

# WorkNC Re-roughing Strategy used in High Speed Milling

*(Abstract) This article analyzes the features and advantages, as well as the difficulties, of HSM applications in mold and part machining and NC programming and points out that "Cutting with Constant Rest Material" is the key point in HSM programming. This article also presents how WorkNC roughing and re-roughing strategies based on the Dynamic Stock Model fulfils the key point.*

**Keywords :** WorkNC, HSM, CAM, Re-roughing Cutting with Constant Rest Material.

## ► Introduction

Mold manufacturers are facing many unfavourable factors in the current market environment. The price for manufactured molds is gradually diminishing, the requested delivery times are becoming shorter and the cost of raw materials are rising, whereas, molds are expected to be of higher quality. Many mold manufacturers import advanced HSM equipment to promote technical competence to enable them to break away from traditional production processes, to face challenges and win opportunities in the market. The HSM technology significantly increases mold milling speeds, decreases working processes and time-consuming hand finishing, which makes it possible to achieve high precision and excellent surface quality in just one process, considerably shortening the mold production cycle.

The HSM technology has been improving along with the development of high-performance CNC equipment, tools and CAM systems. SESCOI - a French company, has been collaborating extensively with world famous machine-tool and cutter manufacturers. WorkNC, their automatic CAM system, enables high speed machining of highly complex rapid prototyping products, parts and molds by using its extremely reliable and highly efficient toolpaths, developed especially for advanced machining.

## 2. Advantages of HSM

### 1. Different types of HSM

There are two types of mold machining processes: machining aimed at stock material removal (roughing and semi-finishing toolpaths) and machining aimed at achieving required product finish quality (finishing toolpaths). Accordingly, HSM is composed of two types based on the machining process:

① Machining methods that use high speed equipment and high feed rates in cutting, fully exploit the performance of the machine-tool and cutters during a shorter period of time to cut and remove large

quantities of stock material (HSC or HSM, or sometimes called high-efficiency machining).

② Using high speed machining to improve the surface precision and surface quality of mold or products; using high speed machining to improve the cutting performances of smaller tools so that the smaller details of molds and parts can be directly machined without using EDM.

## ► Advantages of HSM

### High efficiency

Research shows that the speed of HSM can be up to 5 times higher than ordinary machining. Owing to the adoption of high feed rates during cutting, HSM can cut more stock material within a specified time period, therefore achieving high cutting efficiency.

### Machined products are of high precision and have excellent surface finish quality.

Smaller  $A_p$  and  $A_e$  are adopted during the HSM process to promote part surface quality. By using HSM technology, the surface of molds and parts can achieve a mirror effect; meanwhile as the cutting speed becomes faster and faster during the HSM process, the cutting capability will be lowered by 15-30%, which allows most of the cutting heat to be dissipated by chips, hence the thermal deformation of work pieces is largely decreased. In addition, its high rotation speed and high cutting speed make the machine tool easily overcome the vibration frequency of the system, therefore the whole machining system vibrates less and works under stable conditions, which improves the precision and surface quality of the work piece.

### Process simplified

The roughing process of ordinary milling can only be performed before quenching, while HSM can directly machine hard materials; HSM promotes the cutting capabilities of small tools, thus the EDM process becomes unnecessary; moreover, HSM promotes the precision and surface finish quality of the mold, therefore reducing hand finishing and polishing time.

Here is a comparison of the process for ordinary machining and HSM:

