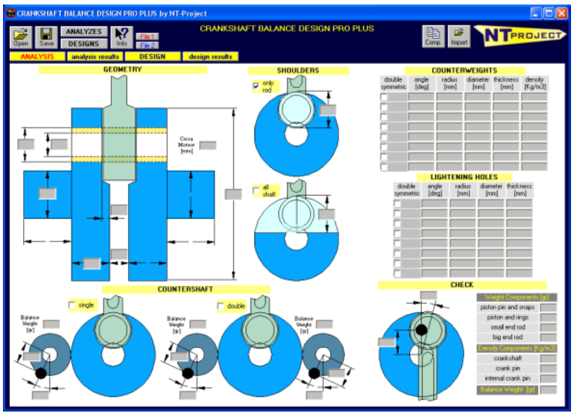
SOFTWARE CRANKSHAFT BALANCE DESIGN PROFESSIONAL PLUS 2016

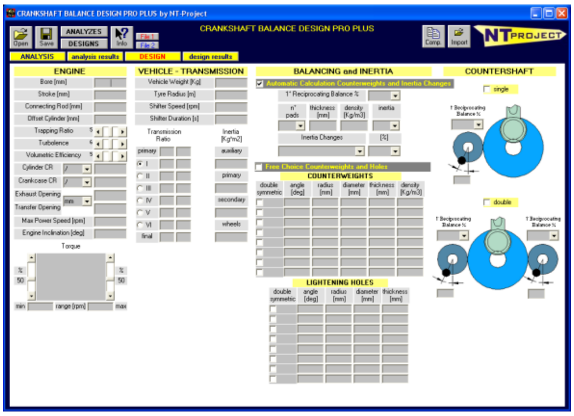
The software Crankshaft Balance Design is designed to provide comprehensive support in the analysis and development of crankshafts for single-cylinder engines.

The software is divided into two work areas, one dedicated to the analysis and one to the design of the crankshaft.

ANALYSIS



DESIGN



The area of analysis allows to have immediately a complete picture of the status of the crankshaft analyzing WEIGHT - BALANCING - SYMMETRY and INERTIA

The area of design allows instead to perform two fundamental functions:

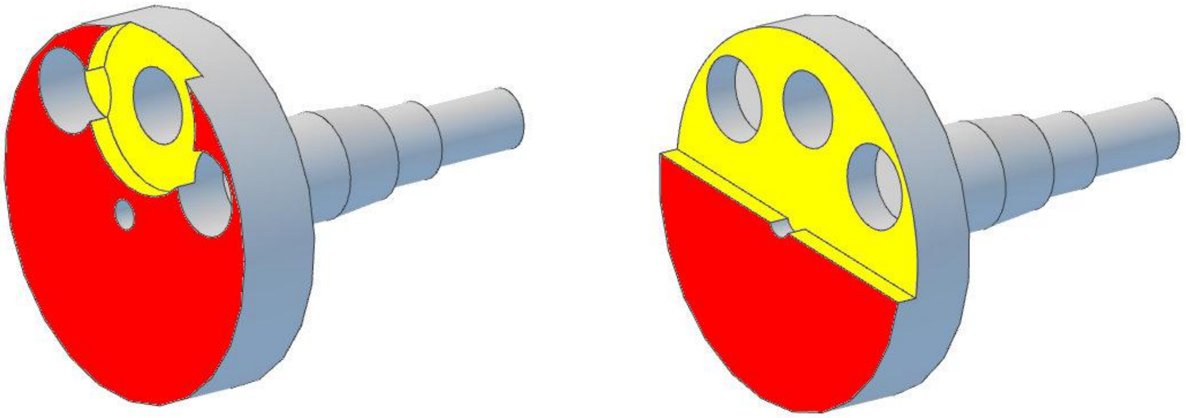
- the calculation of the interventions to be done on the crankshaft to achieve a certain balance and a certain inertia;
- the calculation of FRICTION – FRAME FORCES – ENGINE PERFORMANCE - VEHICLE PERFORMANCE, that the choices of balancing and inertia determine.

Already from this introduction you can understand how with a single software you can have the complete tool to work and develop the crankshaft without neglecting any technical aspect.

