

# PROFESSIONAL CAM PRO - *presentation*

The software PROFESSIONAL CAM PRO is divided into three main areas that allow you to design and test the lift laws and the cam profiles in a clear and comprehensive manner, allowing you to easily follow each stage of the work.



The first area is dedicated to the design of the lift law and of the cam profile of the intake cams.



The second area is dedicated to the design of the lift law and of the cam profile of the exhaust cams.



The third area is dedicated to the design of the combustion chamber and at the check of the interference that there is between the valves and the piston.

Each area is then divided into specific sub-areas that allow you to easily insert all the necessary data and above all allow you to immediately see the results of the choices made, you can then make in real-time the changes necessary in order to arrive quickly at an optimal development that meets the specific needs.

Afterwards we see in detail each subarea so you can appreciate the completeness combined with the ease of use of software PROFESSIONAL CAM PRO

# PROFESSIONAL CAM PRO - *lift law*

Both for what concerns the area dedicated to the INTAKE , both for the one dedicated to the EXHAUST, there are four sub-areas, one dedicated to the definition of the LIFT, one for the KINEMATICS of the valve train system, one for the DYNAMICS of the system, and one that summarizes all the results both graphics and numerical, of the work done.

The most important stage of the design is the definition of lift law of the valve that you want obtain, so the software PROFESSIONAL CAM PRO has studied in the detail this aspect. For first, the software allows you to enter the main data of the lift that you want achieve with the cam, so the valve timing, the maximum lift, and the characteristics of the ramps for the recovery of the lash. In addition to this you can choose the type of lift law that you want to use. The software provides three main types:

LIFT LAW	
type	<input type="text"/>
maximum lift [mm]	<input type="text"/>
TIMING	
opening adv. [°crank]	<input type="text"/>
closing delay [°crank]	<input type="text"/>
lobe center [°crank]	<input type="text"/>
RAMPS	
type	<input type="text"/>
rise lift [mm]	<input type="text"/>
rise duration [°crank]	<input type="text"/>
down lift [mm]	<input type="text"/>
down duration [°crank]	<input type="text"/>

NT-Polydyne

This type of lift law is based on particular "polydyne" polynomials appropriately modified with a special algorithm to optimally connect it to eventual ramps, hence the name "NT-Polydyne".

NT-Spline

This type of lift law is based on "splines" appropriately designed to create laws that satisfy the needs of engine valve train systems and which connect in an optimal manner to eventual ramps, hence the name "NT-Spline".

NT-Trigonometric

This type of lift law is based on trigonometric laws appropriately studied to create laws that satisfy the needs of engine valve train systems, and modified with a special algorithm to optimally connect to eventual ramps, hence the name "NT-Trigonometric".

NT-Polynomial 8°

This type of lift law is based on an 8° polynomial law appropriately modified with a special algorithm to optimally connect to any ramps, hence the name "NT-Polynomial 8°".

NT-Dudley

This type of lift law is based on the particular "polydyne" polynomials developed by Dudley appropriately modified with a special algorithm to optimally connect to eventual ramps, hence the name "NT-Dudley".

For each of these laws it is possible to manage some parameters that modify the level of aggressiveness of the law



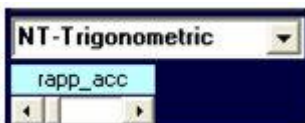
These bars are used to modify the characteristics of the NT-Polydyne, the "expini" bar defines the initial exponent of the polydyne, while the "deltaexp" bar defines the spacing between the exponents. By clicking on the arrows you scroll the cursors and by moving them from left to right you will obtain increasingly aggressive lift laws.



These bars are used to modify the characteristics of the NT-Spline, the "dur+" bar defines the duration of the positive acceleration, while the "dur-" bar the duration of the constant section of the negative acceleration. By clicking on the arrows you scroll the cursors and by moving them from left to right you will obtain increasingly aggressive lift laws.



These bars are used to modify the characteristics of the NT-Spline, the "dur+rise" bar defines the duration of the positive acceleration in the valve opening phase, the "dur-rise" bar the duration of the constant portion of the negative acceleration in the phase of valve opening, while the "dur+down" bar defines the duration of the positive acceleration in the valve closing phase, and the "dur-down" bar the duration of the constant section of the negative acceleration in the valve closing phase. By clicking on the arrows scroll the sliders and move them from left to right you will obtain increasingly aggressive lift laws.



This bar is used to modify the characteristic of the NT-Trigonometric, the "ratio\_acc" bar defines the ratio between the positive acceleration and the negative acceleration. By clicking on the arrows you scroll the cursor and by moving it from left to right you will obtain increasingly aggressive lift laws.