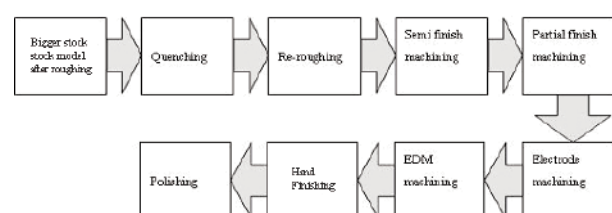


Figure 1. Ordinary machining process

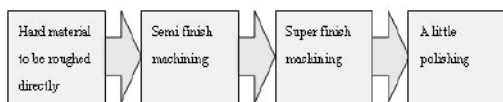


Figure 2. HSM Process

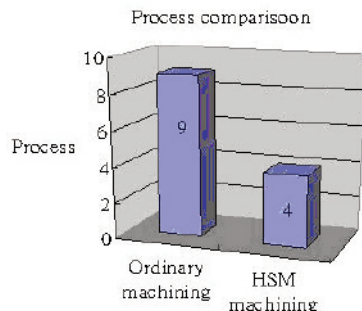


Chart 1. Process comparison

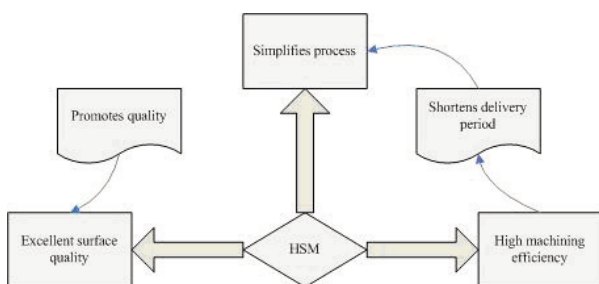


Figure 3. Strengths of HSM machining

### ► Barriers in HSM CAM programming

Some companies are equipped with HSM centres that perform exceptionally well, have balanced tool holders and expensive cutters, however, this high performance equipment does not fully exploit the strengths of HSM.

#### 1. CAM programmers' headaches:

- Why does severe tool wear, chipping or even tool breakage occur easily during semi finish machining?
- Why do distinct tool marks or ridges occur during corner cleaning if the finish machining quality is not so good?

#### 2. Key points of HSM CAM programming

- The tool path should be of constant speed and constant stock quantity removal, avoid quick directional changes and abrupt accelerations and decelerations.
- Avoid high volume chip removal rates. HSM works at speeds 5~10 times higher than ordinary cutting speeds. Once high volume chip removal occurs, severe consequences may result to the work piece, tool and machine tool.

- Control the length/diameter ratio of the cutting tool. HSM requires that the clamping length of the tools be 3~5 times the cutter diameter, otherwise the tools can easily jitter.
- Intelligent cutter approach and retract strategies along with climb milling can promote machining quality and reduce tool wear.

### 3. Barriers in HSM CAM programming

The chip load should be constant and the remaining stock material from the previous process must be constant. Otherwise, when the tools encounter large amounts of stock under high speed machining conditions, the cutting resistance builds up and tool wear. Chipping or tool breakages will be unavoidable.

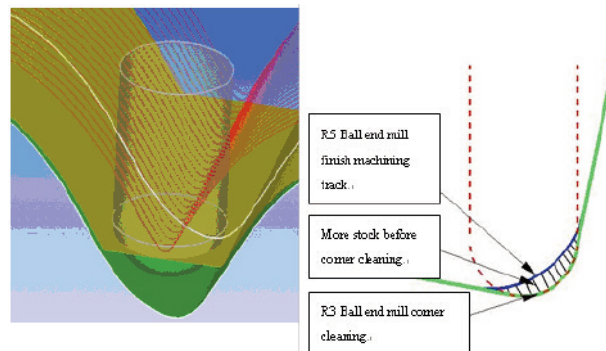


Figure 4. Roughing phase stock material is not constant, which causes tool damage during semi finish machining

Figure 5. Finish machined stock material is not constant, which causes tool damage during semi finish machining

### 4. The core technology of HSM CAM programming - cutting with constant stock material

During the programming of toolpaths for semi finish machining, finish machining and corner cleaning, the residual rest material should be removed evenly before each process starts. Only when the tools are cutting under constant rest material conditions can HSM advantages be fully exploited.

#### ► WorkNC solution on "cutting with constant stock or rest material"

#### WorkNC re-roughing strategy – global roughing / re-roughing introduction

WorkNC has strong re-roughing toolpath capabilities. This strategy could be used for toolpath programming of the whole mold or part rather than being used in the roughing process only.

