery factories
- when use of CAD/CAM can be profitable
- how can CAD/CAM be utilized to the best

At the threshold of the new century, technology can offer substantial support to all the activities of the goldsmith. Particularly in recent years, much research work has been carried out in the field of jewellery production and new sophisticated technology for jewellery manufacturing has been developed. Unhappily, the goldsmith does not always readily accept new technology. To give an example, investment casting was introduced in the late 1940s, but it was not accepted by the industry until the late fifties. Ten years elapsed before it was used in factories.

Consequently, in spite of active research work for end product quality improvement, there are some production steps that seem unaffected by the lapse of time. In particular, there is a step in the production process where, even today, the goldsmith is still unwilling to accept new technology. This step is design or, more precisely, the intercommunication between the designer and the goldsmith - that is, between creativity and practical realization. It has always been believed that a compromise between aesthetic and production technology requirements is difficult to reach, but this has not actually been true for a long while, a statement proved by many examples of industrial design, such as Pininfarina design for the automotive industry. These demonstrate how creativity and imagination can perfectly be harmonized with computer calculations.

The instrument enabling this small miracle is named CAD/CAM. These acronyms denote all systems that assist design (CAD = Computer Aided Design) and manufacturing (CAM = Computer Aided Manufacturing) through a computer.

What is CAD/CAM?

Let us first analyze design. Traditionally, CAD denotes programs that replace the pencil and assist the designer in the representation of his ideas. These programs aid in the achievement of a quick development of the design and allow an immediate control. Moreover, they enable the transmission of the designed geometric patterns to other programs for machining.

I have said "traditionally", because unceasing evolution has somewhat changed the original characteristics of these systems. Initially, this software was mainly used for mechanical design. Later they underwent a true transformation and gave birth to two distinct branches: the first one led to the development of programs named CAE (Computer Aided Engineering), and the second one led to CAID (Computer Aided Industrial Design), both software for model development and study of style.

The programs of the first kind are of a more technical nature. CAID programs don't require operations like dimensioning and patterning and give more emphasis to the creative phase. They enable a perfect simulation of the reality and give immediate concreteness to ideas. Consequently, different kinds of CAD systems have been developed that are devoted to different design and modelling types, such as:

- Polygonal modelling
- Surface modelling
- Solid-parametric modelling
- Hybrid modelling.

Let us briefly describe the above types.

Polygonal modelling: This is the most common CAD modelling software: all models are created as a combination of small squares and triangles, Figure 1.

Surface modelling: This CAD software shapes the surface, ie. the "skin" of the designed object, and enables the achievement of very complex shapes, Figure 2.

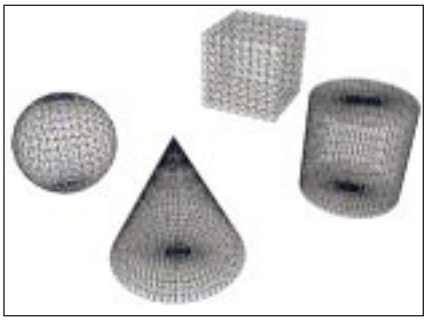

Figure 1 - Polygonal modelling

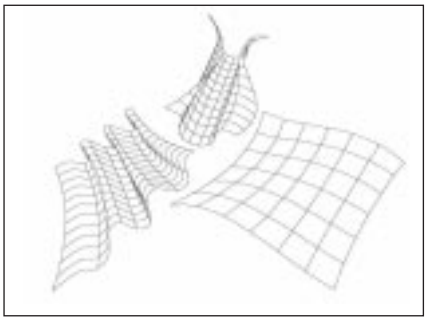

Figure 2 - Surface modelling

Solid parametric modelling: This software is based on the geometric parameters defining the object, Figure 3. The ability to modify the design whilst keeping some parameters constant is typical of this kind of modelling. For example, if we change the scale of the star on the left side of Figure 3 with a non-parametric modelling system, all dimensions of the star will be changed. If we perform the same operation with a parametric CAD, one parameter of the drawing an be kept constant whilst others are changed.

