Optimization of the Geometric Parameters of the Gears

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Abstract *- Gears are the most used mechanical components during the transmission of movement and power. They are defined by several interdependent parameters. Their studies require an iterative approach in order to optimize certain variables taking into account the kinematic and dynamic aspects.*

Also, given the complexity of the design formulas and the variety of types of materials, manual calculation of the characteristics of the gears requires considerable time without leading to exact results. As a result, specialists find that a computer tool is needed to automate these often too boring calculations. This tool must comply with certain data and requirements as well as the cutting parameters (type of teeth, module, pressure angle, helix angle, etc.). In this paper, we have developed a tool to help calculate and optimize the geometric characteristics of gears in a CAD environment.

Keywords - *Geometric characteristics, Gears, Tool, CAD.*

I. INTRODUCTION

Transmission is one of the most common functions of the elements of general mechanics, that is to say mechanical devices intended to replace the human hand as opposed to mechanics.

According to the mechanisms, the transmission can relate to:

- ✓ Position;
- ✓ Movement ;
- ✓ Strength ;
- ✓ Power ;

Gears are used in all branches of mechanics to transmit movements, from watchmaking to reducers in heavy industry. Transmission is done with very good energy efficiency; > 95% on a gear in correct mounting conditions [1], [2]..

II. GEARS

The gears have the function of transmitting power, the two speeds (input and output) remaining in a constant ratio, it is a constant velocity transmission.

Competing solutions:

- ✓ Transmission by coupling, the shafts having to be in line with one another,
- ✓ Friction transmission: friction wheels, flat belts or V-belts on pulleys,
- ✓ Transmission by toothed belt on pulleys or by chain on wheels.

For a moderate cost price, the gears have the advantages of an excellent yield and a rather small space requirement [3].

Meshing has been a known phenomenon for several centuries, windmills used fairly sophisticated wooden gears, and clockwork mechanisms used cogwheels very early on. The development of thermal and electric motors has provoked a strong development of this type of transmission.

A gear is a set of two complementary toothed wheels, each in connection (pivot or slide) relative to a support (often the frame).

The small wheel is called the pinion, the big outside wheel is called the wheel, and the big inside wheel is called the crown. One of the wheels can have an infinite radius, it is then called a rack (Fig.1).

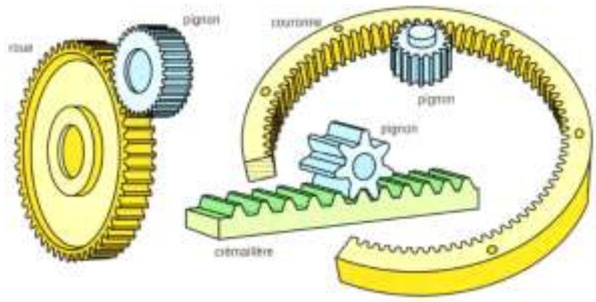

Fig.1 Type of gear [4].

The transmission ratio R is by definition [5], [11]:

$$R = \omega \text{ input} / \omega \text{ output.} \quad (1)$$

Primitive surfaces are called fictitious surfaces of the associated friction wheels giving the same kinematics as the gear.

There are different types of gears [6]:

- ✓ Gears with parallel axes with straight or helical teeth,
- ✓ The gears with concurrent axes with straight or helical teeth,
- ✓ Gears with non-concurrent or left axes (wheel - worm, hypoid)

III. PROFIL EN DEVELOPPANTE DE CERCLE

This is the profile almost universally used for power transmission. The involute of the circle is the trajectory of a point on a line which rolls without sliding on a circle. This circle is called "base circle", of diameter db.

(= Depressive * cos (α)) The area of existence of the involute is located between the base circle and infinity. There is no involute inside the basic circle. So do not try to operate a gear inside the basic circles of the teeth that constitute it.