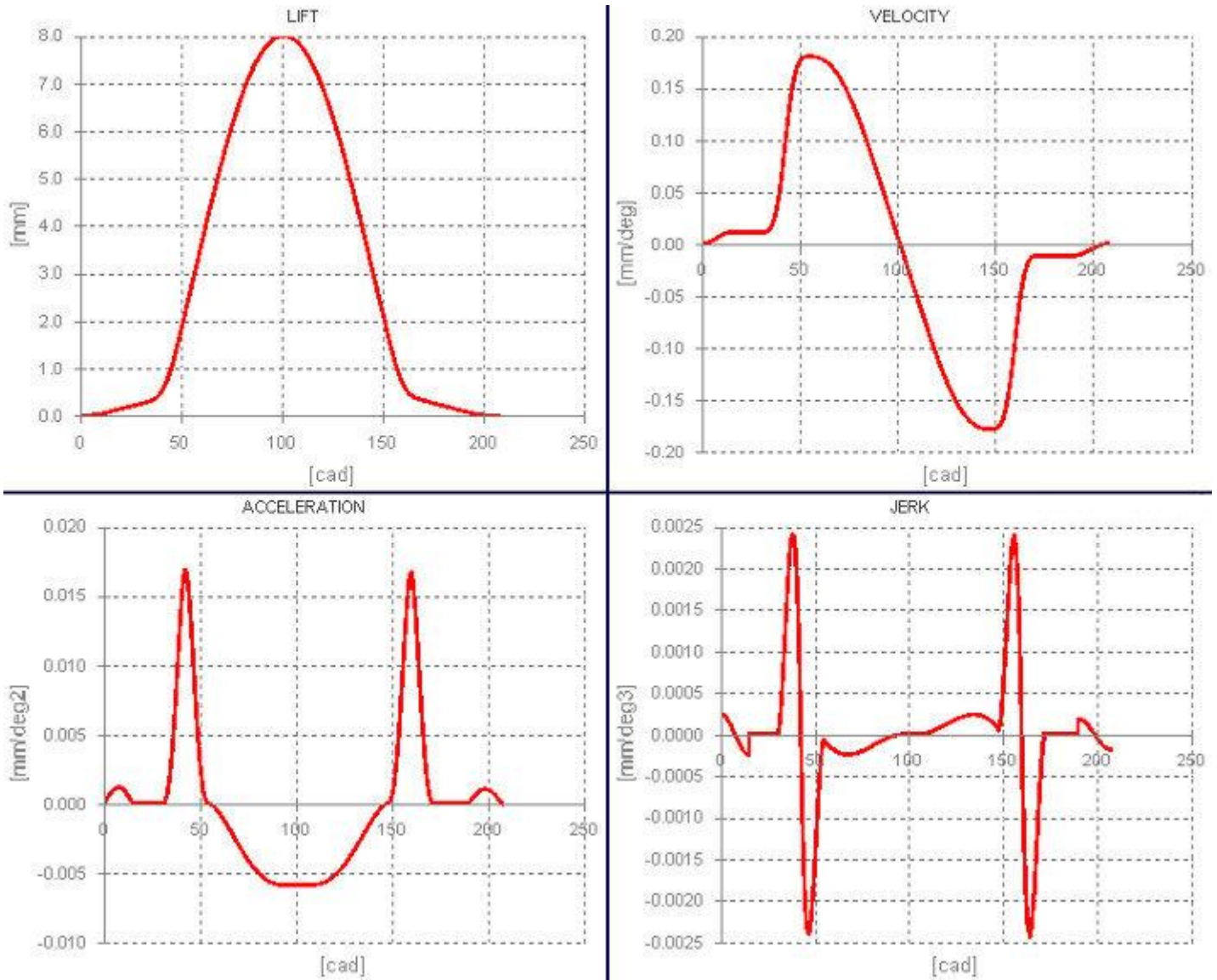


This bar is used to modify the characteristics of the NT-Dudley, the "expini" bar defines the initial exponent of the polydyne. By clicking on the arrows you scroll the cursor and by moving it from left to right you will obtain increasingly aggressive lift laws.

Furthermore these laws can also have ramps to recover the valves clearance, and can also have an asymmetric profile.

# PROFESSIONAL CAM PRO - lift law

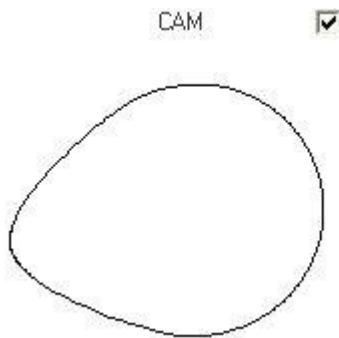
The real strength of the software PROFESSIONAL CAM PRO is that each type of lift law can be manipulated in infinite ways. It is sufficient to move the arrows of the parameters available for each type of lifting law, and in real time it is possible to see how the velocity, the acceleration and the jerk change



## ANALYSIS

LIFT		CAM	
profile efficiency [%]	<b>53.6</b>	min	max
under area [mm*deg]	<b>610.6</b>	curvature radius pos	<b>3.51</b> <b>71.12</b>
TDC lift [mm]	<b>3.55</b>	curvature radius neg	<input type="text"/> <input type="text"/>
	min	max	
velocity [mm/deg]	<b>-0.178</b>	<b>0.180</b>	
accelerat. [mm/deg <sup>2</sup> ]	<b>-0.005</b>	<b>0.016</b>	
jerk [mm/deg <sup>3</sup> ]	<b>-0.002</b>	<b>0.002</b>	

In addition to the graphic visualization of the quantities, are shown in real time the efficiency of the profile, the area subtended and the minimum and maximum values of velocity, acceleration and jerk, in this way it will be possible to evaluate on the one hand what influences the fluid dynamics of the engine, and from the other the aspects inherent to the proper functioning of the system (levels of acceleration and jerk).

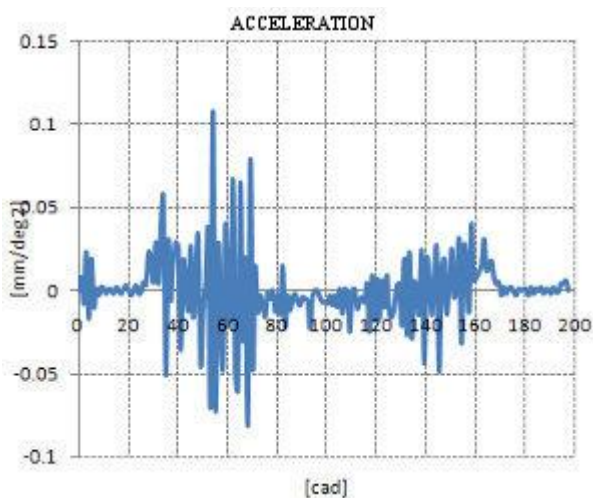


If the valve train system data has been entered, the software also calculates the cam profile in real time, thus it is possible to immediately evaluate whether the chosen lift law is adequate for the system, and therefore whether the cam is feasible, in fact the minimum and maximum curvature radius of the profile are shown.

