MDA 2022 – Porto, 7-8 July 2022
4th International Conference on Materials Design and Applications

Development of an innovative test machine for tyre, wheel and suspension systems for automotive and industrial vehicles

L. Solazzi, A. Mazzoni, M. Cima
University of Brescia (Italy), Department of Mechanical and Industrial Engineering

INTRODUCTION

Reliability and efficiency of automotive and industrial vehicles are strongly affected by the behaviour of the components involved in the interaction with the ground. For this reason, components like tyres, wheels and suspension systems are physically tested for efficiency and durability assessment. Anyway, standard test machines are generally designed for testing only one type of component, such as tyre (rolling and footprint tests), wheel rim (impact test, rolling test, biaxial test), wheel disc (cornering test). In addition, to better understand real loads in working conditions, field tests can be done by means of wheel force transducers (WFT) or data acquisition systems (DAQ) connected to sensors. Although field tests are very useful, they are normally expensive and difficult to do because of the limited availability of vehicles for testing purposes in terms of time and variety of tracks.

Aim of this work is the design of an innovative test machine able to perform different kinds of test on tyres, wheels and suspension systems, using just one test rig. The core of the machine is a hexapod table. Thanks to its six degrees of freedom, it allows high versatility and the possibility of simulating different working conditions for extended time periods or numerous test block repetitions. A flat track configuration is chosen, since it allows a better simulation of real tyre-to-ground contact. The vertical load is generated by a hydraulic press, while lateral loads originate from slip or camber angles that can be imposed through the hexapod table rotation.

MACHINE DESCRIPTION

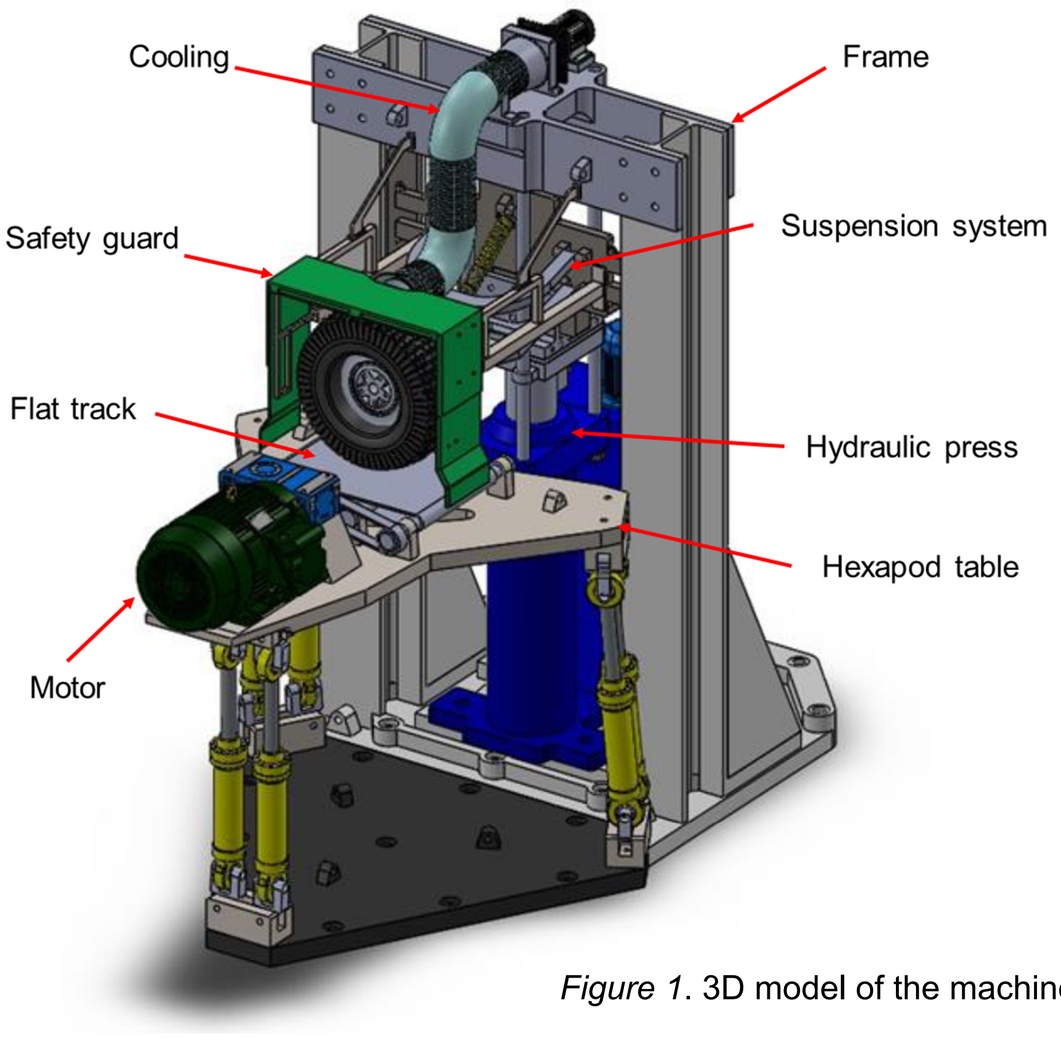
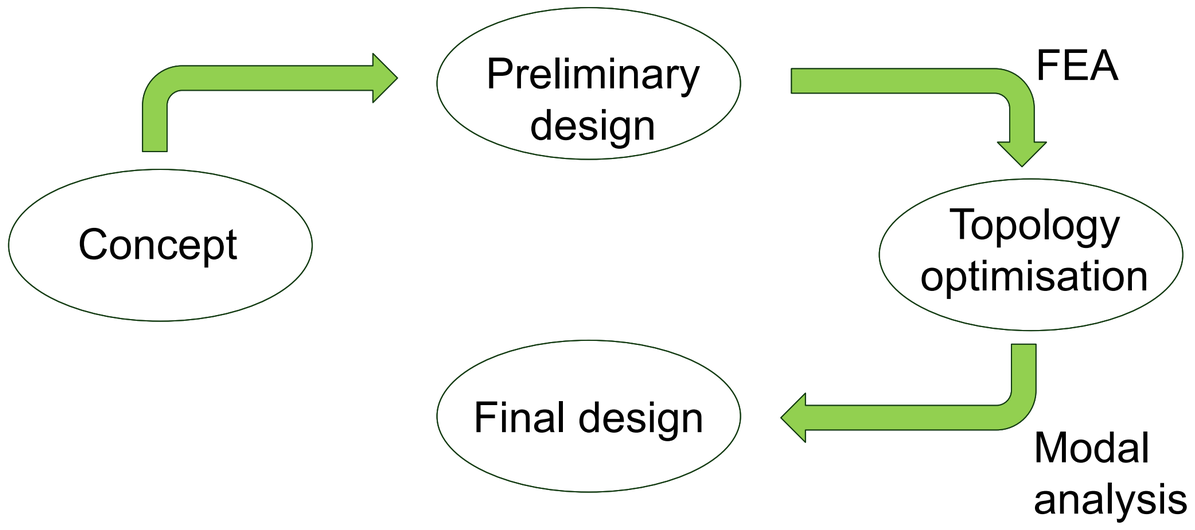