If we consider two basic circles associated with two wheels of the same gear, it is possible to roll without dragging a line simultaneously on the two circles. Therefore the circumferential speed of the points of the circles is the same as those of the line. A point on the straight line (mesh point) will generate the tooth flank on both wheels (Fig.2) [4], [7].

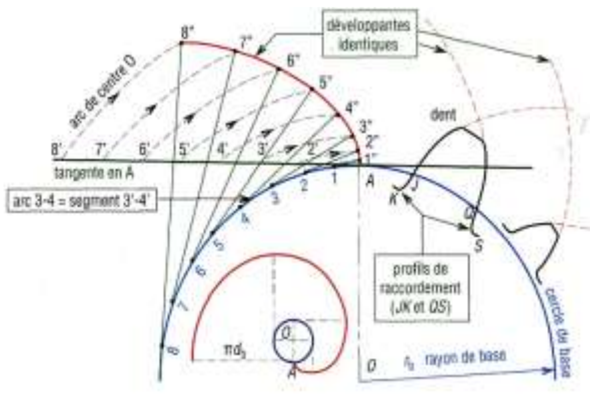

Fig.2 Circle involute

IV. PRINCIPLE OF MESHING

If two basic circles provided with involute curves are spaced by a center distance Δ, we note that during meshing, the two involutes remain in contact along a straight line called action line inclined by an angle α with respect to the tangent common to two circles called primitive circles.

The meshing is equivalent to a drive between two friction wheels of respective diameters the diameters of the primitive circles.

We can show that if r is the primitive radius, we have the relation [1], [8].

$$R = rb * \cos \alpha \quad (2)$$

This angle α is called the pressure angle and in the general case is 20 °. It can however vary (15 ° to 30 °), which makes it possible to define specific teeth for certain applications (Fig.3) [9], [10].

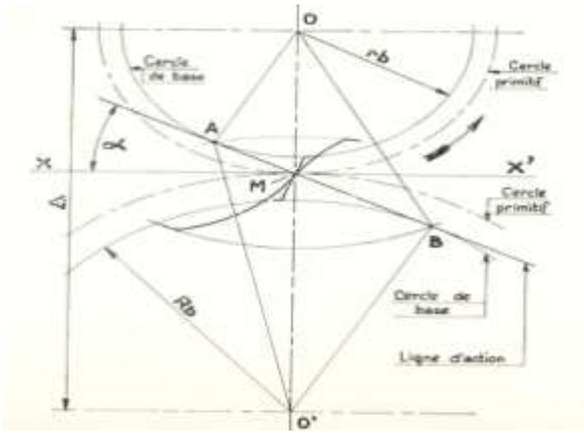

Fig.3 Principle of meshing [1].

V. Program Organization Chart

Fig.4 shows the general flowchart of the module.