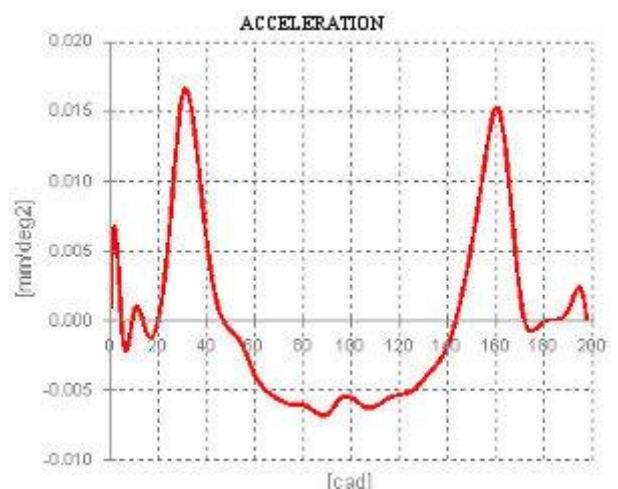
## PROFESSIONAL CAM PRO - *experimental lift law*

Into the software is also possible to import lift laws detected experimentally, and thanks to a special filtering algorithm it is possible to use them to obtain the cam profile.

CALCULATION FROM UNFILTERED DATA



CALCULATION WITH NT FILTERED DATA



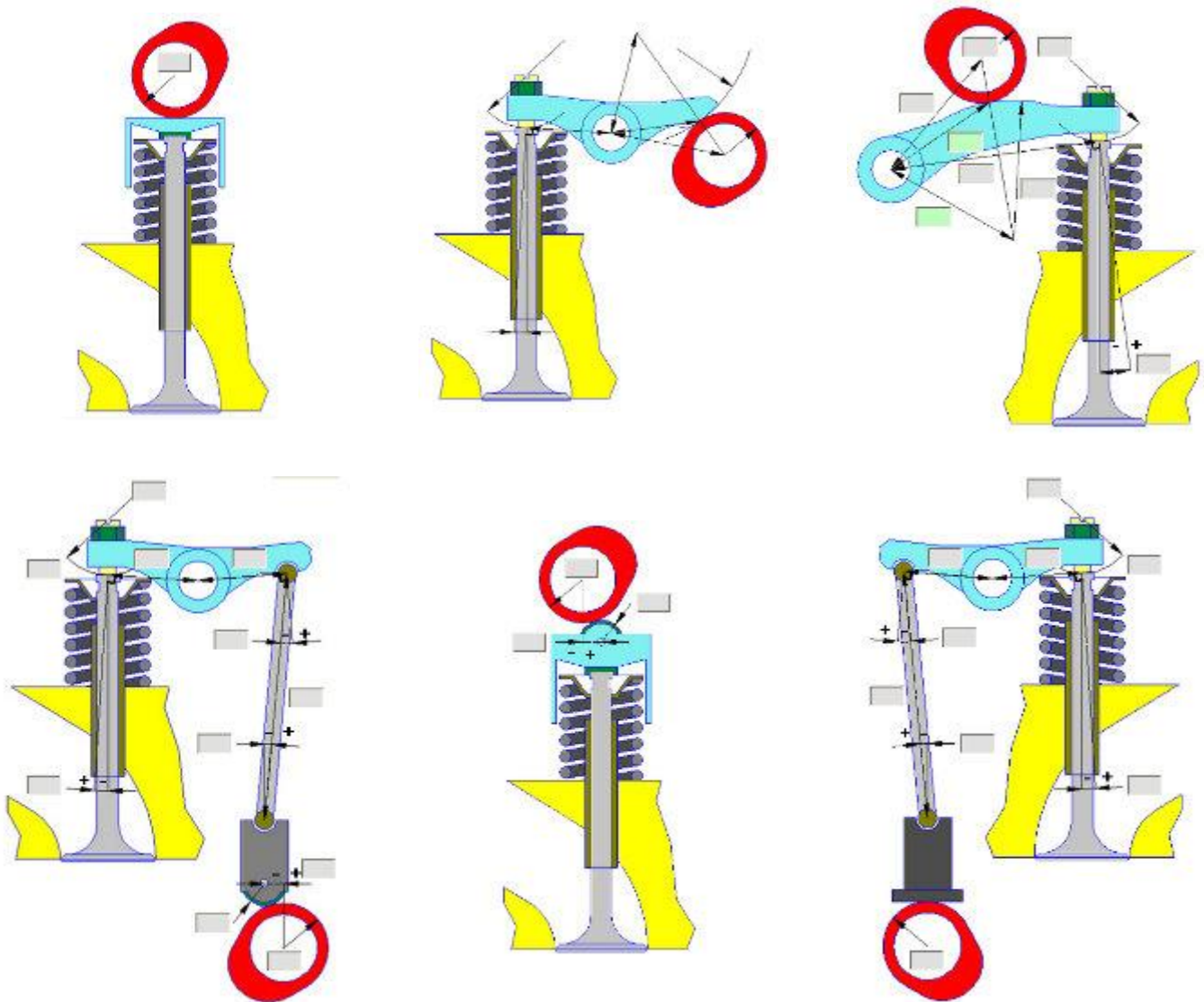
In fact, the lift laws detected experimentally present various measurement errors, which emerge when speed and acceleration are calculated. Therefore, without adequate filtering and reprocessing it would be impossible to reuse them to calculate the cam profile.