Figure 1. 3D model of the machine

- Flat track type machine: better simulation of tyre-to-ground contact.
- Hydraulic press: maximum vertical load 20 kN.
- Hexapod table: 6 DOF for high versatility in simulating road conditions. Possibility of applying slip or camber angle to the wheel.
- Track equivalent linear speed: from 50 km/h to 130 km/h.
- Nominal wheel diameter range: from 12” to 22.5”.

DESIGN APPROACH



- Software for design and FEM structural and modal analysis: SOLIDWORKS Simulation

RESULTS

- Safety factor vs yield stress and buckling phenomena: minimum 3 for all main components
- Topology optimisation: theoretical weight reduction approx. 1970 kg (14% of overall machine weight)
- Modal analysis: safety factor approx. 2 vs expected tests frequency range (15÷20 Hz)

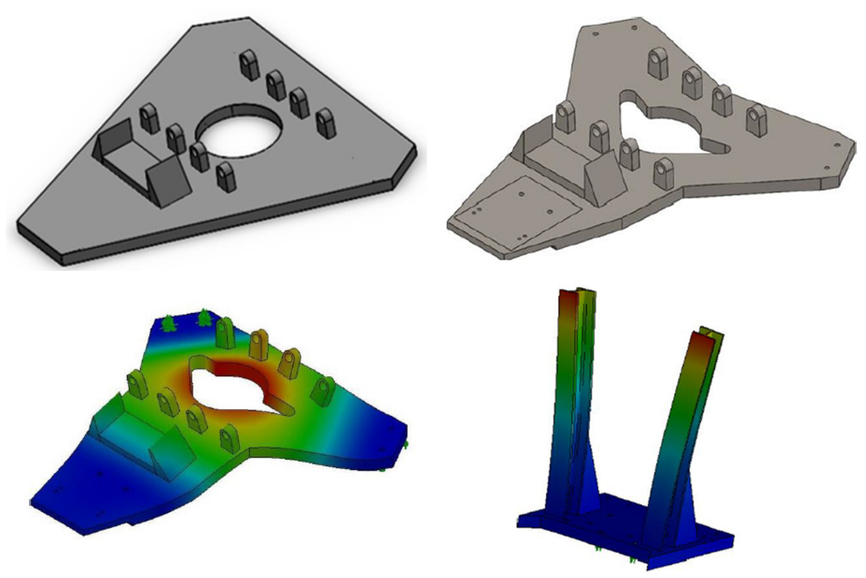


Figure 2. Example of optimisation process for the hexapod table and structural FEA results for hexapod table and frame

Table 1. Natural frequencies of the machine

Mode	Frequency [Hz]
1	30.5
2	32.1
3	38.7
4	41.7

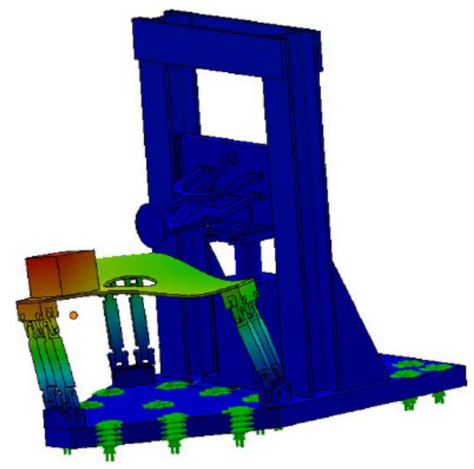


Figure 3. Machine displacement for mode 1

CONCLUSIONS

- The machine concept developed in this work is able to perform tests on tyres, wheels and suspension systems, using one test rig only.
- The main components and the whole structure are validated by static structural and modal analysis.
- Both standard industry tests and customised tests based on field data acquisitions will be feasible.
- Next step: software development for proper machine control and test data acquisition.

E-mail: luigi.solazzi@unibs.it - a.mazzoni003@unibs.it – cima.michele@gmail.com