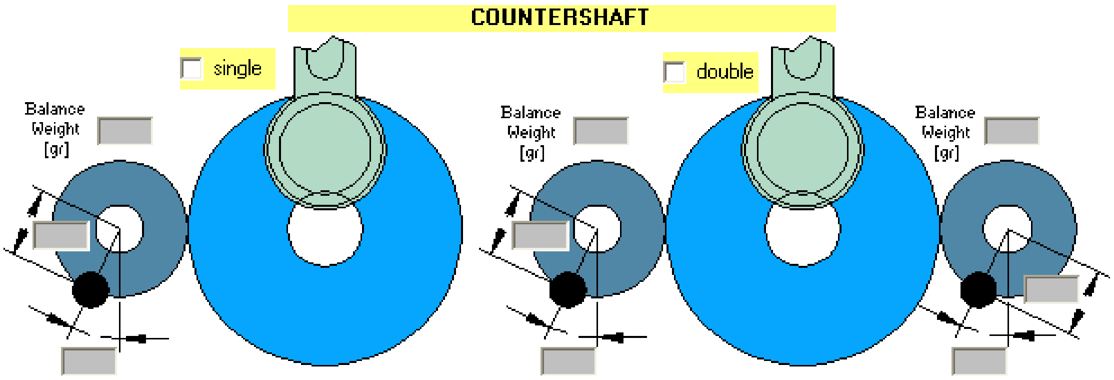
Now let's see in detail the two areas of the software.

CRANKSHAFT ANALYSIS

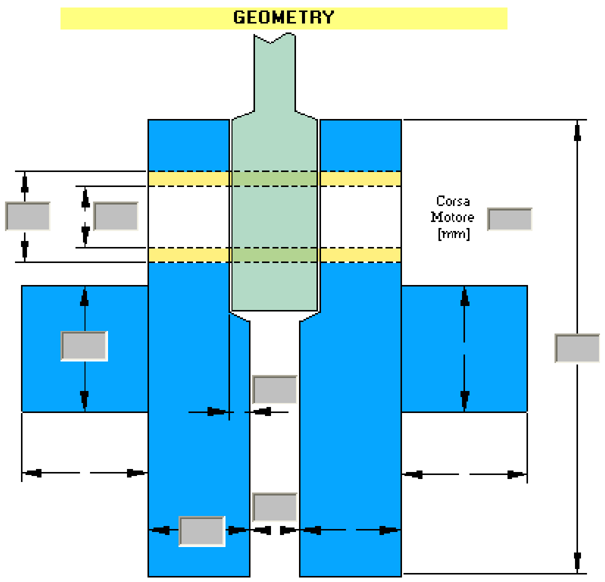
The software allows you to analyze and study full circle crankshaft full circle, both with shoulders limited to the big end rod area, both with shoulders that affect the entire cheek.



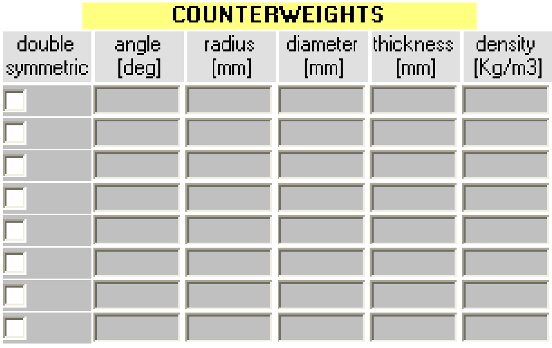
Moreover is possible to study crankshaft provided with single or double countershaft.

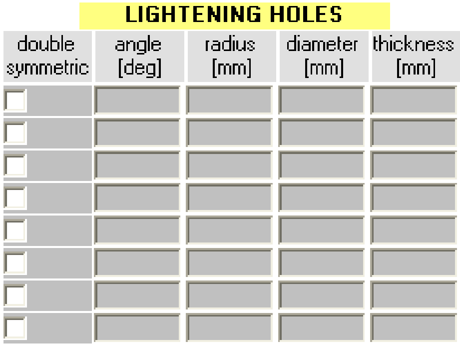


Thanks to simple geometric reliefs is possible to reconstruct in the software the exact geometry of the crankshaft that you want to analyze.

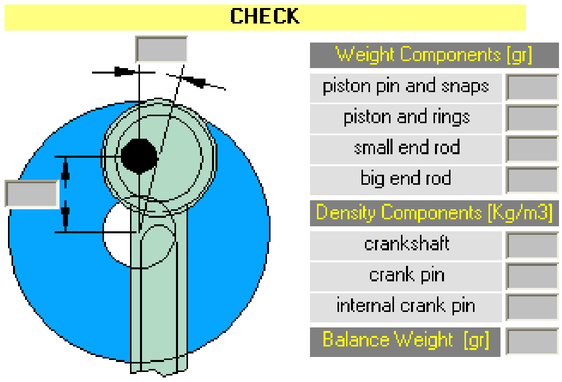


Moreover you can easily indicate the position and the characteristics of eventual holes and counterweights present on the crankshaft.





At this point is sufficient to combine simply the data of the weights of the crank slider, to be able to perform the analysis.