# PROFESSIONAL CAM PRO - *valve train system*

Besides the definition of the lift law, another important aspect is the insertion of the characteristics of the valve train system for which the cam must be achieved. In fact, in function of the valve train system is calculated the specific cam profile which will be able to realize the desired lift law.

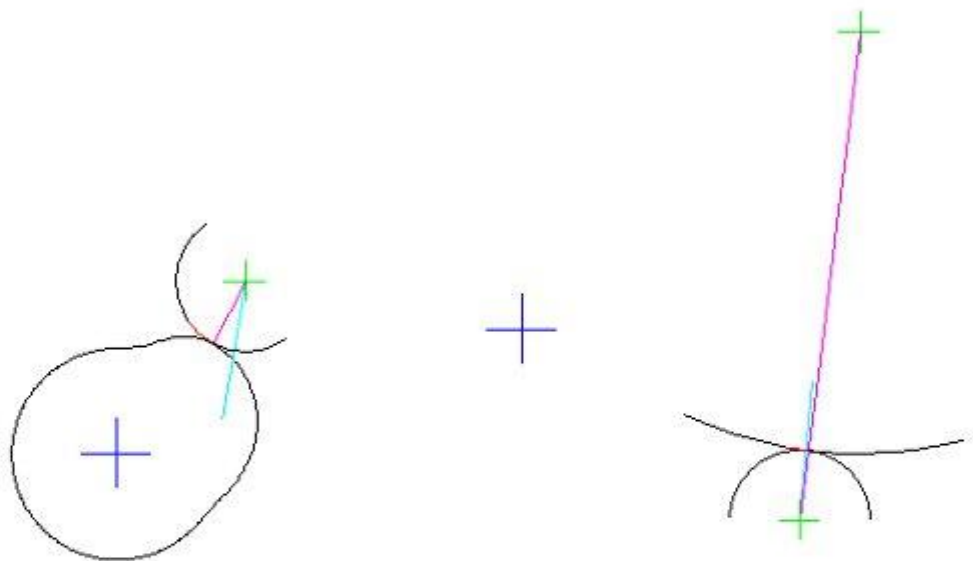
The software PROFESSIONAL CAM PRO is designed to calculate the cam profiles of all the main valve train systems, from those at direct attack, both with flat tappet, both with roller centered or offset, to those with rocker arms or finger arms, until to the systems with pushrods and rocker arms, both with flat tappet, both with roller centered or offset.



# PROFESSIONAL CAM PRO - *system kinematic*

After you've defined the lift law or you've entered the data of the valve train system, the software PROFESSIONAL CAM PRO provides the ability to instantly verify the geometry of the valve train system that has been inserted and simulate the kinematics of the system throughout the entire engine cycle. In addition to the kinematic mechanism are shown for each crank angle degree all the kinematic quantities of interest (rotation angles, angles or arcs of contact, the contact lengths, etc.) so is possible to verify if the operation of the system is correct and whether it satisfies eventual constraints of space or of coupling between the various elements.

PREVIEW	
angolo motore [cad]	490.0
alzata valvola [mm]	7.11
raggio curvatura [mm]	10.46
eccentricità contatto [mm]	
rotazione bilanciere [deg]	9.89
ang. contatto sul bilanciere [deg]	2.82
arco contatto sul bilanciere [deg]	2.95
angolo contatto sulla valvola [deg]	-7.07
arco contatto sulla valvola [deg]	-1.23
lungh. contat. sul bilanciere [mm]	
lungh. contat. sulla valvola [mm]	
ang. contatto sul bil-cam [deg]	26.82
arco contatto sul bil-cam [deg]	4.68
rotazione asta [deg]	



# PROFESSIONAL CAM PRO - *system dynamic*

In addition to the lift law, and to the kinematics of the valve train system, another very important aspect is the dynamic behavior of the valve train system, for this the software PROFESSIONAL CAM PRO has a dedicated area that allows the insertion of the data necessary for this calculation.

ENGINE	
speed [rpm]	<input type="text"/>
VALVE TRAIN	
valve and accessories mass [gr]	<input type="text"/>
spring mass [gr]	<input type="text"/>
tappet mass [gr]	<input type="text"/>
rocker arm inertia momemnt [Kg*m2]	<input type="text"/>
pushrod mass [gr]	<input type="text"/>
cam width [mm]	<input type="text"/>
friction coefficient [-]	<input type="text"/>

For first must be added to the engine speed for which you want to check the system, and then the masses of the elements of the system and the width of the cam.

In addition to these data you can enter the spring geometry, and the software is able to automatically calculate the load that the springs are able to offer, or alternatively if the springs have been verified, you can insert the load curve directly that has been detected experimentally.

