

Horizontally Opposed Engine (Boxer engine)

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Extended Abstract

In the present scenario, maintaining the center of gravity of vehicle is a serious problem because of the engine size. This can be easily balanced by using horizontally opposed engine/boxer engine. Horizontally Opposed engine is one of the types of internal combustion engines. It is also called as 'Boxer /Flat engine'. The pistons face away from each other in 180 degree symmetrical layout around the crankshaft and work to balance out each other's vibrations. The main feature of this engine is that it has low center of gravity than any other engine configurations (Inline or V-type engines). Low center of gravity of engine lowers the center of gravity of entire car. Hence vehicle using them will have better stability and control during cornering. It generally consists of 4, 6, 8 or 12 cylinders. The boxer engines usually find applications in racing cars. They are presently used in automobile companies like Porsche, Ferrari, and Subaru-Toyota. And also they are used as some aircraft engines. Due to their higher manufacturing cost it has limited use in automobile industries.

Our objective is to study and review a research paper on boxer engines and compare its performance, safety with the other traditional engines and obtain 'engine power curve vs rpm' between boxer engine and other engines. And also to study about the benefits of development of this engine for passenger car application. The research paper we have reviewed and presented is 'Advanced engine dynamics using Multi Body Systems: Application to twin cylinder boxer engines', written and presented previously by Yannick Louvigny-Automotive Engineering-University of Liege, Belgium held at 1st Joint International Conference on Multibody System Dynamics on May 25-27,2010,Finland.

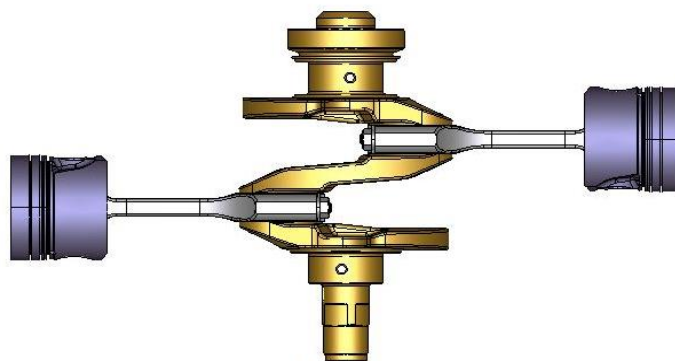


Figure 1. Geometric model of the boxer engine in Samcef Field

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Engine simulation is an important issue to design mechanical components and to reduce the development cost of new vehicles. Dynamic simulations of a twin-cylinder boxer engine are carried out with rigid and flexible multibody models using the finite element approach.

In a first step, simulations of the engine running at constant revolution speed (4000 rpm) are done taking advantages of the actual geometry of engine parts coming from CAD models. Forces due to the gas pressure are added in the simulation to calculate more precisely the load applied on each engine part. Software used – ‘SAMCEF’, which is a FEA software package.

