# CAD Framework for Simulation of Railway Dynamics

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Railways has been one of the most commonly used means of transport worldwide, both for passenger and freight movement. With time, the railways has found more importance in research for providing faster and safer movement. This has led to increase in research activity related to the dynamics of railway vehicles. The railway dynamics comprises primarily the rail-wheel interaction and the dynamics of carbody.

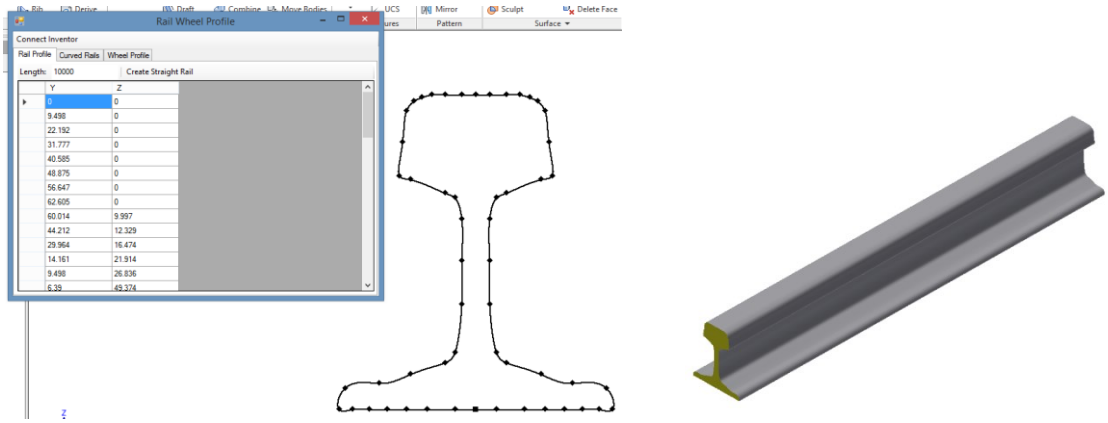
Rail-wheel interaction deals with the determination of contact point between the wheels and the rails and then then forces acting between them, in normal and tangential directions. The dynamics of carbody is analyzed by considering the carbody suspended over primary and secondary suspension system with respect to wheelsets. Different models are considered in the lateral, vertical and longitudinal directions. A detailed explanation on these aspects can be found in [1].

Several commercial software exist that can model and simulate the dynamics of railway vehicles. Some of them include ADAMS Rail, NUCAR, Vampire Dynamics, SIMPACK, etc. However, these software generally include their proprietary software program to solve for the dynamics of the system. Various mathematical models have been proposed by researchers to analyze wheel-rail interaction [2, 3] and the dynamics of carbody as summarized in [1]. In [2], a wheel-rail contact model has been proposed and the results of the analyses are implemented as animation in 3D-DAP, a generic multibody dynamic program. However, most other work mentioned on wheel-rail interaction, such as [3], and carbody dynamics [4] show only 2D images or graph plots of the analyses results. These may require better understanding of the multibody dynamics to comprehend the results or the response of the system. Therefore, there is a need for a CAD framework which can be used for the visualization of the results of dynamics of railway vehicles, in the form of animation.

In this paper, a CAD addin/plugin developed for Autodesk Inventor software has been presented. The primary objective of the addin is to model the wheelset and rails, based on the user input and then allow the motion of the wheelset on the rails. The current form of the addin has been developed using Visual C# and it interacts with Autodesk Inventor through its API (Application Programming Interface). The API allows the addin to read and modify the CAD data, programmatically.

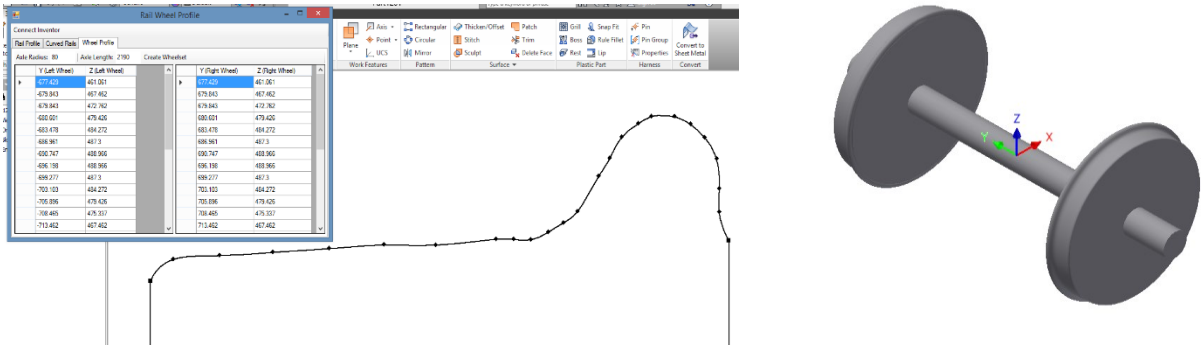
The coordinates of a set of points on the rail surface (in cross-section) are used as input to create a spline profile in a 2D sketch as shown in Fig. 1(a). The profile is later extruded along a straight line to form a rail part by the addin programmatically, as shown in Fig. 1(b). If the rail has to be extruded along a curve, it can be achieved by sweeping the profile over the curve. Similarly, a wheelset requires points on the wheel and tread surfaces (cross-section). Some of the straight lines are then connected between the input points resulting in a profile shown in Fig. 2(a). The wheelset is produced programmatically be revolving the profile about the wheel axis as illustrated in Fig. 2(b). The addin further places the wheelset on the set of rails modeled in an assembly.

The addin can be useful to visualize the animation of the wheelset. As a demonstration, the kinematic hunting behavior due to a later offset of the wheelset modeled using the expressions in [1] is implemented in the addin, as shown in Fig. 3. The transformation matrix of the wheelset, used to place and orient the component in the assembly, is modified programmatically based on the analysis results. Thus, the simulation results, which are generally in the form of plots, can be viewed as animation for better understanding of the response of the system. In addition, the features of Inventor software such as interference detection can be used to validate contact point detection algorithms. In future, the proposed CAD framework will be used to model and simulate the bogie and wheelsets on rails and then for the carbody dynamics.



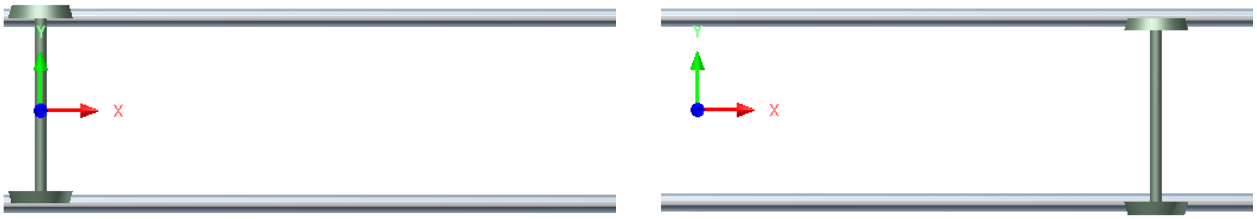
(a) Dialog and rail profile as spline (b) Extruded rail profile

Fig. 1: Inventor addin to create rail using extrusion feature



(a) Dialog to take profile points on wheel tread and wheel flange (b) Wheelset after revolution

Fig. 2: Autodesk Inventor addin to model wheelset using revolve feature



(a) Wheelset with initial lateral offset (b) Wheelset after lateral hunting motion

Fig. 3: Autodesk Inventor addin to move wheelset on rails demonstrating kinematic hunting behavior

## References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