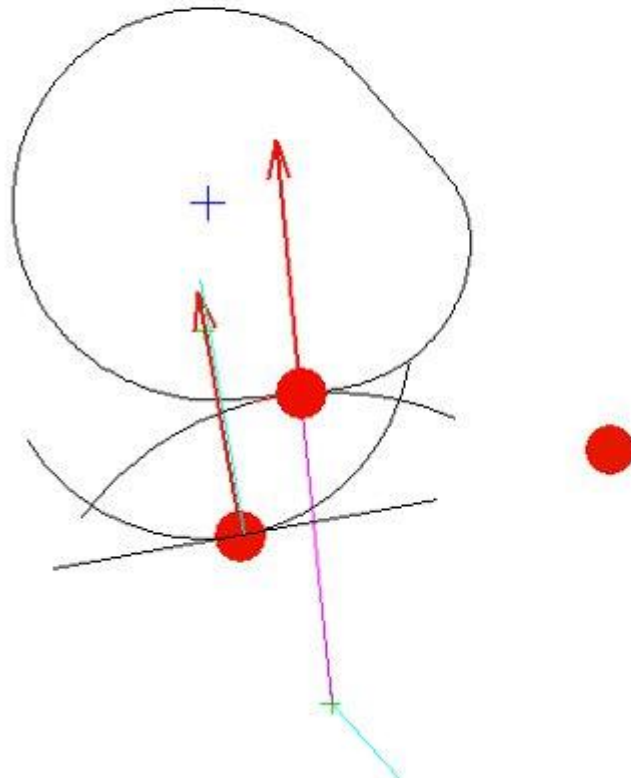
SPRING	
EXTERNAL or SINGLE	
active coils n°	<input type="text"/>
preload lenght [mm]	<input type="text"/>
total lenght [mm]	<input type="text"/>
coil mean diameter [mm]	<input type="text"/>
wire diameter [mm]	<input type="text"/>
shear modulus [N/mm2]	<input type="text"/>
INTERNAL	
active coils n°	<input type="text"/>
preload lenght [mm]	<input type="text"/>
total lenght [mm]	<input type="text"/>
wire diameter [mm]	<input type="text"/>
coil mean diameter [mm]	<input type="text"/>
shear modulus [N/mm2]	<input type="text"/>



# PROFESSIONAL CAM PRO - *system dynamic*

After entering the necessary data the software PROFESSIONAL CAM PRO allows you to simulate the dynamic behavior of the system during the entire engine cycle. In addition to the graphic display, are displayed in real time all the quantities useful to test the system, both for what concerns the forces, both for the friction, both for the contact pressures, thereby it is possible to see immediately if the choices made are adapted to the specific needs.

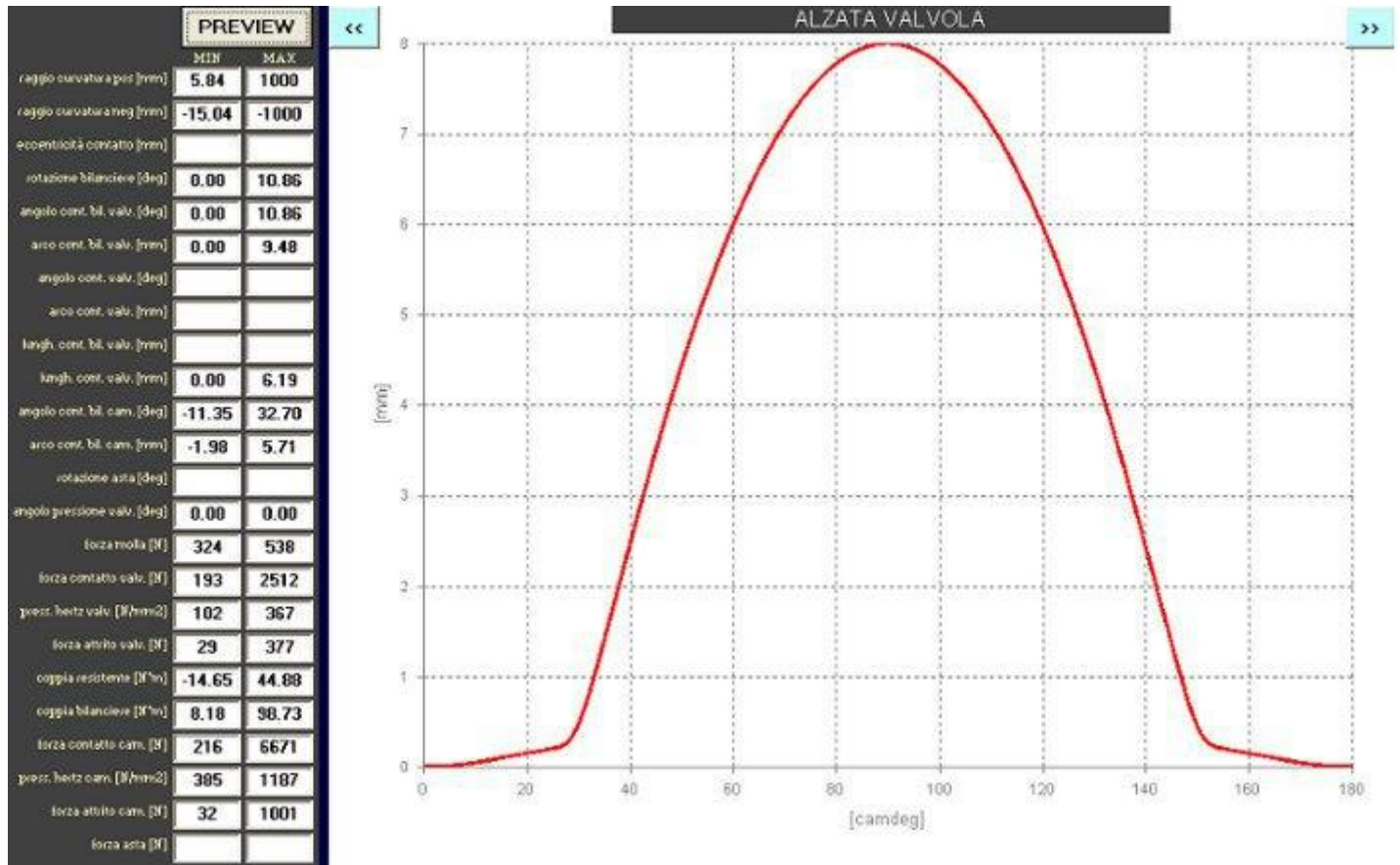
PREVIEW	
angolo motore [cad]	336.0
alzata valvola [mm]	0.75
angolo pressione valvola [deg]	0.00
forza molla [N]	184
forza contatto valvola [N]	794
pressione hertziana valvola [MPa]	333
forza attrito valvola [N]	79
coppia resistente [N*m]	8.95
coppia bilanciante [N*m]	23.17
forza contatto camma [N]	1240
pressione hertziana camma [MPa]	354
forza attrito camma [N]	124
forza sull'asta [N]	