Immediately you can see:

crankshaft weight

The software calculates the weight that has the crankshaft taking into account in addition to the main structure, also in the presence of a possible hole or filling of the crank pin, of the shoulders, of the counterweights and of possible lightening holes drilled on the crankshaft itself. Therefore it will easily see how each intervention will affect the weight of the crankshaft.

percentage of balancing of the reciprocating masses, both due to the only characteristics of the crankshaft, both including that due to possible countershaft

balancing	
counterweights density [Kg/m3]	19250.00
1° reciprocating balance only crankshaft [%]	50.07
1° reciprocating balance with countershaft [%]	50.07

The software based on the characteristics of the crankshaft and on those of crank slider elements, calculates how are balanced reciprocating masses, therefore without having to do practice tests you can immediately see which features of balance has your crankshaft, and make its assessments to make constructive changes.
If there are single or double countershafts, in the software is possible to enter the their main features, and in the calculations of balancing the software will take into account also of the countershafts effect.

crankshaft symmetry

simmetry	
centroid angle crankshaft with rod [°]	0.0
centroid angle crankshaft with reciprocating [°]	180.0
centroid angle crankshaft with rod and countershaft (TDC) [°]	0.0
centroid angle crankshaft with reciprocating and countershaft (BDC) [°]	180.0

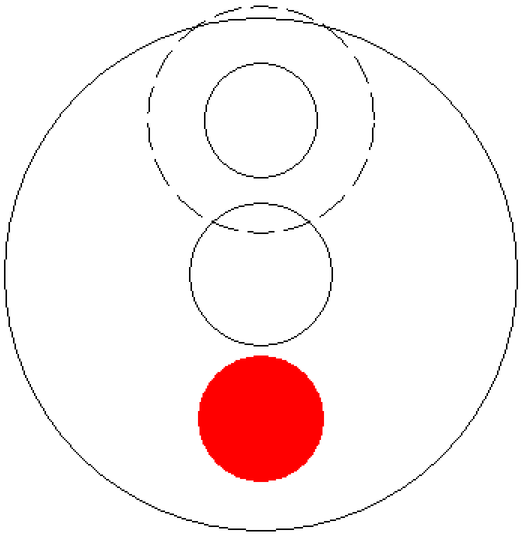
Usually the crankshafts have a balancing symmetric, and then in the rest position the crank handle always lies on the vertical axis, but sometimes it may happen to have with crankshaft that presents a certain asymmetry balancing for translating inertia loads in the engine cycle.
The software also studied this aspect, showing the presence of a possible asymmetry and also the entity, indicating how rotates the crankshaft in dead centers for effect of the asymmetry.

total inertia and inertia distribution

inertia	
inertia [Kg*mm2]	2186.0
inertia crank pin [%]	5.0
inertia big end rod [%]	4.1
inertia shoulders [%]	-3.8
inertia counterweights [%]	6.2
inertia holes [%]	0.0

The calculation of inertia is always one of the most complex aspects because, depending of the shape, the position, etc., each parts of the crankshaft produces a different inertia. Often these calculations are made with simplified formulas (pd2, etc.) but this does not allow you to really evaluate the differences between the different geometries or modifications that you want to practice, so the software performs an accurate calculation of each individual part that makes up the crankshaft and in addition to calculating the real total inertia that produces the crankshaft, calculates also how it is distributed in the different parts relatively to the main structure of the crankshaft.

crankshaft drawing



Besides to the numbers, a graphical view of the data entered it is fundamental both to see if the geometry data that have been entered are correct and no mistakes were made, and to evaluate the possibilities of space for any changes that you intend to do. For this reason, the software draws the crankshaft and also creates its image that can be printed.

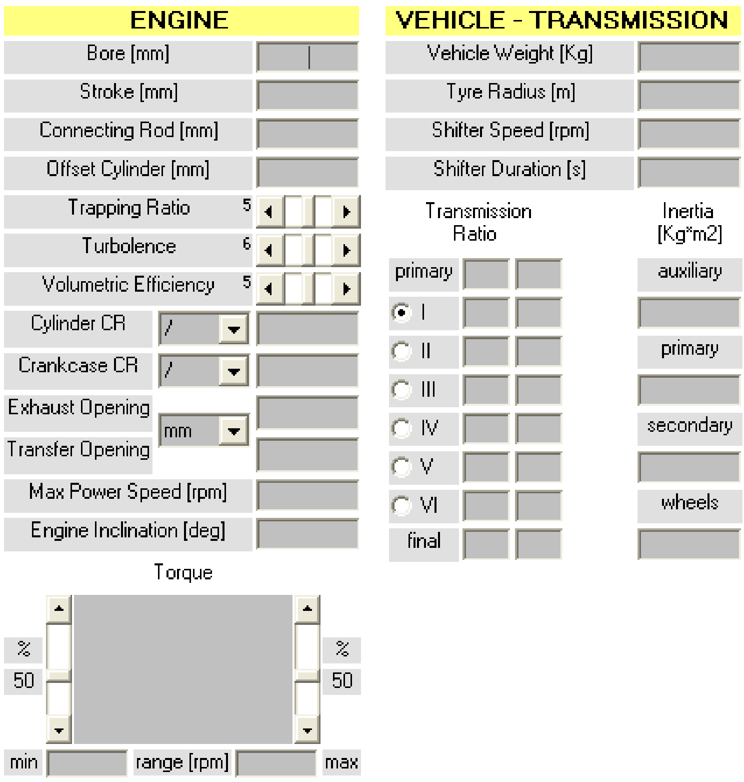
CRANKSHAFT DESIGN

After the analysis phase is possible to study the changes to the crankshaft analyzed or studying a new crankshaft thanks to the design area.