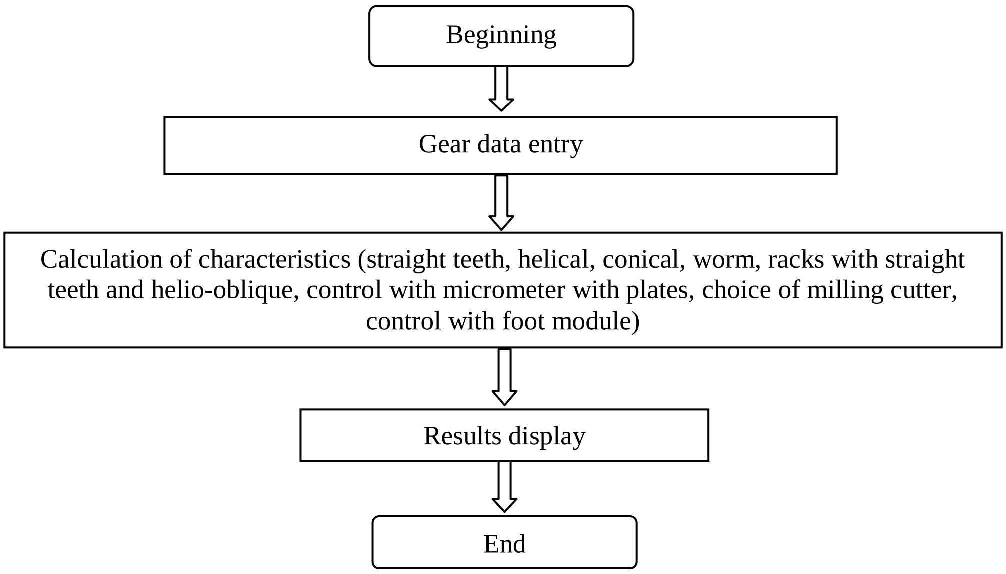

Fig.4 General flowchart of the module

VI. PRESENTATION OF THE MODULE

Fig.5 shows the interface for calculating the characteristics of the gears.

Fig.5 Presentation of the Gear CAD module 18.2.

A. *Main duties*

This module fulfills several parameters of the different types of gears:

- ✓ Spur gear;
- ✓ Helical gear;
- ✓ Bevel gear;
- ✓ Worm gear;
  - Racks with straight teeth;
  - Racks with helical teeth.

B. *Representation of the different types of gears without center distance*

Fig.6 illustrates the different types of gears without center distance:

- ✓ Gear with straight teeth;
- ✓ Helical gear;
- ✓ Bevel gear;
- ✓ Worm gear;
- ✓ Racks with straight teeth;
- ✓ Racks with helical teeth.

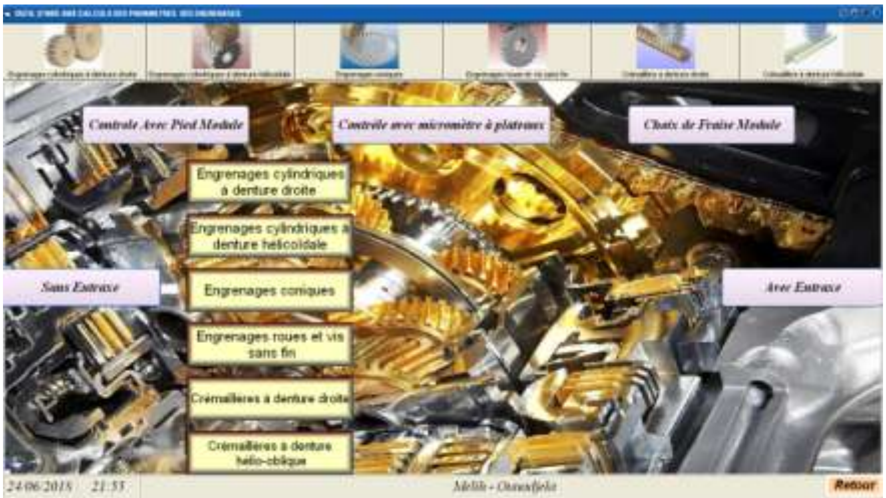

Fig.6 Representation of the different types of gears.

C. Spur gear

Fig.7 illustrates the data on spur gears are:

- ✓ Module;
- ✓ Pressure angle;
- ✓ The constant k;
- ✓ The number of turns;
- ✓ Number of teeth;

After clicking on the command: "calculate parameters".

Fig.7 Data of spur gears with straight teeth..

Fig.8 illustrates the display of results on spur gears with different characteristics.