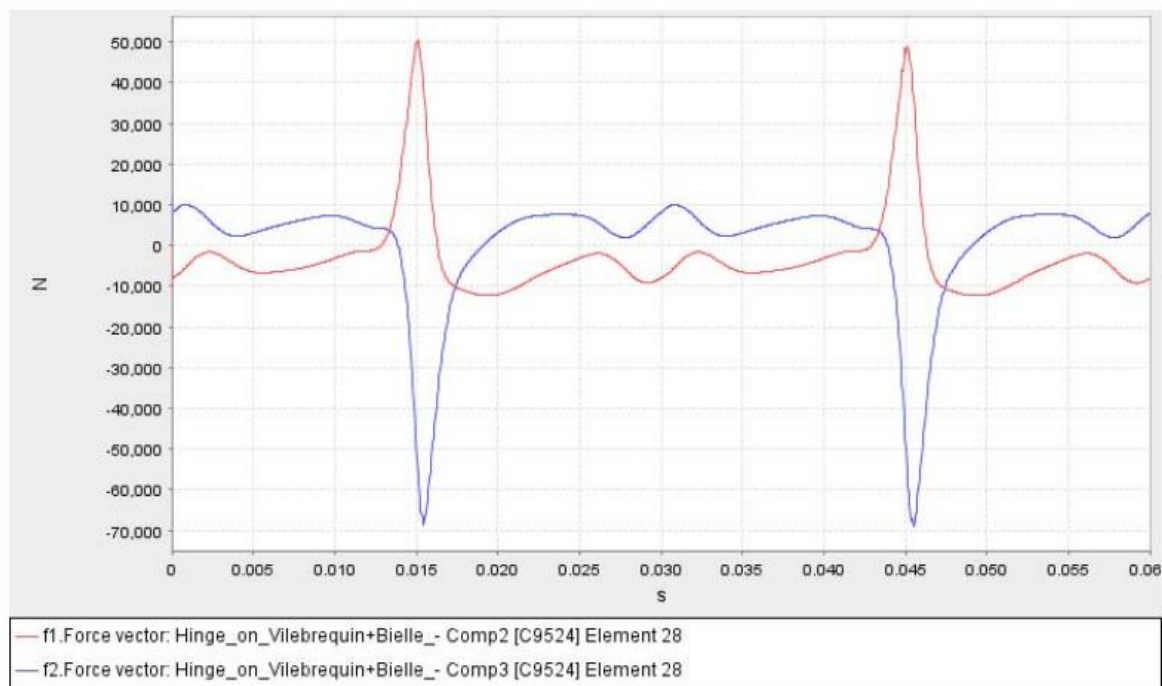


Figure 2. Forces transmitted from the connecting rod to the crankshaft (4000 rpm)

A mixed model is developed; pistons and connecting rods are considered as rigid bodies while the crankshaft is meshed with flexible brick elements. With this model, calculation of crankshaft stresses and displacements is possible. The meshing of crankshaft is shown in fig.3 below which is composed of 232281-

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-volumetric elements .This requires a CPU time of approximately 6days. And also stress was computed which is shown in fig.4.

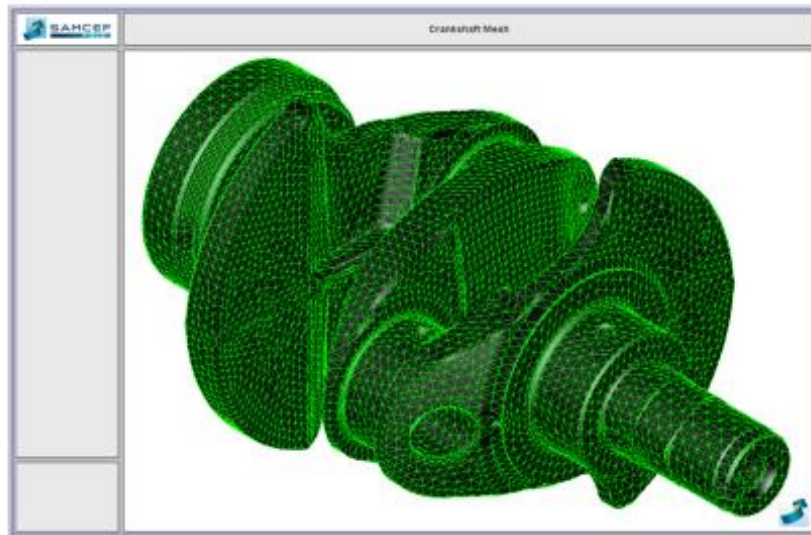


Figure 3. Crankshaft mesh (232.281 volumic elements)

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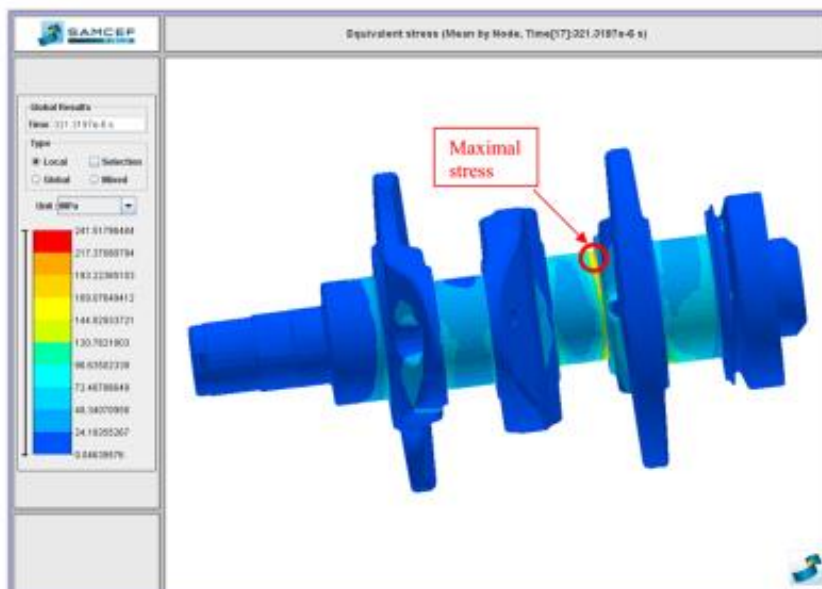