In this area of the software you enter more in depth and you can evaluate all the significant quantities to arrive at the optimum design of the crankshaft in relation to your needs.

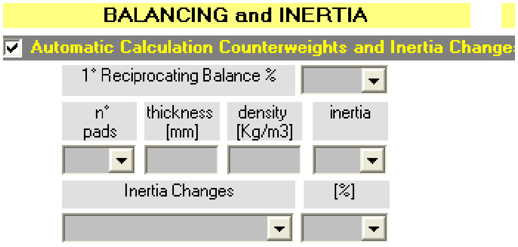
In fact, the choices of balancing and inertia to be used for the crankshaft depend on the characteristics of the engine on which it will be applied the crankshaft, and from those of the vehicle on which it will be applied the engine.

The software allows you to easily take account of both. In fact, for the engine, it will be sufficient to insert the main data and thanks to these the software will simulate the values of the pressures in the cylinder, the combustion, etc. in order to get the loads to which the crank slider will be subject during the engine cycle. Same goes for the vehicle, in fact inserting its main data and those of the transmission and gearbox will be possible to see how the performance of the engine then translates on the vehicle.



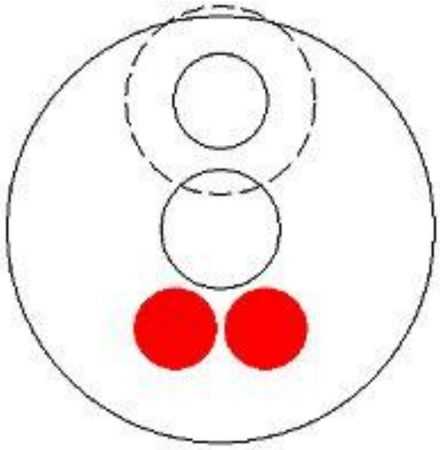
Only thanks to these calculations will be possible to actually see how the choices of balancing influence the friction and then the mechanical losses of the engine, and how the choices of inertia affect performance of the vehicle during acceleration, gear shift and throttle release.

After entering these data in the design area it will be possible to calculate the software interventions that must be carried on the crankshaft to achieve a certain balance and a certain inertia.

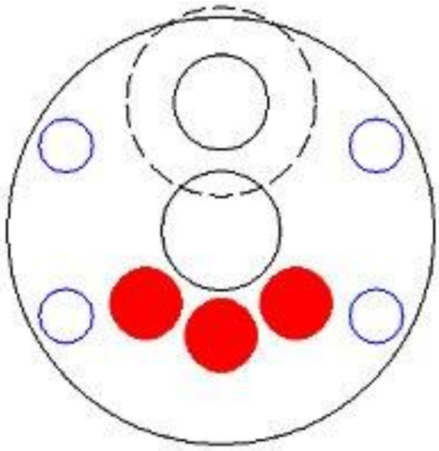


The types of calculation that the software performs are multiple:

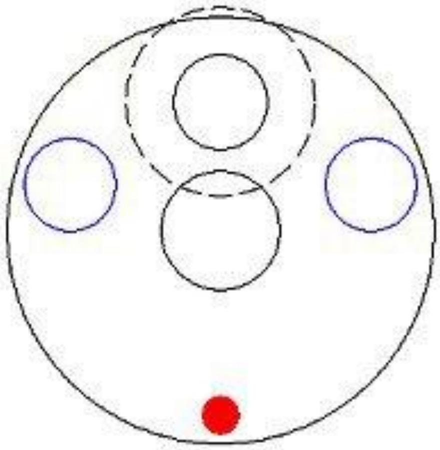
- balancing symmetrical with the possibility of indicating the number of counterweights that you want to use and if the position of the counterweights must be designed to provide the minimum or maximum inertia of the crankshaft;



- balancing symmetrical with reduction of the crankshaft inertia practicing hollows or holes on the crankshaft;



- balancing symmetrical with reduction of the crankshaft inertia practicing holes in the upper part of the crankshaft.