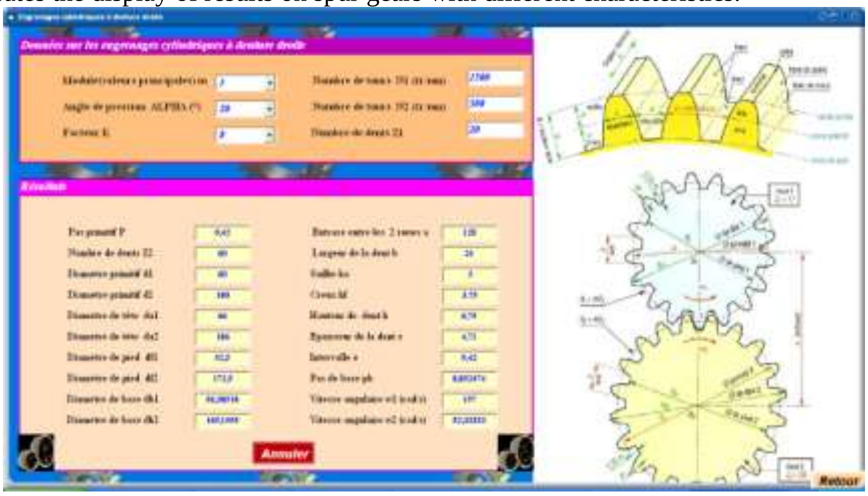

Fig.8 Calculation of the results of spur gears.

D. Helical gear

The Fig.9 illustrates the data on the cylindrical spur gears with helical teeth are:

- ✓ BETA helix angle;
- ✓ Real module min;
- ✓ Real pressure angle ALPHAn;
- ✓ Number of turns N (1; 2);
- ✓ Number of teeth Z2;

After clicking on the command: "calculation of parameters".

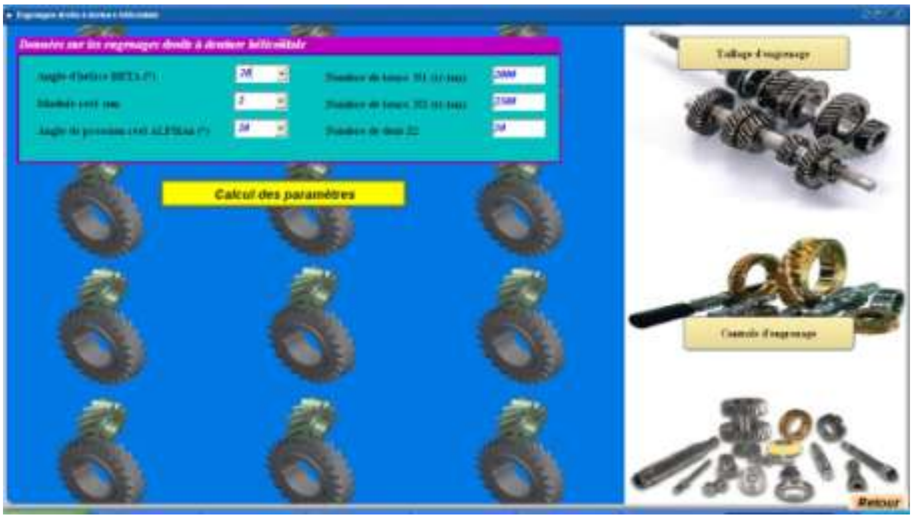

Fig.9 Data of spur gears with helical teeth.

The Fig.10 illustrates the display of the results on the spur gears with helical teeth of the different characteristics.

