Flexible gear grinding machines

In recent years some extremely innovative gear grinding machines have come onto the market both in terms of how they are constructed and of how they operate.
It is a well-known fact that the two main gear grinding techniques used today are grinding using a form wheel (the profile grinding method) and grinding using a worm wheel (the continuous generating grinding method).
There are advantages and disadvantages with both of these methods which may influence production times, accuracy, surface quality of the ground tooth and so on.
With this new generation of machinery, however, it is now possible to choose which method to utilise and even to alternate between the two methods within the same cycle and on the same gear.
There are consequently notable reductions in grinding times and the overall quality of the gear produced is better.
The most important gear finishing methods are:

- *Shaving*
- *Profile grinding*
- *Continuous generating grinding*
- *Hob skiving*
- *External honing (shave grinding)*
- *Internal honing*

Gear shaving is until now the most convenient in term of cost, but the great limit of this technology is that we must shave before heat treatment.
Therefore the accuracy of the finished gear many time is not acceptable because the heat treatment produces some distortion.
Involute profile and helix shape can lose 1 or 2 DIN class of accuracy.
Today grinding operation is more and more used for to produce high quality gears, especially for low noise gear boxes and gear speed reducer.

The most established grinding methods are**:**:

- *Continuous generating grinding with a worm wheel*
- *Profile grinding with a form wheel*

The following point must be considered when we must choose a grinding machine<.

- *It is possible to use either ceramic or CBN grinding wheels with both methods.*
- *Each of the two methods are suitable for certain types of gears and certain types of production.*
- *In general it is not possible to say that one method is better than the other unless dealing with a specific type of production.*
- *Each of the two methods has advantages and disadvantages*

Notes on the continuous generating grinding method

- *The worm wheel can either be ceramic or CBN with a diameter that ranges from about 100 to about 350 mm.*
- *The wheel may have more than one start just like a hob. The kinematics are the same as in hobbing.*
- *This method is suitable for medium-large batch production.*
- *In general grinding times are shorter compared to form grinding if grinding gears with Z>15 but longer with Z<15.*
- *It is only possible to grind profiles that are obtainable by generation.*

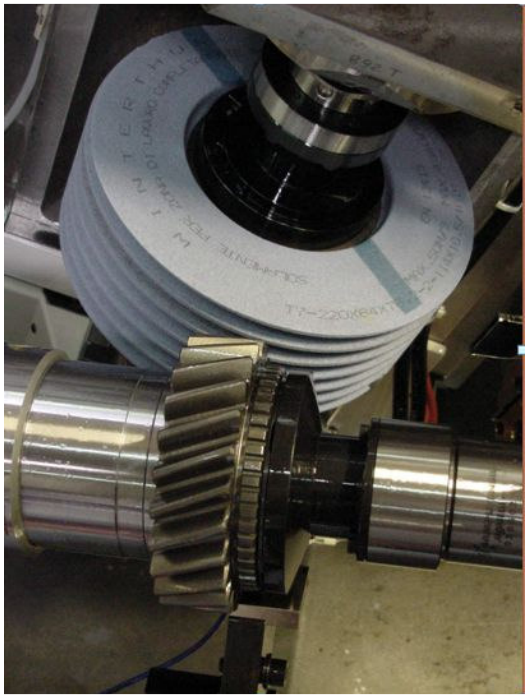


Fig. N°1- *Continuous generating grinding with a worm ceramic wheel*

Notes on the profile grinding method

- *The accuracy of the ground gear depends essentially on the accuracy of the grinding wheel profile. It is possible to attain accuracy in class DIN 1 – 2.*
- *The grinding wheel profile corresponds essentially to the form of the tooth vane unless modifications are necessary to compensate for possible interference between the grinding wheel and the gear tooth.*
- *It is possible to use either ceramic or CBN wheels with diameters of even up to 40 mm which is useful when grinding a gear close to a shoulder.*
- *It is possible to grind profiles that are not involute (splines, rotors, special worms etc.).*
- *This method is suitable for small-medium batch production.*

Fig:N°2- *Profile grinding with a electroplated CBN form wheel*

On the following pages the advantages and disadvantages of the two grinding methods are illustrated. The comments made, however, are of a general nature and so may not be valid in some specific cases. In fact there are so many different types of gears that are ground that it is impossible to apply a general rule without exceptions.