Hybrid modelling: CAD systems that combine surface and solid modelling, Figure 4, and enable the creation of complex patterns, starting from simple models.

These classifications do not have a commercial purpose, like classifying the products from different software houses; each type denotes a specialization, with a completely different approach to design, and has advantages and drawbacks. A design that is quite easy using one type of software can become very complex if another one is used.

For example, to design a model with recurrent geometric patterns, like a bangle adorned with fretwork, Figure 5, then a true CAD, that is a solid modelling system, is preferable. In contrast, if I want to design an artistically very elaborate object, Figure 6, a CAID system, that is a surface modelling system, is preferable.

Consequently, software selection should be carefully considered and should be based on production characteristics and potential of the company. It must be remembered that CAD design is definitely not automatic and always man is the "thinking" subject. A wrong choice can cause big problems in the use of the system and, in some cases, can make it completely useless. There is a wide range of modelling systems offered on the market and an inexperienced company can have great difficulties in making the correct choice.

After this premise, we can consider the step that comes after CAD modelling, by CAM. CAM is a computer directed and controlled production activity. CAM technology not only allows direct control of machines and of a company's functions, but can also enable production planning, in order to reach the following objectives:

- automatic diagnostics of production process,
- product quality analysis,
- collection, organization and recording of data on process stages and work progress,
- and, principally, production control.

In practice, CAM denotes all industrial production activities where the different production stages can be planned and controlled. More simply, CAM denotes the programs used for the implementation of CAD geometries and for the subsequent machining in numerical control systems that include a wide range of machines where machining can be programmed, such as copying machines, milling machines, lathes and spark machining systems.