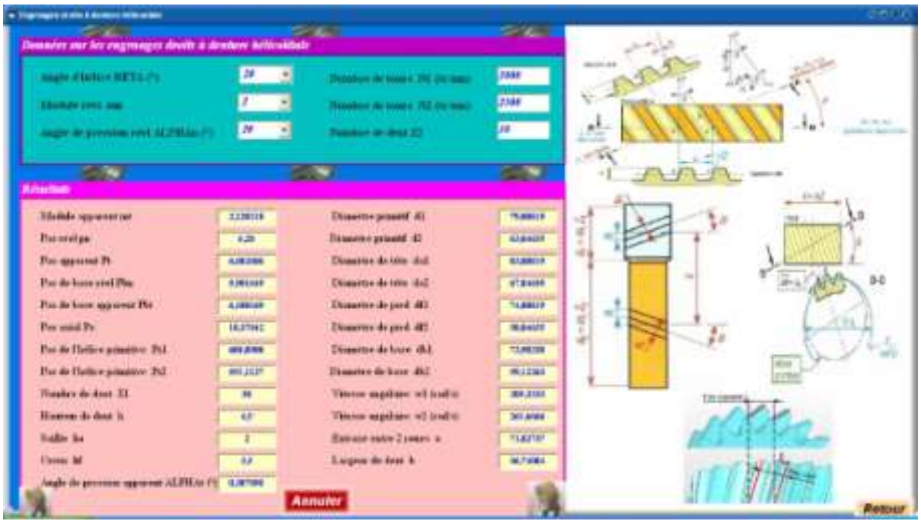

Fig.10 Calculation of the results of straight gears with helical teeth.

E. Bevel gear

Fig.11 illustrates the data on the bevel gears are:

- ✓ Module (m);
- ✓ Pressure angle (ALPHA);
- ✓ Number of teeth (Z1);
- ✓ Number of turns (N1, N2);

After clicking on the command: "calculation of parameters".

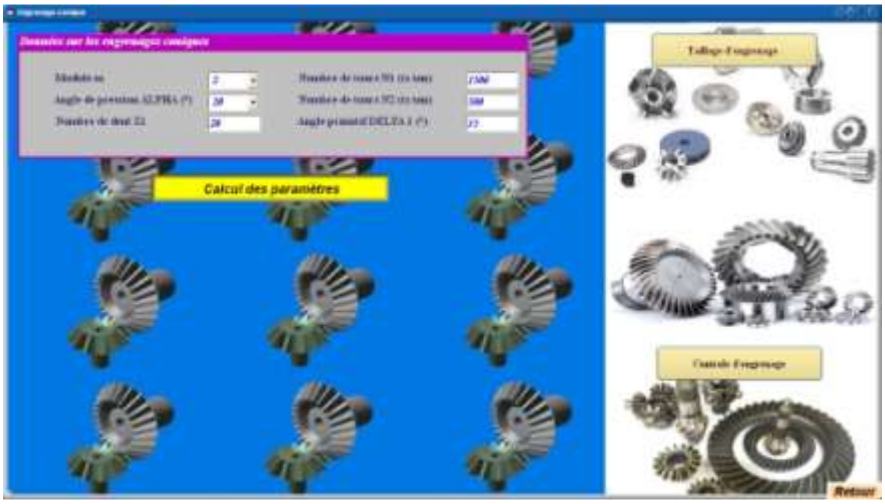

Fig.11 Data of bevel gears.

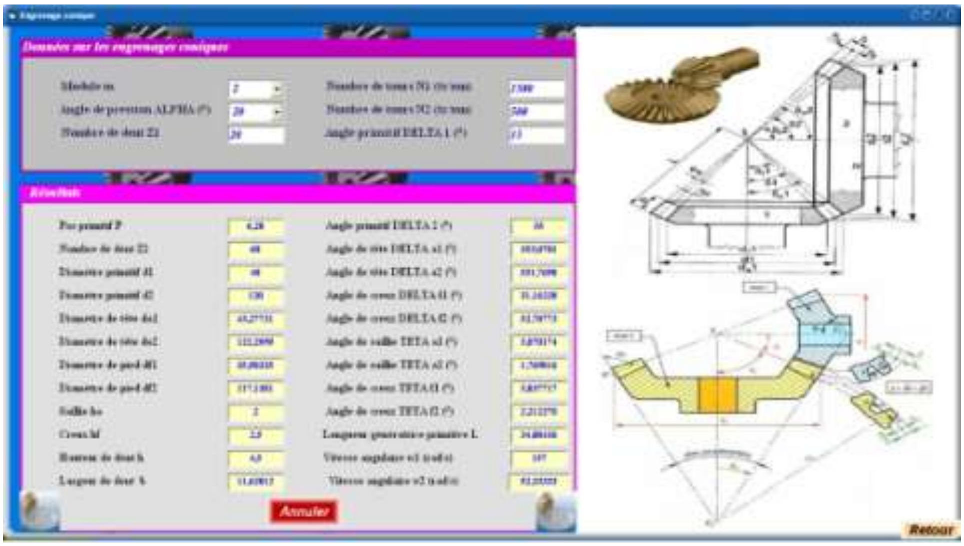

Fig.12 illustrates the display of the results on the bevel gears of the different characteristics.