# PROFESSIONAL CAM PRO - *graphs*

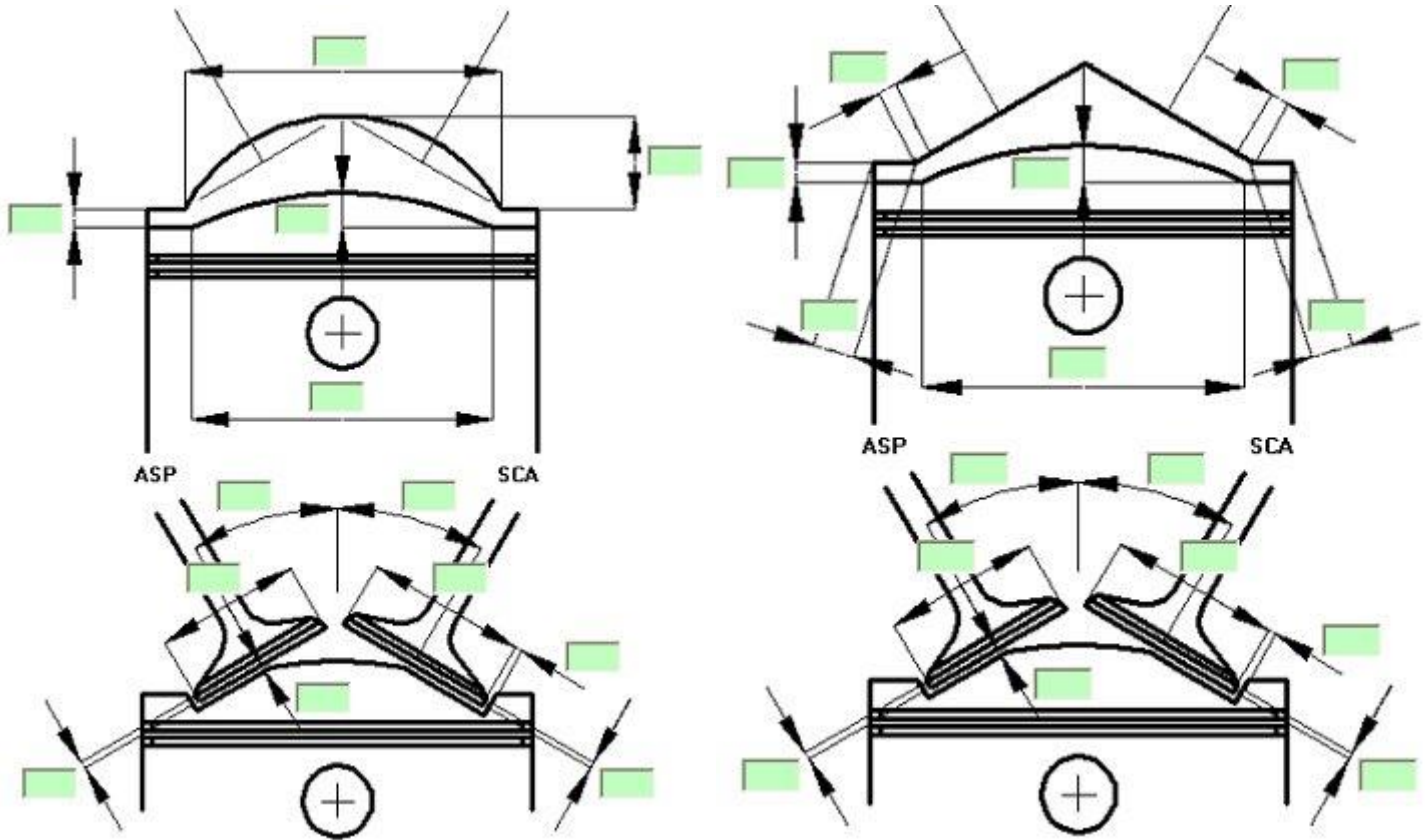
The last sub-area of the areas of INTAKE and EXHAUST is the summary of all the results obtained in relation to the choices made for the lift law, and to the geometric and dynamic characteristics of the valve train system entered.

This subarea shows the minimum and maximum values of all the significant quantities calculated from those of the cam profile, until those of the kinematic and of the dynamic. Moreover are shown the graphs of all the calculated quantities.



# PROFESSIONAL CAM PRO - engine

After designing the lift laws and the relative cams, the software PROFESSIONAL PRO CAM offers the ability to check for eventual interference between the valves and the piston. To do this, the software allows you to enter the data to define the geometry of two of the most used combustion chambers, at roof or hemispherical.



Il software oltre ad utilizzare i dati inseriti per verificare le interferenze, calcola anche le caratteristiche principali della camera di combustione (rapporto di compressione, rapporto area/volume, diametro massimo delle valvole di aspirazione e scarico), ciò può essere pertanto utile anche in fase di progettazione della camera di combustione.