Figure 4. Crankshaft stresses for the "rigid hinge" contact model of the bearing surfaces

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Then, simulations are made with engine speed variations to evaluate the effect of inertia. Speed is varied between 3800 to 4000 rpm. The maximal value of force decreases at each rotation since inertia forces decreases as shown in fig.5 below. The force due to gas pressure has been adapted to remain in phase with the crankshaft piston. The radial force (red curve) reaches a maximum of 51000 N and the maximum tangential force (blue curve) 69000 N. The maximal value of the forces (radial and tangential) peaks decreases at each rotation because the inertia increasing and is opposed to the force generated by the gas pressure when the engine is increasing.

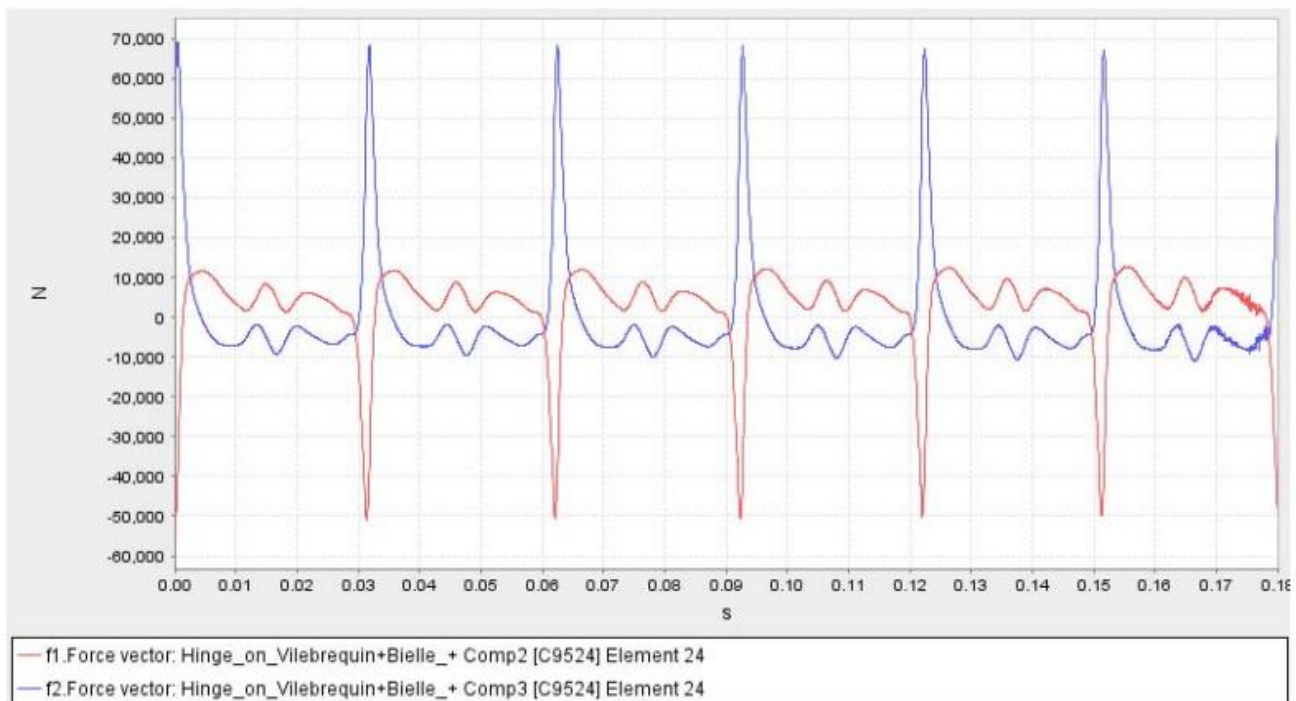


Figure 5. Forces transmitted from the connecting rod to the crankshaft (3800 => 4200 rpm)

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Due to the complex shape of the crankshaft, the CPU time and computer resources can be important. As simulations with available rotation speed have to be carried out on a larger number of engine revolutions, it becomes difficult to work with the fully detailed crankshaft geometry. So, simplified models (a tridimensional model with simplified geometry) of the crankshaft neglecting holes and fillets are developed and compared. These models are first validated with different tests including results of constant speed flexible simulations. Simplified model is meshed with 15569 elements and simulated to obtain stress which is show in figure below. This is done on lesser time compared to previous models.