For all these types the software automatically calculates the position and the size of all the counterweights, hollows or holes which must be drilled to obtain the desired result, and shows also the relative drawing. Therefore create a crankshaft with a specific balancing or with a certain inertia will become extremely fast and effective.

crankshaft weight [Kg]	2.01399

balancing	
1° reciprocating balance only crankshaft [%]	50.00
1° reciprocating balance with countershaft [%]	50.00

counterweights [n°]	thickness [mm]	diameter [mm]	radius [mm]	angles [deg]
2	20.0	8.2	18.6	164 / 196

inertia machining

holes [n°]	diameter [mm]	radius [mm]	depth [mm]	angles [deg]
2	19.5	33.2	20.0	73 / 287
2	10.7	37.7	20.0	47 / 313
2	3.3	41.3	20.0	35 / 325

In addition to these possibilities of automatic calculation of the balancing and of the inertia, the software offers the possibility to study freely interventions both for the application of the counterweights, both for the introduction of lightening holes. This will make it possible to study any kind of solution, evaluating for each the pros and cons, and then choosing the one most appropriate for your needs.

Free Choice Counterweights and Holes

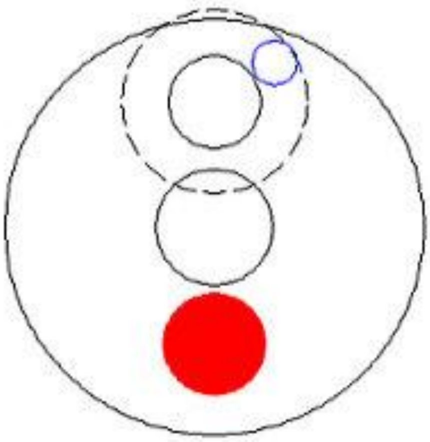
COUNTERWEIGHTS

double symmetric	angle [deg]	radius [mm]	diameter [mm]	thickness [mm]	density [Kg/m3]

LIGHTENING HOLES

double symmetric	angle [deg]	radius [mm]	diameter [mm]	thickness [mm]

Among these it will be possible for example to study interventions that make the crankshaft asymmetrical to move the loads in the engine cycle and obtain advantages in terms of friction and mechanical losses.



At the end of the calculation in addition to the actions to be done in order to obtain the balance and the inertia desired, the software shows how these choices affect the performance of the engine and vehicle, are in fact calculated:

friction forces and torque

slider - crank			
	MIN	MAX	MED
cylinder-piston friction force [N]	0.00	186.38	92.98
crank friction torque [N*m]	0.06	4.04	0.96

The loads acting on the crank slider and on the crankshaft inevitably cause friction and consequent mechanical loss. Based on these calculations will be possible to see how the choices of balancing influence this aspect, and then finding the solution that generates fewer losses and consequently the best performance for the engine.

slider - crank			
	MIN	MAX	MED
engine torque [N*m]	-161.26	163.15	24.08
engine power [CV]	-310.05	313.68	46.30

frame forces

slider - crank			
	MIN	MAX	MED
frame vertical force [N]	-8977.65	4512.37	2.11
frame horizontal force[N]	-6010.59	6010.59	0.00

In addition to the performance of the engine, also the reliability and the behavior of the frame are essential to achieve the best results, for this reason the software calculates the forces that generate the choices of balancing, will then be possible to see the extent of the forces, if these are preponderant in horizontal or vertical direction, and make accordingly appropriate assessments also in relation to the type of frame and vehicle which is applied the engine.

phases duration

phases duration [cad]						
	I	II	III	IV	V	VI
blowdown	33.002	33.003	33.003	33.004	33.005	33.006
transfer	129.878	129.938	129.960	129.978	129.988	129.995
exp	64.812	64.901	64.934	64.960	64.975	64.984
compr	65.066	65.036	65.026	65.018	65.014	65.011
exhaust	196.011	196.013	196.015	196.017	196.020	196.022
exp	97.813	97.904	97.938	97.964	97.980	97.990
compr	98.198	98.109	98.077	98.054	98.040	98.033

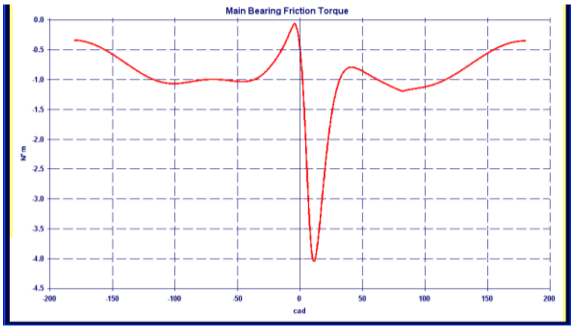
The choices of inertia albeit slightly alter the duration of the phases and this can alter the fluid dynamics of the engine, therefore the software according to the inertia, calculates the fluctuations which occur in the engine cycle and as consequently change the phases of the blowdown, exhaust and transfer.