The global roughing / re-roughing tool path strategy has the following features:

- **Auto recognition of stock model :**

WorkNC can automatically and intelligently recognize the status of the stock model and can update the stock model for use by the following toolpath. The stock model is dynamic and automatically updated. This function works throughout the whole tool path programming process.

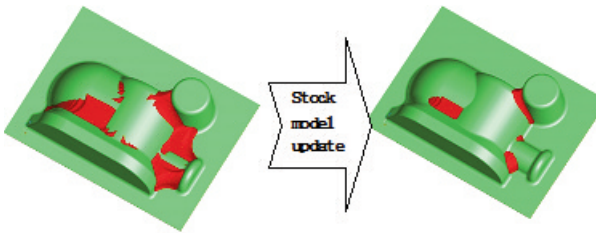


Figure 6. Automatic recognition and updating of the stock model

- **Spiral down climb milling reduces retracts**

One of the aims of HSM is to promote machining efficiency. Other software applications adopt climb / conventional milling in order to avoid retracting, thus accelerating tool wear in favour of machining efficiency. Unlike these, WorkNC adopts spiral down climb milling to avoid retracting when machining stock , which ensures the continuity and stability of toolpaths.

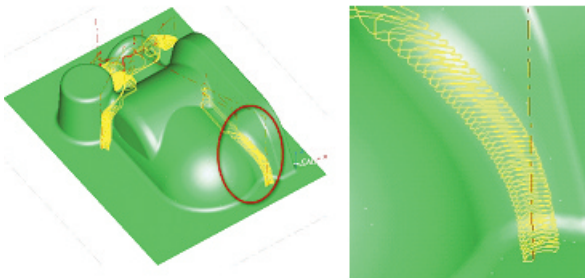


Figure 7. Spiral down climb milling reduces retracts

- **Cutting with constant rest material promotes cutter feed rates**

WorkNC is the first to propose programming techniques based on “dynamic stock model” in the HSM domain. Its real time detection ensures that chip loading remains stable, greatly promoting feed rates and cutting stability of tools during the HSM process, air-cutting is totally avoided.

Under the circumstances that cutting with constant rest material is achieved, finer details of the mold can be partially obtained by directly using tools with smaller diameters, which has a positive effect in promoting the quality of the final corner cleaning process.

- **Dynamic stock management provides solutions in deciding effective tool lengths**

For deep cavity molds or detailed structure, longer or shorter tools are usually used depending on the different depths of the mold. WorkNC calculates, in real time, the interference between the tool holder and the dynamic stock model to control the effective length of the tools and allocates the cutting parameters to tools of the same diameter but of different lengths, thereby promoting overall cutting efficiency and stability.

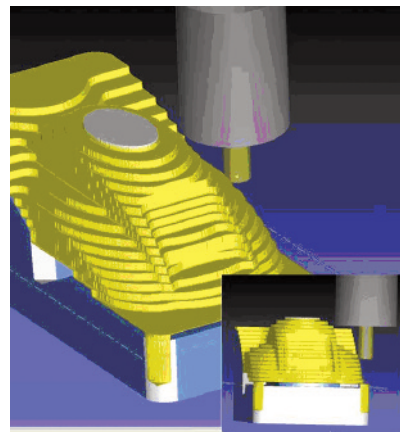
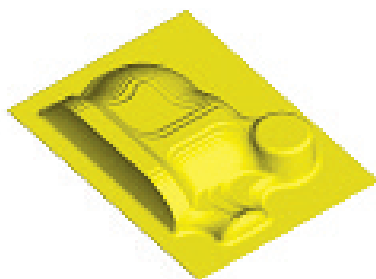


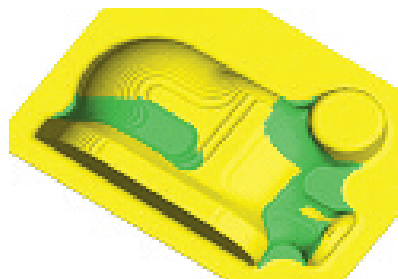
Figure 8. Dynamic stock provides solutions in deciding effective tool lengths