Comparison between a form wheel and a worm wheel

Characteristics	Form wheel	Worm wheel
Geometric accuracy	↑	↓
Surface quality	↓	↑
Grinding times with Z<15	↑	↓
Grinding times with Z>15	↓	↑
Ease of modifying wheel profile	↑	↓
Possibility of using a small diameter wheel	↑	↓
Possibility of grinding the tooth root with Z<15	↑	↓
Possibility of using the same wheels for different Z	↓	↑
Cost of diamond dressing wheels and rollers	↑	↓
Possibility of grinding profiles that are not involute	↑	↓

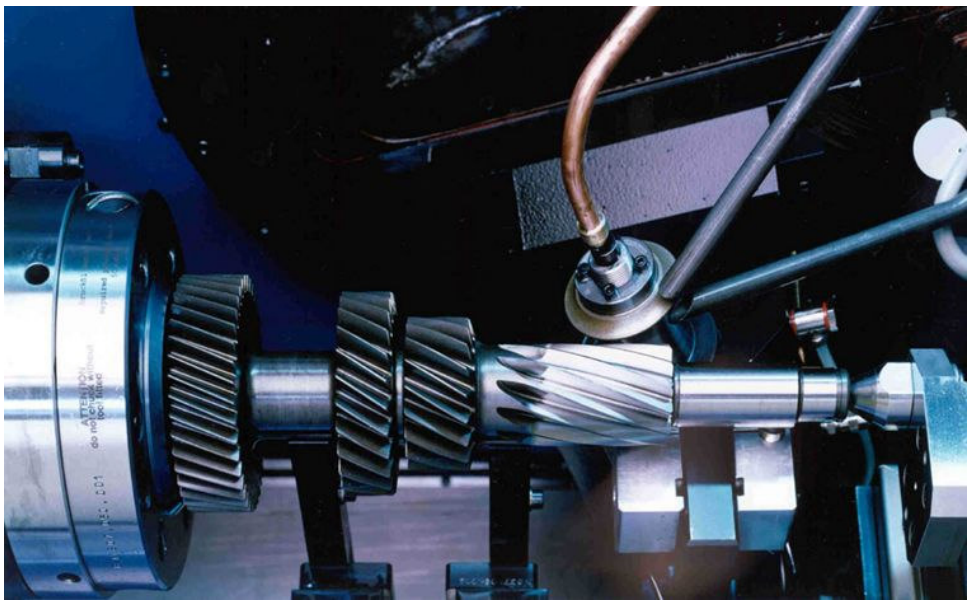
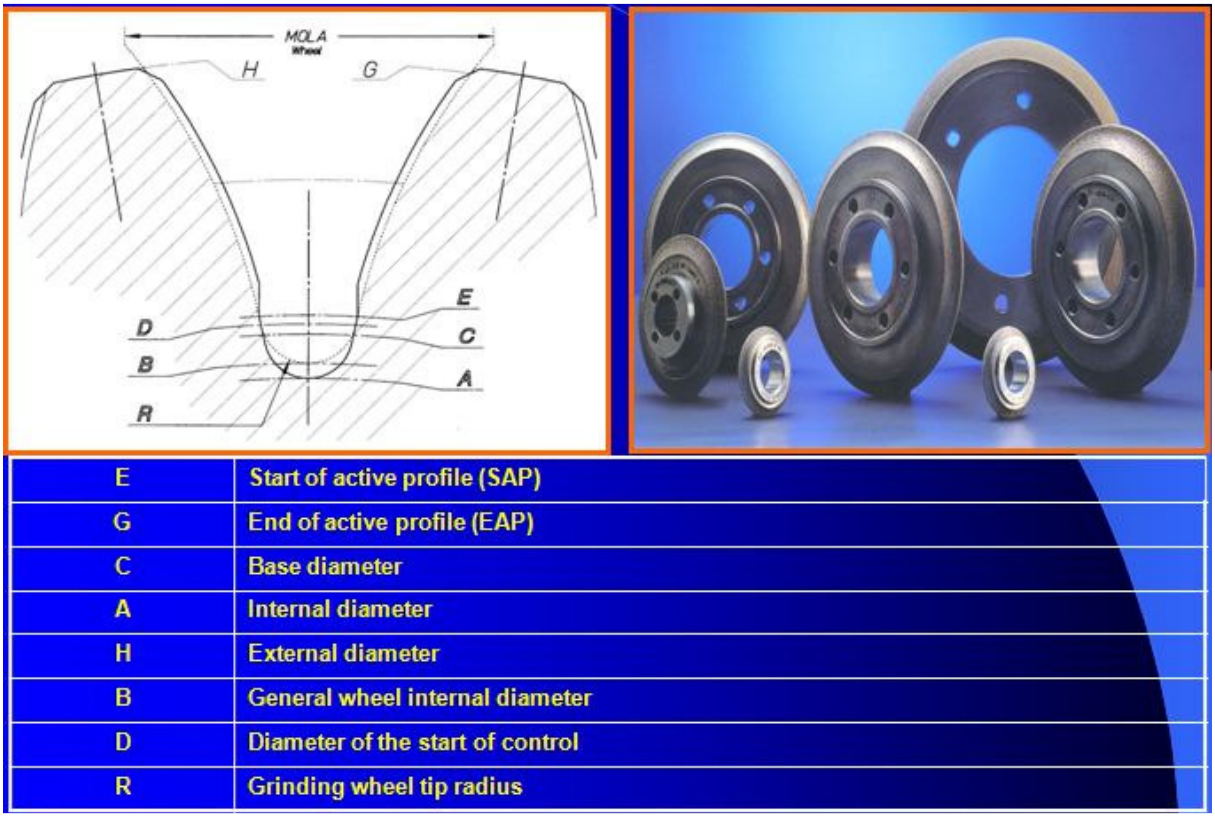