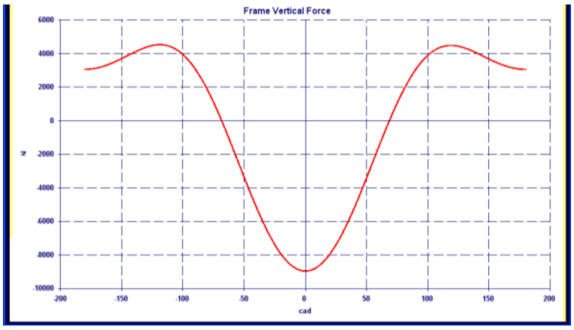
acceleration and brake engine

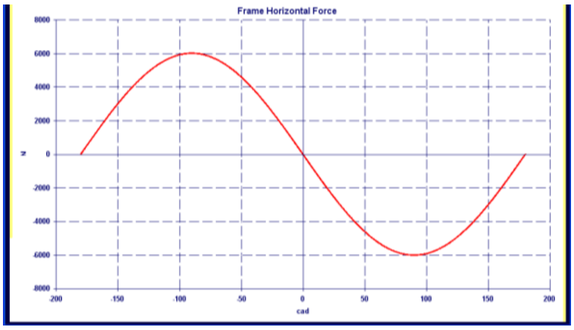
performance	
ACCELERATION time to reach maximum speed [s]	9.918
ENGINE BRAKE stop from maximum speed [s]	50.704

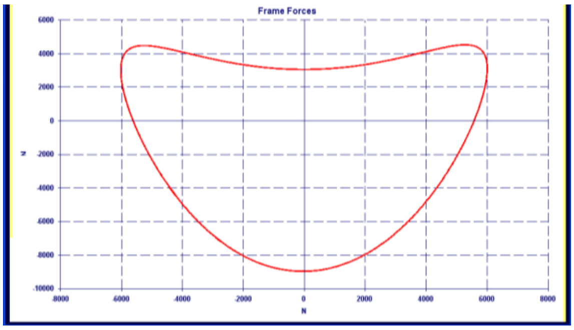
In addition to the duration of the phases the choices of inertia are critical for the behavior of the vehicle during acceleration, in gear shifting, and in the throttle release, for this reason the software performs these calculations, and will therefore be easy to see how each choice can determine or less advantages in different situations.

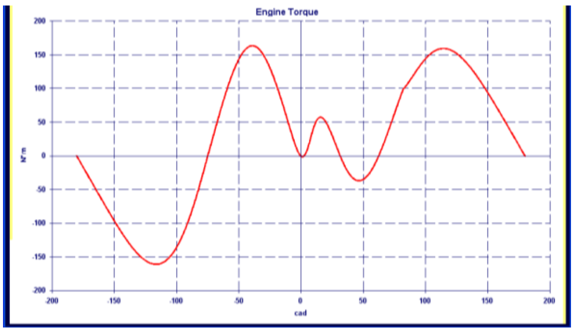
Each of these results is accompanied by relevant graphics to facilitate even more evaluations and comparisons between the different solutions.

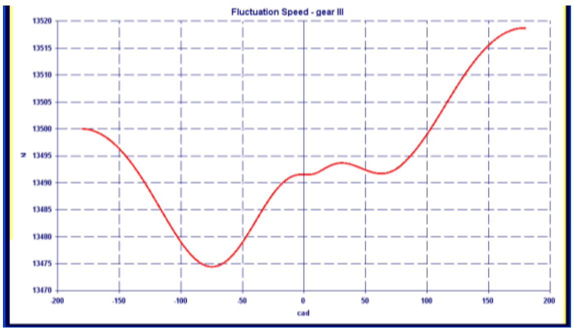












OTHER USEFUL FUNCTIONS OF THE SOFTWARE

Many of the calculations which we have just seen in the design area can also be used to make choices independent from the crankshaft.

For example thanks to the software it is possible to determine the optimal rpm of gear shift to obtain the better acceleration according to the shape of the torque curve of your engine.

Or it is possible to see the inertia that the flywheel or other organ connected to the crankshaft must have to improve the gear change according to the shifting duration that a driver may have with respect to another.

And so on for other assessments that can be done thanks to the calculations of engine and vehicle performance simulation that the software is able to do.

COMPARISON SOLUTIONS

Both for what concerns the analysis phase, and for that of design the software allows to compare two solutions both for what concerns the numerical results, both for the graphs of all the main quantities.

Thereby identifying the best solution, or weigh the pros and cons of each solution to suit your needs will be very simple and easy.