► **Strategies for constant stock models**

- **regular stock models before semi finish machining**



D20R3 roughing stock model

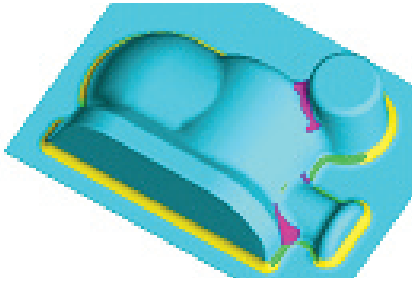


D10R1 re-roughing, stock model becomes more regular

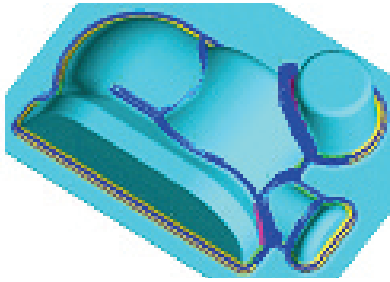


D6R3 re-roughing, ensures D10R5 stock become more regular before semi finishing

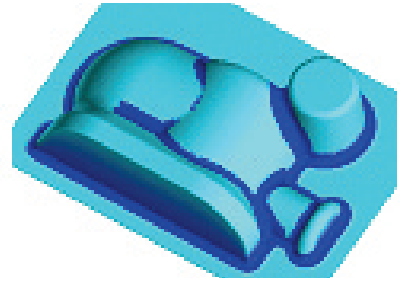
• **Regular stock model material before finish machining and corner cleaning**



*D10R5 stock model after semi finish machining*



*D4R2 re-roughing tool path, ensures D6R3 stock becomes more regular before semi finish machining*

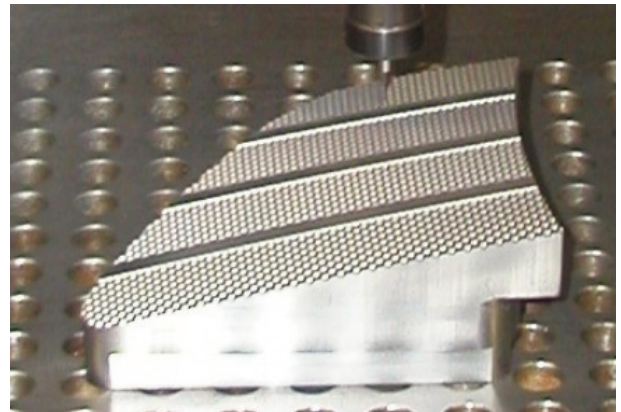


*D6R3 stock status before finish machining*

The process of obtaining a regular amount of stock material before corner cleaning is similar to finish machining. After this phase, it is not surprising that during semi finish machining or finish machining or corner cleaning, cutting with a constant amount of rest material has a positive effect on promoting the final machining quality and machining efficiency.

► **Shanghai Koito Automotive 5.**  
**Application case**

Lamp Co., Ltd. is the largest and the most professional automotive lamp producer in China. Using the re-roughing function of WorkNC, the mold production department of the company ensures that the stock model is absolutely constant before finish machining. Under the circumstances that cutting with a constant amount of rest material is executed, they use ball end mills with minimum  $\varphi 0.4$  for the high speed machining of surface details. The result shows that: high precision is achieved, which satisfies the optical photometric standards for automotive lamps; good quality – mirror effect is obtained as well, thus the difficult manual polishing work is no longer necessary and the unique advantages of HSM are demonstrated.



► **Sources**

Author - SESCOI International SAS

**For more information:**

**SESCOI International SAS**

Blvd General de Gaulle,  
BP 75, 71009 Macon Cedex, France  
Tel.: +33 385 216621

**SESCOI USA Inc.**

2000 Town Center  
Suite 1730 - 48075 Southfield, MI, U.S.A.  
Tel : +1 248 351 9300

international@sescoi.fr

www.sescoi.com