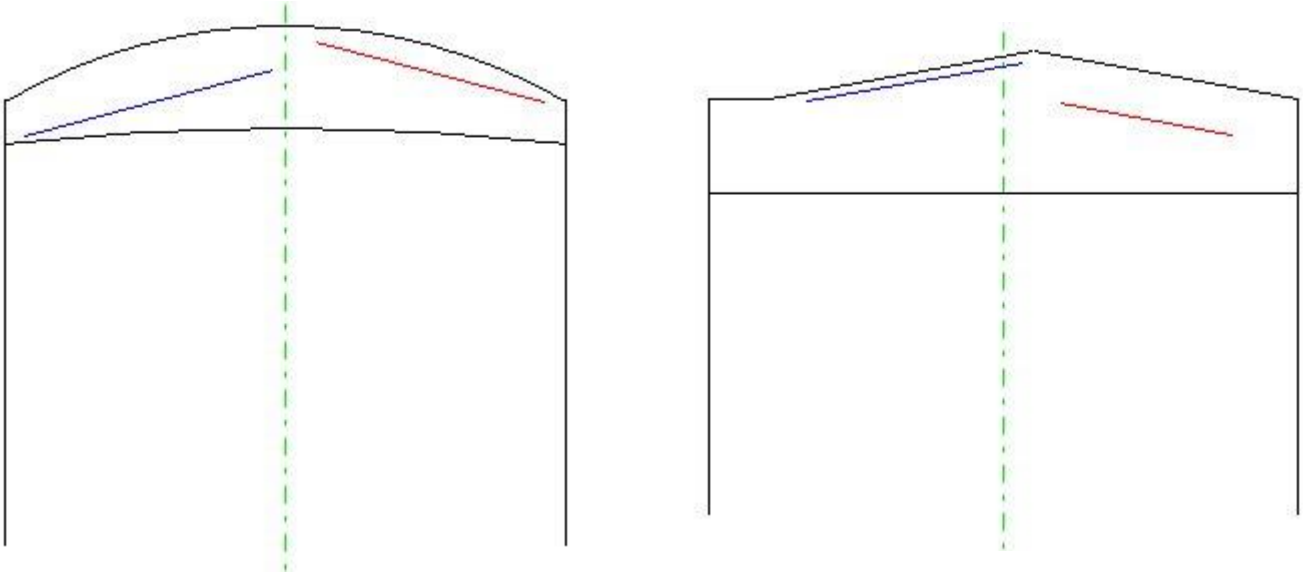
Oltre a questo inserendo la geometria del manovellismo (corsa, alesaggio, lunghezza biella), il numero di valvole ed il numero di cilindri, il software calcola la potenza e la coppia spesi per mantenere in movimento la distribuzione.

diam max valv asp [mm]	29.71
diam max valv sca [mm]	25.71
rapporto compressione	13.12
area / volume [l/cm]	5.53

coppia tot spesa distr [Nm]	1.84
potenza tot spesa distr [kW]	0.87

# PROFESSIONAL CAM PRO - engine

By entering together with the combustion chamber the data also those of the engine the software PROFESSIONAL CAM PRO can perform the simulation of the movement of the valves and of the piston in the entire engine cycle, thus will be possible to see in real time if there are possible interferences, and the margins of contact that there are.

