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A NEW TRAIN TECHNOLOGY LEADS TO A REVOLUTION IN TRANSPORT NETWORKS

ABSTRACT

Securing of our future necessitates product and service innovations. These innovations will decisively contribute to the creation of jobs and to the maintenance of high standard of living as well as enabling sustainable development. Great opportunities for products and services for the markets of tomorrow arise as a result of the combined growth of companies and economies, together with the dynamic development of technology. One rapidly growing innovation area is that of track-based transport systems. After an era of partial improvements to the fundamental techniques of the previous century, the time is ripe to move to new methods for the race to the future.

KEY WORDS

new train tecnology, revolution in transport, transport modules

1. INTRODUCTION

When compared with the technological breakthroughs of the last 150 years, it can be seen that, since the building of the first railway on the principle of propulsion by power transfer through the wheel-track contact, no essential progress has been made to the railway system. The main functions of transportation, steering and propulsion are realised exclusively through small contact surfaces between rail and wheels. After a long period of partial improvement, this principle has been developed to the limits of its capabilities. Significant increase in customer use, demands a disproportionately high expenditure for research and development.

The main thrust of development in the last ten years has mainly concentrated on the increase of speed and not on actual customer needs - shortening of journey time from door to door, a broader choice of departure times and journey comfort. In the meantime, the car and plane have, with different development thrusts, usurped the standing of the train. The separation of local and long-distance travel and also the necessity to change trains evidently destroys a considerable section of customer use.

The lack of perspective of track based transport, has resulted over the last ten years in the closing down of stretches of tracks as a result of the oncoming influence of new direct routes and real estates. In Germany, in view of the lengthy authorisation process for new routes this trend must be stopped. Competitive track based transport necessitates rather more than fewer connections and stations.

The rapid growth of road transport of goods and, simultaneously, the shrinking of rail freight allows the impression that there is no long-term plan to combat the shrinking of the rail freight market. It does not take much imagination to recognise that the furthering of the development of the past 10 years is leading to a dead-end.

The over sixty years old history of the maglev (magnetic levitation) propulsion as matured in the system of the "TRANSRAPID" highlights the inability of companies to show visionary power and to recognise the potential for success offered by the future. En route to the products and services and markets of tomorrow, we need to develop a culture of innovation.

It can and must be possible for the rail system to realise the success of the second half of the 19th century and to lead to vivid renaissance.

2. VISION

The following vision describes the desirable (and attainable) situation in approximately 20 years' time. It should be seen as a fundamental orientation for concentrating energy onto the creation of an innovative integrated train system.

Track-based traffic is an integral part of the total conception in which the car, plane and train well balanced co-operate in a transport network. Each large town in Europe has at least one railway station. The main stations usually form top-ranking urban nuclei amidst densely built-up areas and commercial activities, eventually around the clock. Near each large town, there is a rail network point. This station belongs to the basic infrastructure of the community. It is not just the access to the train transport system but also the crystallisation point for urban life until late in the evenings.

The transport of people and goods arises primarily through small autonomous transporters, so-called 'shuttles'. These shuttles can be ordered by anyone through the telecommunications network and are configured according to specific journey requirements, e.g. arrangement of a shuttle for a business meeting with the usual infrastructure. On more highly frequented stretches of the network, shuttles will meet with one another when they, without contact, form convoys. Passengers have the choice to make stops at special stations. There is no longer a distinction between local and regional traffic.

For the transport of goods the shuttles are reconfigured in just a few minutes. Goods transport takes place at times when the demand for passenger transport is low, leading to a balanced use of the whole system around the clock. Loading and unloading is facilitated by standardised automated loading systems.

Transit times could be much reduced since goods trains would not have to wait when fast passenger trains want to overtake. The transport capacities of the tracks would increase by a factor of 5-10. Hence the transport costs would be much reduced since capital outlay (infrastructure, train system) could be shared among greater transportation capacity. Beyond this, due to a higher number of manufacturing specifications, the trains could be better adapted to the need and therefore be more cost effective.

The skeleton of a shuttle consists of a carrier structure made from light materials (aluminium frame or fibre-glass). The 3 modules: propulsion/braking, steering and suspension/tilt modules are also made

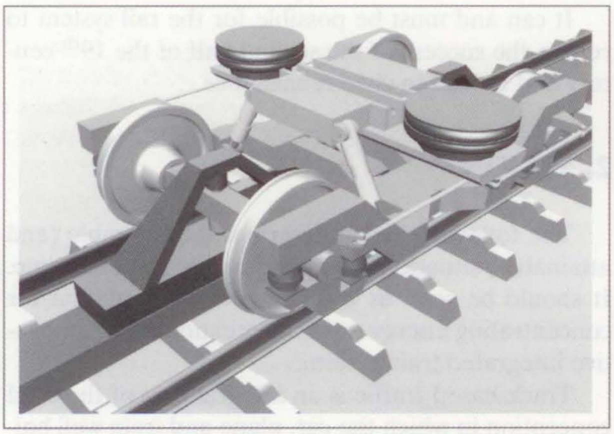

Figure 1 - The modular bogie system

from similar light materials. The power for the extra functions is transferred by induction in the shuttles. The shuttles are similar to private cars of most modern technology, particularly in the areas of safety, comfort and telecommunications. Through the application of manufacturing principles and experiences of the car industry, the cost per shuttle is in the range of that of a car. Extensions to the standard transport model would include further specifications such as joining doors between shuttles, transport of special goods, carrying of cars etc.