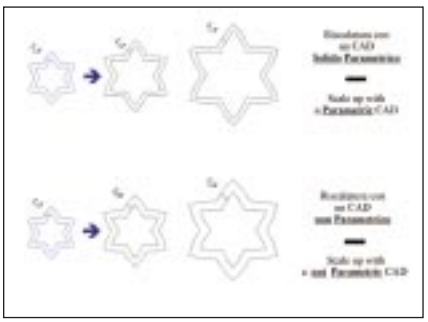

Figure 3 - Solid parametric modelling

Figure 5 - Model of a bangle with recurrent geometric patterns

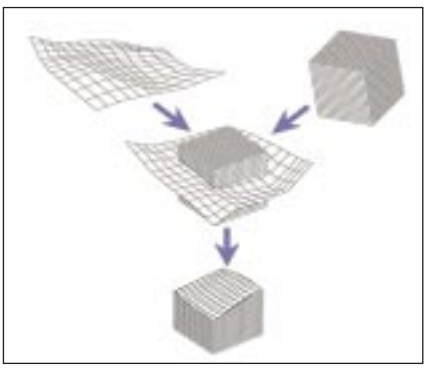

Figure 4 - Hybrid modelling

Figure 6 - Model of an artistically elaborate item

Figure 7 - The designer's sketch

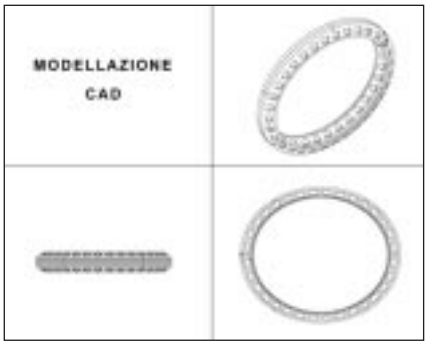

Figure 8 - Realisation of the model by CAD drawing

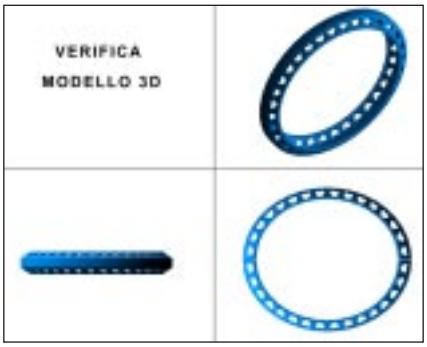

Figure 9 - Model after mathematical analysis and verification

To gain a better understanding of the above topics, we will examine a practical application of CAD/CAM in jewellery manufacturing. The task of the jewellery designer and of the goldsmith can be divided into two phases. The first phase concerns CAD modelling: The designer's idea (usually a sketch drawn on paper) is the starting point, Figure 7. The next stage is the realisation of the drawing with the CAD program, Figure 8. In this case we have preferred a solid parametric modelling program because, as said above, the bangle shows simple recurrent fretwork patterns, such as small hearts. Moreover, if we want to produce the same bangle in a different size, a solid parametric system will enable us to change the size of the object while keeping, for example, the thickness constant.

The mathematical model is analyzed with the same program to verify the surfaces and control any possible errors, Figure 9. Finally, to get a better understanding, the finished object is simulated. This phase is named "rendering" by the technicians, Figure 10, but is not essential for the production of the model. It is used only to check the aesthetic characteristics of a jewellery piece.

Now comes the second phase, CAM manufacturing, where the machining route is planned. Supposing the work is to be carried out on a milling machine, the following stages should be performed:

The geometry of the item is fed into the CAM system and a parallelpiped is created with a slightly larger size than the designed model. This parallelpiped simulates the material block that will be actually machined, Figure 11. Obviously, the material machined is not necessarily gold but, more commonly, a cheap material is used, such as wax, plastic or a base metal.

Figure 10 - Model after rendering

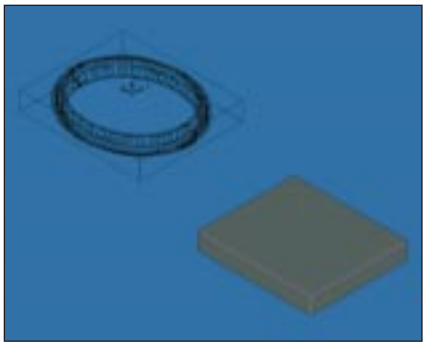

Figure 11 - Importing the model into the CAM system

When tool type and machining technique have been defined, simulation of machining can begin, Figure 12. In this figure, we can see the tool of the milling machine carrying out the first rough shaping. In the subsequent finishing phases, Figure 13, the object is more precisely defined until the final finishing cut that completes the manufacturing operations. Now the machining route is ready and it can be sent to numerically controlled machines for the manufacture of the real object.

To sum up, what does a CAD/CAM system mean today? A CAD/CAM system is able to carry out the development, control and preparation of the model, or of the tools required for model manufacturing, such as moulds or templates, setting of machine tools. Above all, it enables a clear integration of the above phases in an integrated 3-dimensional modelling environment.

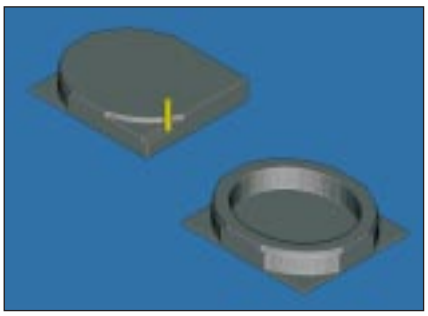

Figure 12 - Simulation of rough machining of the model. The tool of the NC machine is seen.