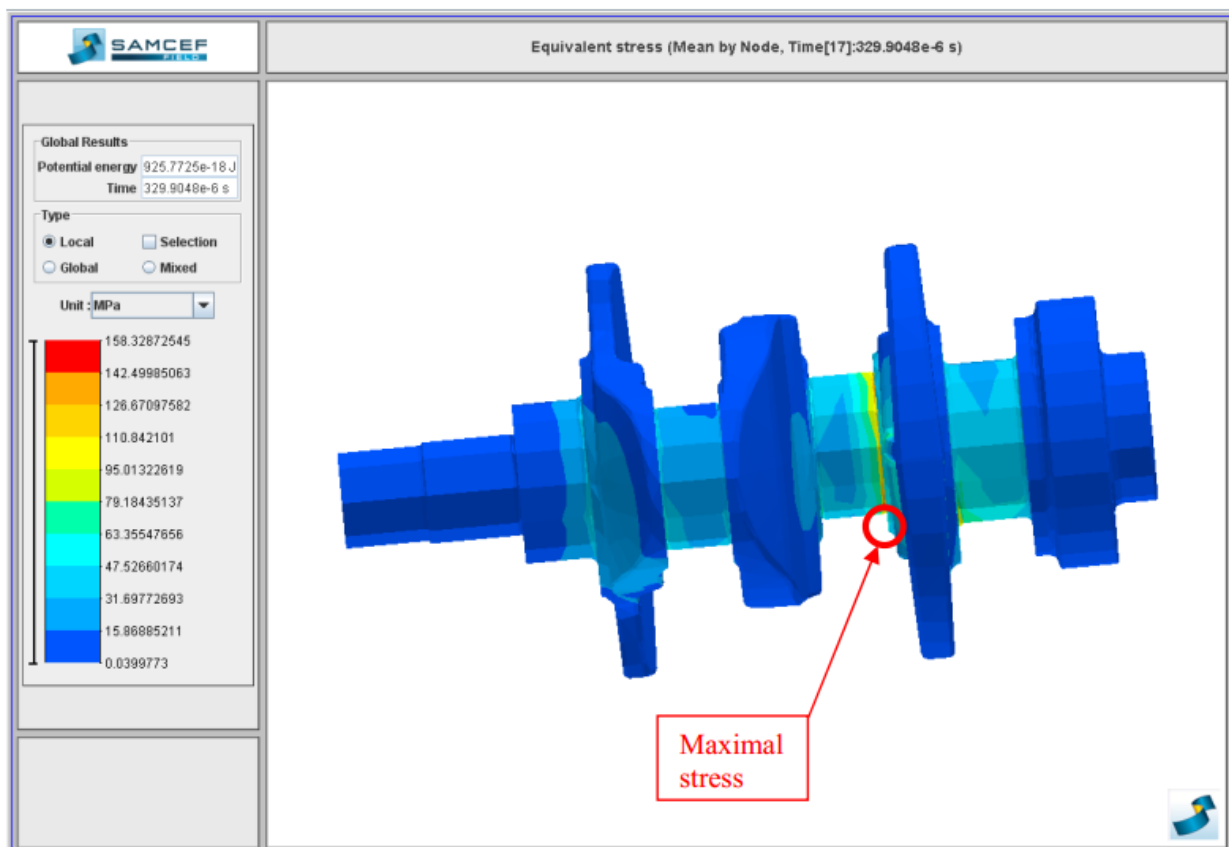


Figure 8. Crankshaft stresses at time 32 μ s for the simplified 3D model

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The rigid multibody simulation allows quick calculations of inertia forces and moments inside the engine. Moreover, the exact forces acting on each component are also known from this simulation but without taking interaction of deflection and stresses. The flexible multibody simulations allows to carrying-out stress and strain analysis during all engine rotation, which is one of the most important factors to design engine. Hence simulation with these two models can be used by designers at early stages of engine for better design.