3. TECHNOLOGY

We suggest a modular train system that relies on the use of information and telecommunications technology. Information technology combined with actors and sensors offers the potential for a completely new intelligent transport system.

The core of this transport concept arises from no longer realising propulsion functions through the wheels but instead linear propulsion that is integrated into the track system. The decoupling of propulsion from the wheels enables an optimal compensation for friction. Through this, travel comfort can be improved and wear and tear on wheels and tracks is reduced. The modular train system is based on three modules.

Propulsion/braking module: Due to the linear propulsion, acceleration and braking can take place without wear and tear. Simultaneous use of both old and new systems is also possible.

Steering module: By using active steering it should be possible to steer the train wear and tear free along the track.

Suspension and tilt module: An active system results in a very comfortable carriage suspension (secondary suspension) and simultaneously a tilt technology enables unprecedented travel comfort.

The application of the above device together with the manufacturing methods of the car industry and the massive availability of telematic results in huge technological potential for the formation of an attractive and fully integrated train system.

4. PROPULSION/BRAKING MODULE WITH SYNCHRONOUS LINEAR DRIVE

In the railway system presented, a synchronous linear drive has been implemented. The stator is installed between the rails and generates a magnetic field moving along the rails. The surface of the stator is oriented horizontally.

The coaches are equipped with electric coils that make up the excitation field in the secondary part of the drive. The position of this secondary field is variable if the secondary part is equipped with three-phase windings. This design allows relative motions between stator- and rotor-field. The coaches are able to interconnect or to vary the distances between them.

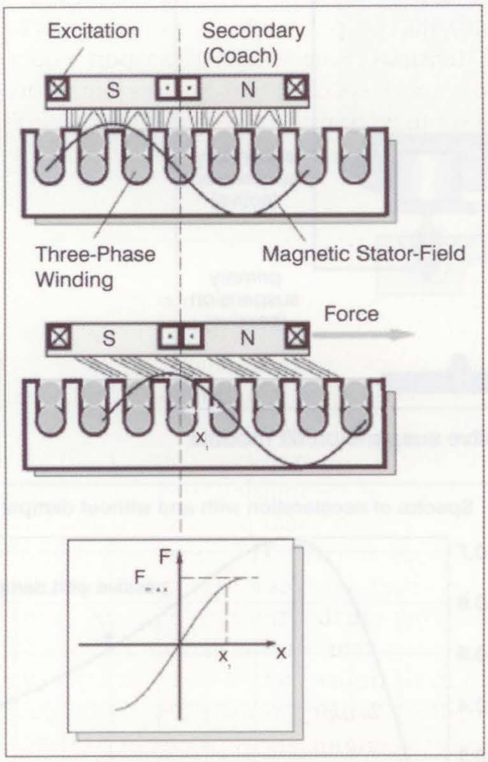

Figure 2 - Force generation with the synchronous linear drive

The field-oriented control of the drive is used to generate defined shear- and decelerating forces. These forces are transmitted without friction or contact via the magnetic air-gap flux between primary and secondary parts.

To ensure effective use of energy, only that part of the stator section where the coach is moving will be supplied with energy. The design of small stator sections allows to adapt the stator power to landscape topologies. To manage slopes, the stator can be designed to convey more power; this additional power need not be carried on board the coach. Thus the coach is less heavy and able to climb up steeper slopes.

The power supply on board has to supply the excitation windings and other board electronics (data transmission, etc.). This is reached by means of linear generators integrated in the poles of the secondary parts. Power supply by overhead conductors can be omitted.

The speed of the train is controlled by a speed controller with a subordinate current control. The current is controlled in two directions, normal and in parallel to the excitation field. This concept allows the generation of enough motion forces to ensure secure operation.

The position of the coach is determined precisely by sensors installed inside the train. Wireless data transmission to the controller closes the control loop.

