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Improvement on Virtual Testing in the field of dynamic behaviour - WP7.3 of PIVOT-2 Project

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Abstract

The work described here is done in the context of the Work Package 7 of PIVOT-2. (Issued by Shift2Rail project).The main objective of this WP7 is to provide a major contribution on virtual testing, with the aim of improving the approval process of the dynamic behaviour of railway vehicles, which is currently given by EN14363:2016+A1:2018. The work began in October 2019 and a first deliverable has been provided in December 2020.

Work has been concentrated on:

- Worldwide benchmark on practices to assess vehicle dynamic validation.
- Investigations on methods of building and validating a vehicle model.
- Propositions and recommendations about using simulations for the acceptance of running characteristics of railway vehicles.

Keywords: virtual tests, running dynamics, model validation, vehicle performance

1 Introduction

The work exposed here is done in the context of the Work Package 7 of PIVOT-2. PIVOT-2 is a project issued by Shift2Rail project, which is the first European rail initiative to seek focused research and innovation (R&I) and market-driven solutions by accelerating the integration of new and advanced technologies into innovative rail product solutions.

The main objective of this WP7 is to provide a major contribution on virtual testing, with the aim of improving the approval process of the dynamic behaviour of railway vehicles.

EN14363+A1:2018 [1] is the standard which gives all requirements about assessment of dynamic behaviour of rolling stocks. This is historically done by on-line tests, but this last version of EN14363 opens possibility to assess partly the train with the help of simulations.

Nevertheless, if EN14363 reflects good ways to assess a vehicle with simulations, it is sometimes hard to apply requirements properly (model validation, access to data, need of test to validate a model, complexity of certain phenomenon…).

This research work has the ambition to propose new ways, new solutions and improvements in the current framework. This is done in respect of safety points, which are fundamental when dealing with dynamic behaviour of railway vehicles.

2 Methods

The work began in October 2019 and a first deliverable has been provided in December 2020.

Even if the subject was dealing with “virtual” testing, the method of work was very pragmatic: Vehicle manufacturers, railway undertakings and infrastructure managers were collaborating in this project, with recognized European experts in dynamic behaviour and simulations tools. Regular meetings were organised and the focus was always on the deliverable.

Moreover, a link with CEN/TC256/WG10 “Vehicle/track interactions” (which is the group that is responsible of EN14363) was established. The idea was that outcomes and findings from this project can be addressed in the standardization process. This is a guarantee that results of the work will be quickly applicable.

The project has been divided into 3 mains stages:

- Firstly, a worldwide benchmark has been done and concentrated on practices to assess vehicle dynamic validation. Three main ways have been identified: validation by on-track tests, validation by simulations and validation by combinations of both approaches.

- Secondly, investigations were made on methods of building and validating a vehicle model. The building and validation of a vehicle model is as important as it is difficult to do it in full accordance with the requirement of EN14363. A focus on existing methods has been done to precisely identify difficulties and new proposals has been provided.

Thirdly, some recommendations have been made about using simulations for the acceptance of running characteristics of railway vehicles, on different specific subjects.

3 Results

Firstly, the benchmark showed that on-track tests are the main way to assess dynamic behaviour all over the world.

Europe opened the possibility to use simulation (last version of EN14363). Nevertheless, concrete and complete applications remain rare for the moment and the process needs to be boosted.

In the US a different approach is implemented, with simulations as a major part, completed by

specific tests (maximum intended cant deficiency and testing with overspeed). This approach retained our attention.

Secondly, efforts were concentrated on the model for simulations, as a validated model is needed for virtual testing, even in a partial use.

Investigations have been done to further improve this fundamental part of the process.

They showed that an automatic tool (specifically developed) can be of great help. This tool provides several routines to assess parameters and has been developed during this project.

Furthermore, concerning input parameters like track geometry and contact conditions, it appeared with no surprise that these parameters are very important and influence the validation results by a major part. Recommendations about wavelengths for track data or about the knowledge of dominant rail profiles have been confirmed by our project.

Finally, new ways to validate a vehicle model for a homologation process have been explored.

More specifically, work has been done (and still need to go further) on:

- The level of correlation between tests and simulations
- The acceptance criterion to consider a model as validated
- The exploration of new ways to validate a model for a homologation process, as validation of each sub-system one by one: primary suspension, secondary suspension, connection between wheelset, bogie, carbodies, etc.

For the following WP of the project, the focus will be on the whole process of vehicle validation. The idea is to explore and improve parts of the process that are time consuming or complex to organize when on-track tests are done.

These subjects are:

- over-speed testing. The major difficulty is linked to the fact that strong non-linearities may dominate the behaviour at the maximum design speed of the train (bogies instabilities).
- tests in case of fault modes. An appropriate model which correctly represents the fault mode to evaluate remains a difficult point.

4 Conclusions and Contributions

The way the dynamic behaviour of railway vehicle is assessed in Europe is still requiring a lot of on-track test, expensive and complex to organise. The last version of EN14363 opened the possibility to use simulations, but practice shows that few manufacturer or railway undertaking used this opportunity.

The objective of this project was to provide major contribution on virtual testing, in the aim to improve the homologation process for dynamic behaviour of railway vehicle.

As this is a complex stage in the whole validation process, the working group began a worldwide benchmark, which showed that Europe seems to be “up to date” concerning simulations uses.

Even if other approaches are possible about assessment of dynamic behavior, the one defined in EN14363 remains a very good base, which can be improved, with the help of simulations.

Afterwards, exploration about concerns and difficulties on model validation has been done. This fundamental step in the process needs some improvement to reach efficient virtual test. Some propositions are made to go in this way.

This was followed by suggestions of improvement on the whole process of assessment, with the help of simulations.

Four main propositions have been expressed and work will be pursued in Working Party 8.3 (year 2022).

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References

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