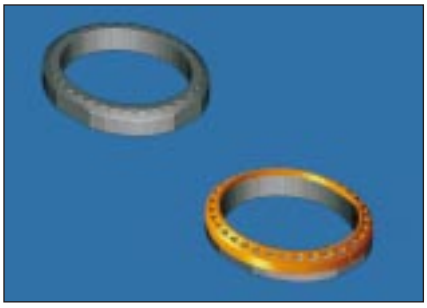

Figure 13 - Simulation of the finishing stages

CAD/CAM in the factory

Now the next question to be answered is 'how can these technologies be introduced in the jewellery factory?' Introduction of these new technologies in a company, or to arrange for the company to utilize them by means of new specialised design companies, can give substantial advantages in terms of cost and time required for making a model, but it is not exempt from problems. In particular, it has been observed that, generally, the introduction of these new technologies can lead to one of two opposite reactions: either the company totally refuses to consider the new technology or takes a liking to it and tries to use it at all stages of the production process, possibly fully in-house.

In the first case, the refusal generally comes from the fear of change. At the start, some manufacturing operations will require changes that will result in some unavoidable opposition inside the factory by the operators who will see it, wrongly, as a challenge to their work or to their position. I stress "wrongly" because these new technologies absolutely do not aim to reduce or limit the tasks of designers or model makers. On the contrary, when these new systems are integrated into the factory production process, they will have much wider freedom of action and a stronger stimulus to imagination.

There is also the second case, when these techniques are not only accepted, but even extolled, when the first results are achieved. At this moment a new problem arises that is exactly opposite to the first case: the entrepreneur tries to do every thing with the computer, even the operations that can still be made more easily, logically and economically by hand.

To sum up, let us try to show when it is profitable to use CAD/CAM and when it is not through some examples:

Cases where CAD/CAM utilization is profitable

When a pair of earrings is to be manufactured, after making the model of the first one, Figure 14, the bigger problem is to make the model of the second one of the pair as a mirror image copy of the first, Figure 15. This operation is very complicated and time consuming when carried out by hand, even more than the production of the base model. By means of the computer it is quite simple and fast, Figure 16. The time required for the production of a mirror copy depends only on the power of the computer in which the

Figure 14 - Earrings: The designer's original sketch

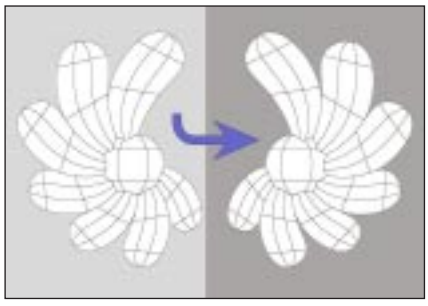

Figure 15 - Making the mirror image exact copy

power of the computer in which the program has been installed. The more power, the faster it is. The same reasoning is applicable to the resizing of a ring or of a clasp or a pendant.

We know very well that, when we put a new set of jewellery on the market, we cannot offer a single model, but we should offer several variants, even if only in the different standard size variants, that is small, medium and large. To satisfy this simple requirement, the model maker would have to make the same model three times, each in the different dimensions. When a computer is used, it is sufficient to scale up or down the relevant CAD model parameters to obtain all the required size variants offered by CAD/CAM designing, Figure 17.

Fretwork is another example of the advantages offered by CAD/CAM designing. The bangle discussed earlier, Figure 7, is a good example: If a model maker is required to cut by hand a set of little hearts or flowers on a bracelet, he needs several hours' work, and eventually the work may not be accurate enough. If the same operation is carried out with a computer, the time required is much shorter and the final result is accurate to a hundredth of a millimeter. The same holds for joints or hinges for watchcases and wrist-watch bracelets.

Cases when CAD/CAM utilization is not profitable

A fairly common error made by companies that use CAD/CAM is trying to make their models completely with this system for all cases. In practice, it may be preferable to produce some extremely technical and complicated pieces, that are difficult to make by hand, by means of a milling machine or other suitable machine. Other pieces can be committed to the skill of the goldsmith. Therefore, CAD/CAM should not be considered as a substitute for traditional techniques, but as a complementary technique that helps the goldsmith to carry out some operations more rapidly and more accurately.