Fig.N°3- *With a small diameter form wheel it is possible to grind gears close to a shoulder*



E	Start of active profile (SAP)
G	End of active profile (EAP)
C	Base diameter
A	Internal diameter
H	External diameter
B	General wheel internal diameter
D	Diameter of the start of control
R	Grinding wheel tip radius

Fig. N°4- *Form wheels are able to grind along the whole tooth profile*

Comparison between surface quality obtained with the different finishing methods

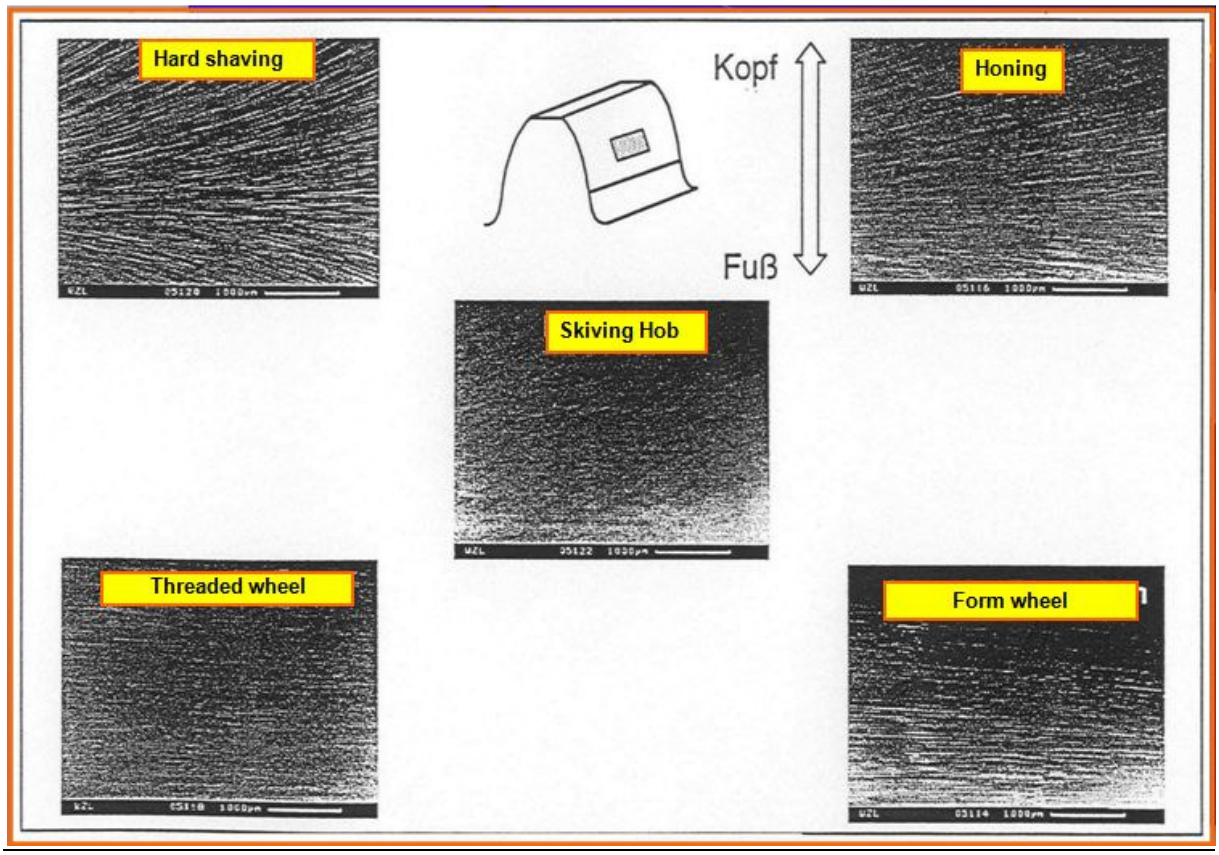


Fig. N°5- *Comparison between surface quality obtained with the different finishing methods*

Cost of grinding operation

The cost of grinding operation depends of the grinding method, of the wheel type and of the number of pieces produced.
The following data are referred to a different grinding conditions with a Samputensili grinding machine mod. G400GT.