5. STEERING MODULE

In current railway vehicles, bearing, guiding, driving, and braking are realised with the forces between wheel and rail. Since driving and braking are in the new system fulfilled by the linear motor, wheel and rail are used only for bearing and guiding. The forces between wheel and rail are composed of constraint and creep. They bear the vehicle. Constraint forces are perpendicular to the contact plane of wheel and rail. These vertical components bear the vehicle, whereas guiding is controlled by the horizontal components. Since constraint does not cause relative motion between wheel and rail, it does not dissipate energy. Hence, bearing and guiding is performed by the wheel/rail system without relevant wear. Creep forces are tangential forces in the contact plane. They are used in conventional railway vehicles for driving and braking. These relative motions are anti-parallel, therefore, dissipate energy, and therefore, cause wear.

To optimise the guiding of the vehicle, the bogie is equipped with an active steering system. The actuators of the system should reduce lateral displacements as well as rotations about the yaw axis much faster than in the passive case. Furthermore, the knowledge about the track can be used for pre-controlling. The measure reduces the wear between wheel and rail, especially in bends.

6. ACTIVE SUSPENSION AND TILT MODULE

The basic concept presented, dispenses all dampers of the secondary suspension to be found in conventional railway undercarriages. A passive suspension of the coach body, of relatively low frequency, is actively influenced via displacement of the base of the air-spring, thus damping the vibration of the coach body. The tilting device of the coach body inhibits tilting and allows for higher speed by means of the same actuator system through a feed forward of the cornering acceleration.

Figure 3 illustrates the operating principle of the active suspension. While the air-spring isolates the vibrations in the upper part of the frequency range, the desired damping in the lower frequency range is reached by active interference. This means that the coach body is almost entirely shielded from the disturbances resulting from unevenness in the rails (both vertical and horizontal). This allows very satisfactory ride comfort in both vertical and horizontal direction.

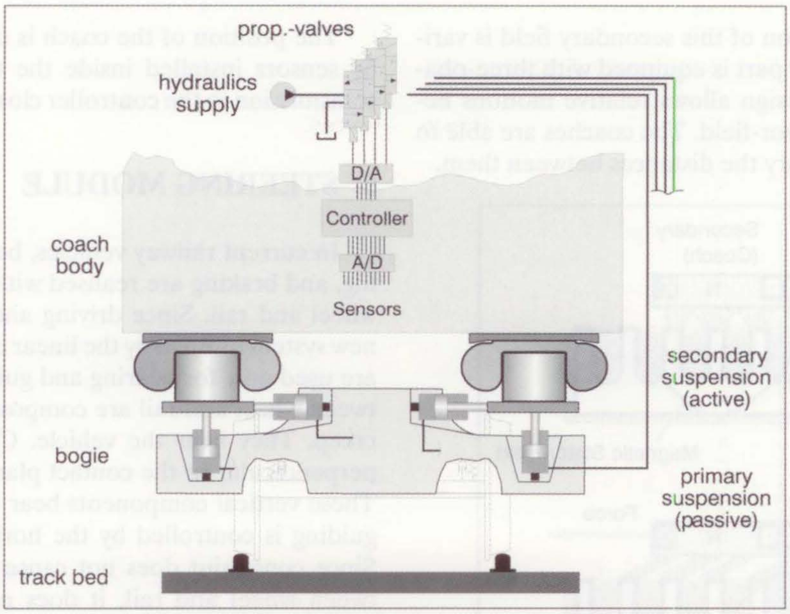

Figure 3 - Construction principle of the active suspension/tilt module

The information required for the control of the base displacement is measured by appropriate sensors and processed in a multivariable control system.

To demonstrate the potential for improvement, a ride over uneven rails with a passive undercarriage (with damper) and an active one (without damper) was simulated. Fig. 4 displays the spectra of amplitude of the coach-body acceleration in the two systems. The areas below the spectra of amplitude indicate the accelerations affecting the passenger. The active suspension system is able to realise an increase in ride comfort of more than 90 %.

The suspension/tilt module presented here has been mounted on the testbed in Paderborn on a scale of 1 : 5.

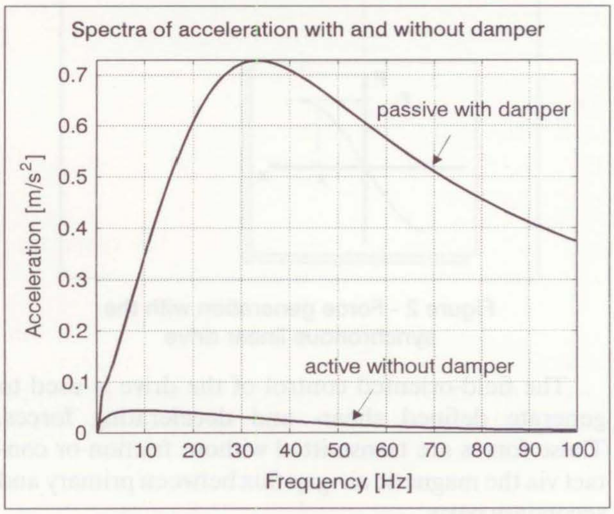

Figure 4 - Comparison of passive and active suspension