Fig.12 Calculation of the results of the bevel gears.

F. Worm gear

Fig.13 illustrates the data on the wheel and worm gears are:

- ✓ Real module (min);
- ✓ Real pressure angle (ALPHAn);
- ✓ Number of screw threads (Zv);
- ✓ Screw helix angle (BETAv);
- ✓ Number of screw turns (Nv);
- ✓ Number of wheel turns (Nr);

After clicking on the command: "calculation of parameters".

Fig.13 Wheel and worm gear data.

Fig.14 illustrates the display of the results on the wheel and worm gears of the different characteristics.

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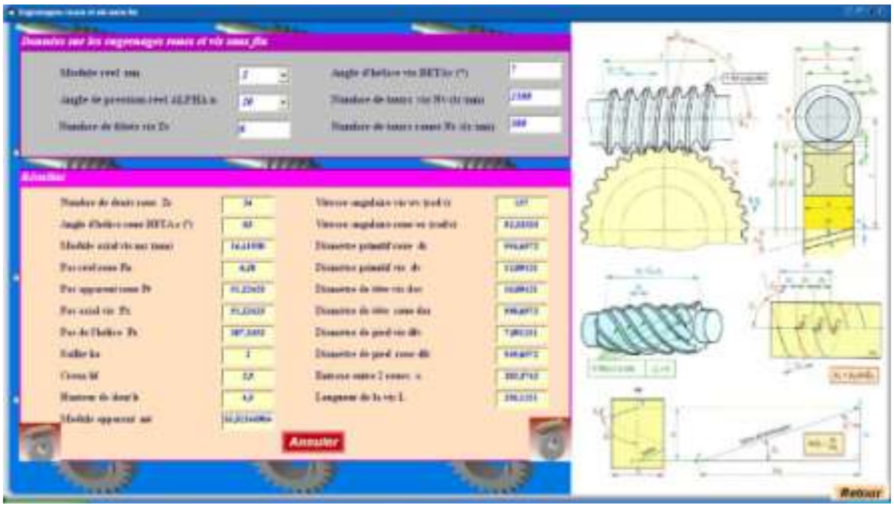

Fig.14 Calculation of the results of the wheel and worm gears.

G. Representation of the different types of gears with center distance

The Fig.15 represents the different types of gears with center distance

- ✓ Spur gear;
- ✓ Helical gear;
- ✓ Bevel gear;
- ✓ Worm gear;

Fig.15 Representation of the different types of gears without center distance.

H. Spur gear

The Fig.16 illustrates the data on the spur gears are:

- ✓ Module;
- ✓ Pressure angle;
- ✓ The constant k;
- ✓ The number of turns;
- ✓ Number of teeth ;
- ✓ Center distance of two wheels;

After clicking on the command: "calculation of parameters".

Fig.16 Representation of the data of spur gears.

Fig.17 illustrates the display of the results.