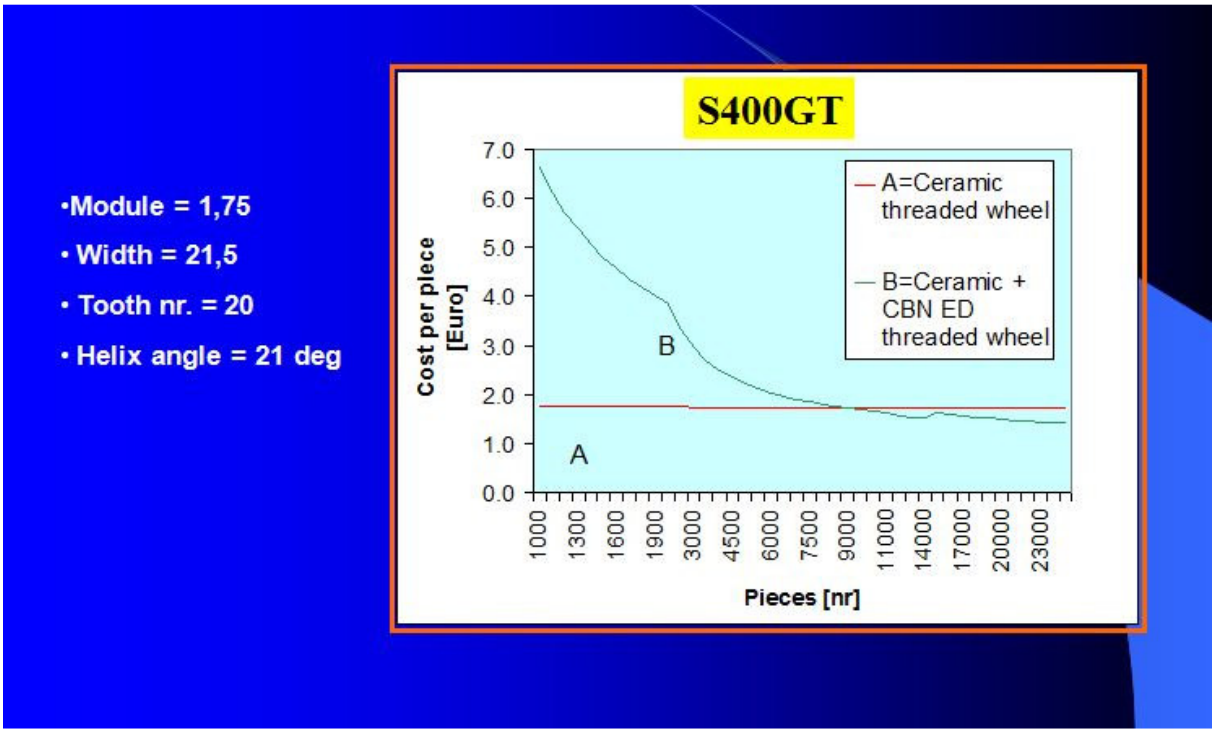


Fig.N°6- *Cost comparison per piece between the different grinding methods*