crankshaft weight [Kg]	2.16515	2.05520
balancing		
counterweights density [Kg/m3]	19250.00	19250.00
1° reciprocating balance only crankshaft [%]	50.59	62.40
1° reciprocating balance with countershaft [%]	50.59	62.40
simmetry		
centroid angle crankshaft with rod [°]	0.0	0.0
centroid angle crankshaft with reciprocating [°]	180.0	180.0
centroid angle crankshaft with rod and countershaft (TDC) [°]	0.0	0.0
centroid angle crankshaft with reciprocating and countershaft (BDC) [°]	180.0	180.0
inertia		
inertia [Kg*mm2]	2200.7	2047.2
inertia crank pin [%]	5.0	5.0
inertia big end rod [%]	4.1	4.1
inertia shoulders [%]	-3.8	-3.8
inertia counterweights [%]	7.0	8.2
inertia holes [%]	0.0	-9.1

crankshaft weight [Kg]	2.13668	2.17334

balancing

1° reciprocating balance only crankshaft [%]	50.00	50.00
1° reciprocating balance with countershaft [%]	50.00	50.00

counterweights [n°]	thickness [mm]	diameter [mm]	radius [mm]	angles [deg]
1	20.0	21.9	25.4	180
2	20.0	17.0	23.0	156 / 204

inertia

crank pin [%]	big end rod [%]	shoulders [%]	counterweights [%]	machining [%]	total [Kg*mm2]
5.0	4.1	-3.8	6.2	0.0	2211.7
5.0	4.1	-3.8	6.0	0.0	2208.4

phases duration [cad]

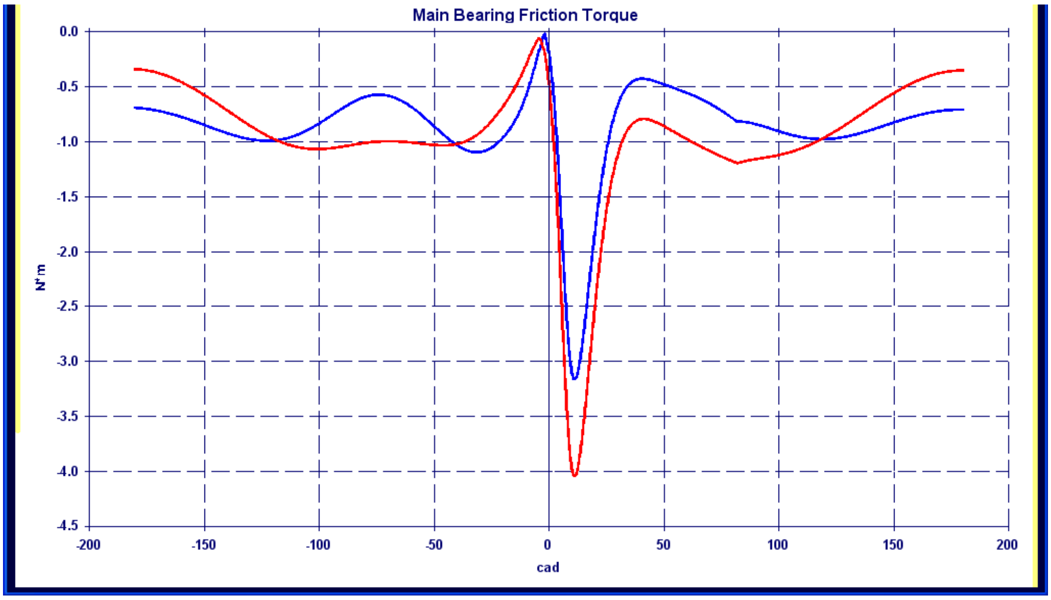
	I	II	III	IV	V	VI
blowdown	33.002	33.003	33.003	33.004	33.005	33.006
	33.001	33.002	33.003	33.004	33.005	33.006
transfer	129.878	129.938	129.960	129.978	129.988	129.995
	129.870	129.935	129.959	129.977	129.988	129.995
exp	64.812	64.901	64.934	64.960	64.975	64.984
	64.800	64.898	64.932	64.959	64.974	64.984
compr	65.066	65.036	65.026	65.018	65.014	65.011
	65.070	65.038	65.027	65.018	65.014	65.011
exhaust	196.011	196.013	196.015	196.017	196.020	196.022
	196.010	196.013	196.015	196.017	196.020	196.022
exp	97.813	97.904	97.938	97.964	97.980	97.990
	97.801	97.900	97.936	97.963	97.979	97.989
compr	98.198	98.109	98.077	98.054	98.040	98.033
	98.209	98.112	98.079	98.054	98.041	98.033