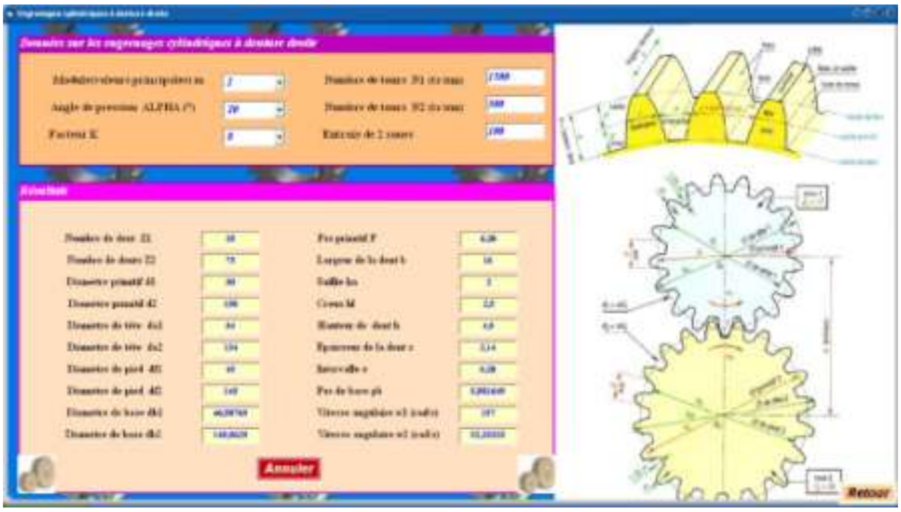

Fig.17 Results display

I. *Helical gear*

The Fig.18 illustrates the data on the spur gears with helical teeth are:

- ✓ BETA helix angle;
- ✓ Real module min;
- ✓ Real pressure angle ALPHAn;
- ✓ Number of turns N (1; 2);
- ✓ Number of teeth Z2;
- ✓ Center distance of two wheels;

After clicking on the command: "calculation of parameters".

Fig.18 Representation of the data of helical gears.

Fig.19 illustrates the display of the results of helical gears.

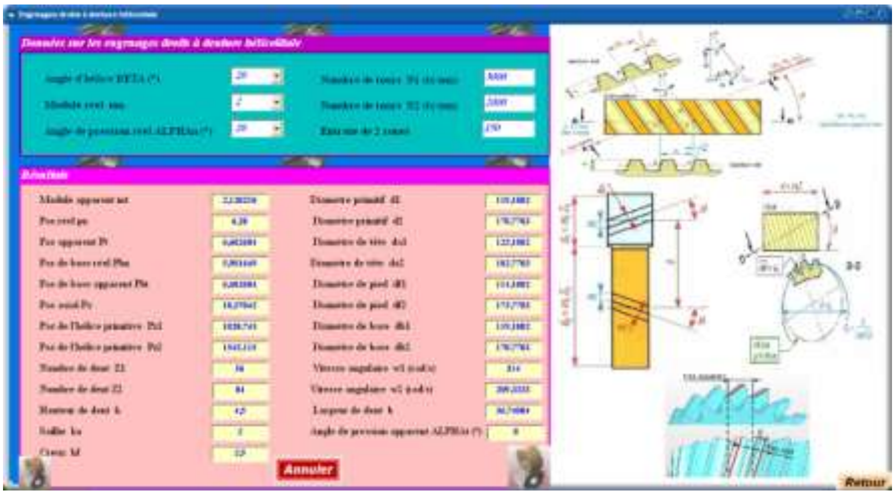

Fig.19 Representation of the results of helical gears.

VII. Conclusion

Despite the advantages of belts and chains, gears remain the most applicable solution in a large part of the industry because of its strength and durability. The gear is the ultimate power transmission device: it perfectly meets the performance, precision and specific power requirements imposed in modern mechanical architectures. Recently, the criteria of acoustic comfort and vibration resistance have been the source of new technological pressure on this component. The meshing then appears as the main source of excitation, both sound and vibration.

Gears with different types are widely used in aeronautical or automotive transmissions and in industry. They have complex tooth geometries like spiro conical. The initiative of these studies is to meet the increasingly strict industrial requirements. The studies induced on the global calculations of the gears also become extremely difficult for this we develop a calculation and optimization tool under CAD environment to save time and smooth operation with less cost.

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