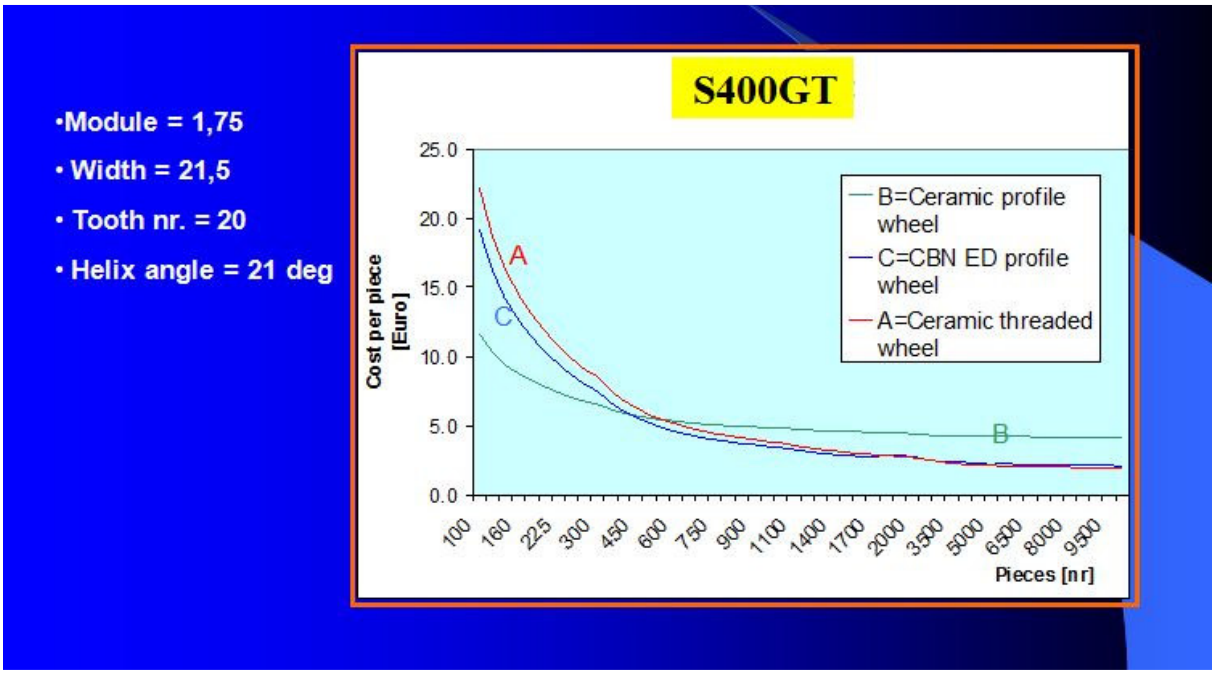


Fig.N°7- *Cost comparison per piece between the different grinding methods*