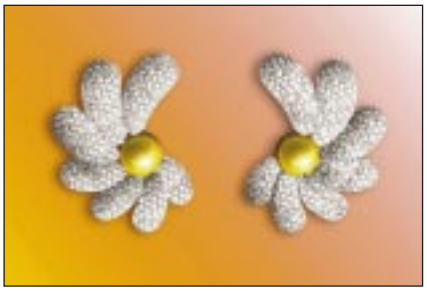

Figure 16 - Use of CAD to produce the matching pair of models

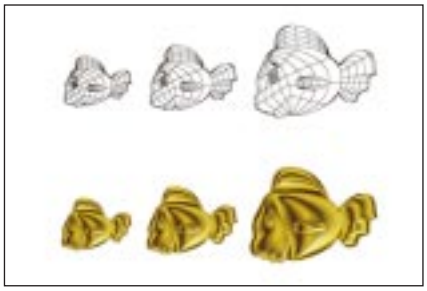

Figure 17 - Use of CAD to make size variants of the model - large, medium and small

Obtaining the best from CAD/CAM

Firstly, a project should be defined that enables planning of the different steps required for making a model. Lack of planning often leads to full or partial remaking of the model, because some production problems have not been taken into account; for example, a bracelet with a poorly limbering hinge, or a clasp that does not stay closed, and other problems that every goldsmith normally meets during his everyday work.

Design requires a sequence of choices and brings two different worlds into contact - the world of creativity and the world of production. These worlds should integrate to achieve a common objective: aesthetic and technical high quality of the end product. The problem is to get agreement between the ideas of the designer and the rules of the design. It requires overcoming distrust and language, educational and cultural differences. It should be realized that using a computer doesn't mean it will make the company's production dull or banal. The opposite is true: where creative effort and care for high product quality are more vigorous, there are more possibilities to get the best results from these new technologies.

Another problem of CAD/CAM design stems from the fact that the development of these systems has always been bound to the requirements of big companies. Consequently, very sophisticated software has been developed and put on the market. This software is often over-sized when the needs of the average jewellery producer are considered. The company intending to use these techniques should, firstly, be able to select the technology that best fits its needs. As stated earlier, a wrong choice can effectively make the new machines useless. This causes not only a remarkable loss of money, but also a strategic setback in comparison to competing companies that have been able to make a better implementation of new technology. In addition, an analysis should be carried out within the company aimed at evaluating the production capability, problem areas and workforce skills. It is important that any changes in company organisation and management arising from the implementation of such new technology should be fully explained.

In conclusion, there is no single way to introduce CAD/CAM technology into a company, and, principally, there are no pre-packaged systems that can be purchased to overcome all the problems. The route to be covered is formed by a set of strategies that concern the organization, management and programming of the whole company. Technology should be considered as an instrument that can make this change easier, but it cannot be a solution for all problems. The company believing all its problems to be solved because it uses advanced technology is wrong: it will only succeed in computerized chaos!

CAD/CAM systems should be run by expert operators who know the jewellery manufacturing process very well as well as the utilization of computers. For this reason, in recent years new types of professional are emerging, who are able to introduce the new technologies into the factory. In this way, a company is not obliged to make large investments to put together people and machines able to carry out the production operations described above.

At this point, I already know the question that rises in your mind: What if the service company I entrust with my designs decides to "clone" my models and offer them to a competitor? There is only one answer: THAT SERVICE COMPANY WILL SHUT DOWN! Any service company *must* keep all projects strictly confidential if it wishes to continue in business; not doing so is not only morally censurable, but is also injurious to its business. Serious service companies have generally already begun to take the measures required to guarantee confidentiality and secrecy of past and future work.

In other fields, these technologies have been used for many years. Today, no product is produced, be it a car, an electrical household appliance or a piece of furniture, that has not been designed on a computer and scrutinized in its aesthetic and technical aspects. In my opinion, in the near future this will occur in the field of jewellery, to satisfy the quality standards the market has required for some time.

Acknowledgement

The authors wish to thank the World Gold Council for their help and encouragement in the preparation of this presentation and the Delcam International company for provision of technical information and advice.