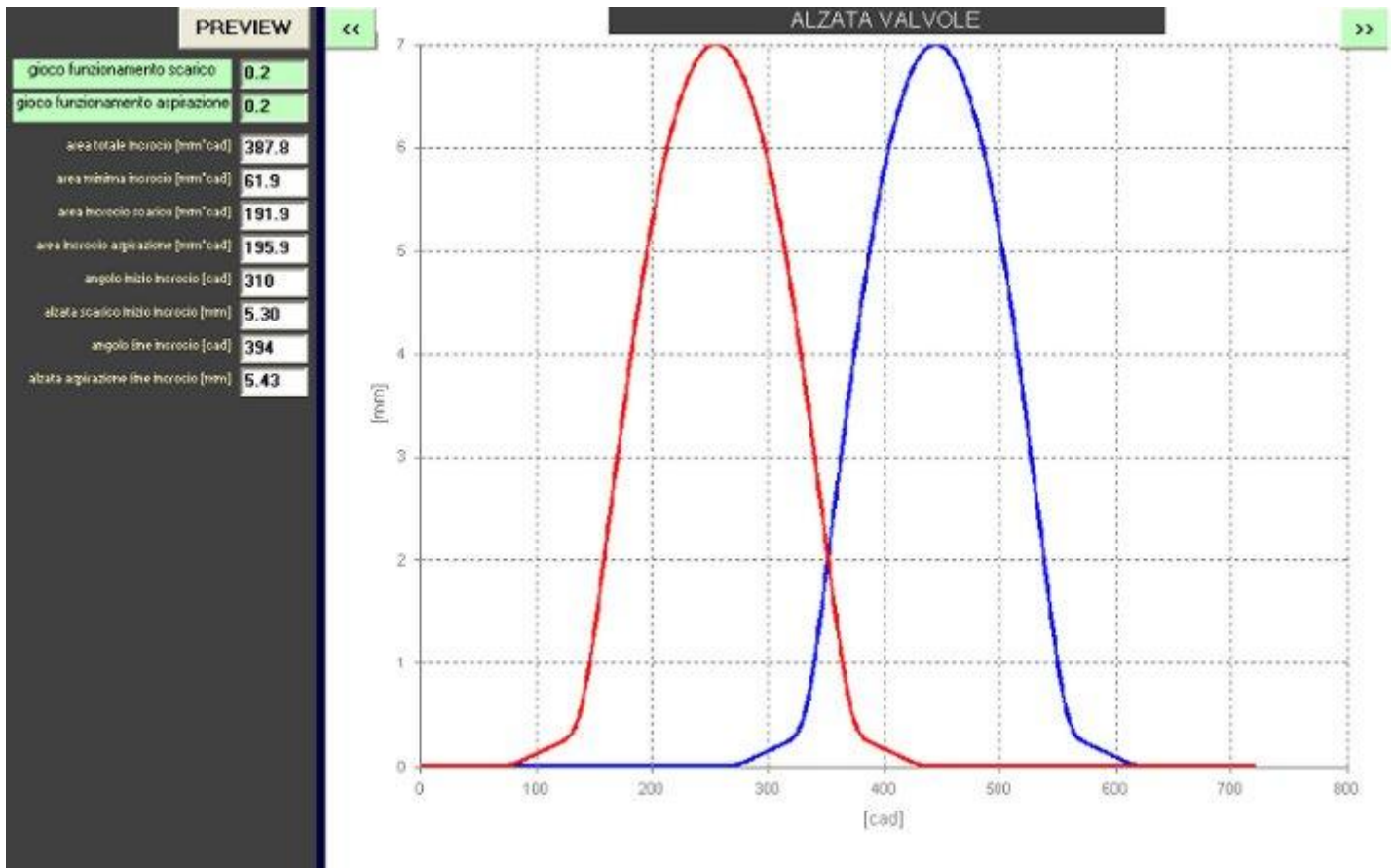


		ang.mot.	pos.pis.	alz.asp.	alz.sca.
interf max v asp [mm]	-1.31	367	0.27	3.16	1.87
interf max v sca [mm]	-0.48	353	0.27	2.08	2.93
interf max valve [mm2]					
posizione pistone [mm]	3.63				
alzata scarico [mm]	0.65			alzata aspirazione [mm]	4.51
interferenza valvole [mm2]	115.16	interferenza aspirazione [mm]	0.72	interferenza scarico [mm]	5.14

If interference occurs between the valves, or between the valves and the piston, the software stores the angular position where there is the maximum interference, and the magnitude of such interference, thereby it will be possible to know with precision as must be made the milling on the piston, or how you must change the geometry of the chamber, or the squish to have optimal operation.

# PROFESSIONAL CAM PRO - engine

Also for ENGINE area there is a subarea where are shown all the graphs of the calculated quantities, specifically are shown the valves and the piston movements in the engine cycle, so you'll be able to view possible interferences.



In addition to the graphs are displayed all the informations on the overlap period, when it starts, when it ends, the areas involved and the valve positions, so you can get a complete picture of this important phase of the engine.



# PROFESSIONAL CAM PRO - *file output*

After to have performed the calculation and saved the results, the software stores in specific files all the calculated quantities. These files are in TXT format so they can be easily opened and processed with spreadsheets, etc. to use them at the best according to your needs.

These files collect all the results relatives to the lift law that has been defined, the kinematic simulation, to that dynamic and to that of the engine.

In addition to these files are created appropriate TXT file with the data for the cam profiles that have been calculated.

These files contain the profile both in Cartesian coordinates or polar coordinates, in this way will be possible to easily insert the profile of the cams for the realization with CNC machines.

In addition the profile of the cam calculated is also saved in DXF format file so it can be easily imported into any CAD-CAM system to draw the camshaft and proceed to the realization with CNC machines

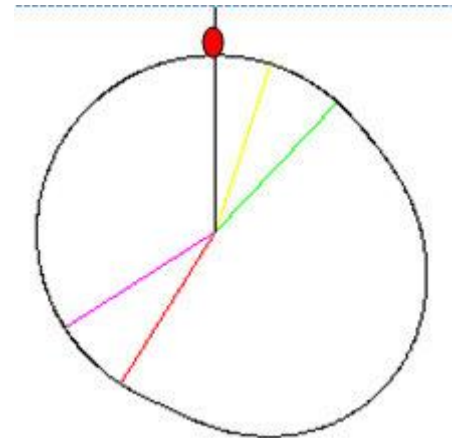
In the drawings dxf in addition to the drawing of the cam are tracked the lines: :

start rise ramp (magenta color)

start phase (red color)

end phase (green color)

end down ramp (yellow color)



The cam is positioned with the engine at top dead center during the combustion phase.

The point of contact with the follower (tappet, or rocker arm) is assumed to be on the vertical above (red circle in the figure).

The direction of rotation considered is the one that has been entered into the software (clockwise or anti-clockwise).



# PROFESSIONAL CAM PRO - *comparison results*

In addition to the numerical data the software PROFESSIONAL CAM PRO compares the graphs of all the calculated quantities, in this way you will appreciate even more in detail the differences between the compared solutions.



# PROFESSIONAL CAM PRO

As you have seen from this brief presentation the software PROFESSIONAL CAM PRO is the ideal tool to obtain the optimal design of the cams.

It allows you to choose between the different types of lift laws that can be manipulated in real time in endless ways so you can find easily and quickly the law which meets the desired characteristics.

Calculates the cam profile for all the main valve train systems, allowing you to check the characteristics of the profile in relation to the lift law choice.

Carries out both kinematic simulation, and that dynamic, so you can verify the operation of the valve train system in all its aspects and evaluate arches and contact angles, forces, friction, surface pressures, etc.

Check possible interference between the valves and the piston, and calculates the characteristics of the combustion chambers at roof and hemispherical.

It generates output files with all the variables calculated and with the cam profiles in Cartesian coordinates, polar coordinates and already included in drawings in DXF format, thus allowing a rapid use in CNC machines and CAD-CAM systems

It allows you to directly compare the calculated solutions, enabling you to check the differences and then to make the best choice for your needs.