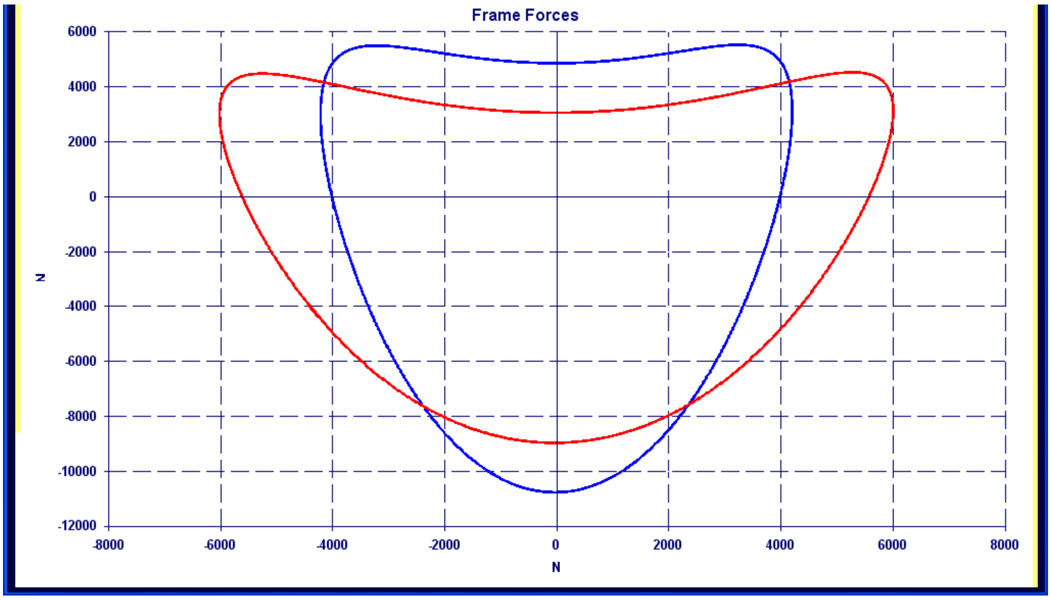
slider - crank

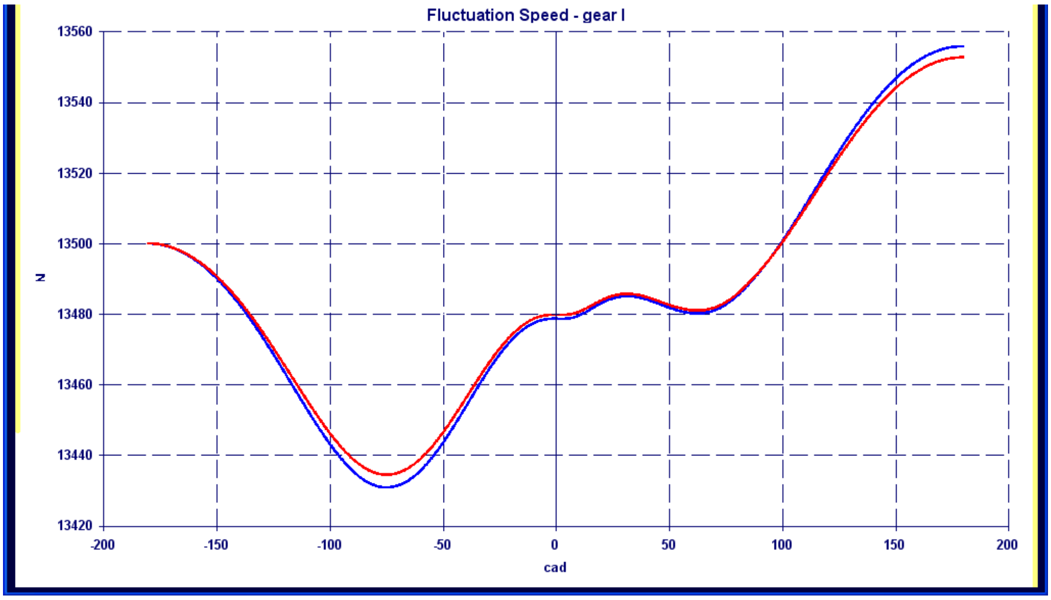
	MIN	MAX	MED
cylinder-piston friction force [N]	0.00	186.38	92.98
	0.00	186.38	92.98
crank friction torque [N*m]	0.06	4.04	0.96
	0.02	3.16	0.87
frame vertical force [N]	-8977.65	4512.37	2.11
	-10780.81	5515.10	3.36
frame horizontal force[N]	-6010.59	6010.59	0.00
	-4207.41	4207.41	0.00
engine torque [N*m]	-161.26	163.15	24.08
	-161.24	163.11	24.17
engine power [CV]	-310.05	313.68	46.30
	-310.02	313.61	46.47

performance

ACCELERATION time to reach maximum speed [s]	9.918
	9.894
ENGINE BRAKE stop from maximum speed [s]	50.704
	48.628


Main Bearing Friction Torque
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
N*m
-200
-150
-100
-50
0
50
100
150
200
cad


Frame Forces
6000
4000
2000
0
-2000
-4000
-6000
-8000
-10000
-12000
N
-8000
-6000
-4000
-2000
0
2000
4000
6000
8000
N


Fluctuation Speed - gear I
13560
13540
13520
13500
13480
13460
13440
13420
N
-200
-150
-100
-50
0
50
100
150
200
cad

As you can see from this presentation, the software Crankshaft Balance Design is a key tool in the development of the crankshaft, because it is the only software that allows you to analyze and study the crankshaft being able to evaluate all the significant technical aspects and being able to see how every technical choice is reflected in the performance and reliability of the engine and chassis.