VEHICLE SYSTEM DYNAMICS
https://doi.org/10.1080/00423114.2020.1740748

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OBITUARY

Hans B. Pacejka (1934–2017): a life in tyre mechanics

Hans Pacejka, famous for his work on tyre mechanics, died on 17 September 2017, peacefully at home. He was 83 years old. The cause of death was an incurable liver disease, from which he had suffered already for some years (Figure 1).

Figure 1. Hans B. Pacejka, 1934–2017.

Hans Pacejka was born in the city of Rotterdam in the Netherlands, on 12 September 1934, in an Austrian family. His parents, Eduard S. Pacejka and Edith Messmer, were originally from Vienna and emigrated to the Netherlands in 1932. His father, Eduard, was already familiar with the Netherlands through a World War I humanitarian children's act. After that war, ill-fed Austrian children were sent to foster parents in the Netherlands for nourishment. After Eduard finished his secondary school in the Netherlands, he went back to Austria to study mechanical engineering at the Vienna University of Technology. Directly after graduation, he married Edith Messmer and started looking for a job. In the meantime, his foster parents from the Netherlands were working at the TMS Technicum in Rotterdam, a polytechnical school oriented towards an engineering education. They offered Eduard a job as a teacher at the Technicum, and in 1932, Eduard and Edith emigrated to the Netherlands. In that same year, they were naturalised, and in 1933, their first child, Edith Marijke Pacejka, was born. The next year, 1934, Hans Bastiaan Pacejka was born.

After having finished primary school, partly through home education because of World War II, Hans started his secondary school education in Rotterdam at the Erasmiaans Gymnasium in 1946. In 1948, his father was offered a professorship in mechanical engineering at the Technical University of Bandung, and the family moved to what is now Indonesia in

1949. Hans continued his secondary school education in Bandung. He enjoyed life in Bandung, but his parents were getting more and more concerned about the safety of the family after the independence of Indonesia. In 1952, the family moved back to Rotterdam, where his father became director of the TMS Technicum and Hans finished his last year of secondary education. Hans, always interested in engineering, started his studies in mechanical engineering at Delft University of Technology in 1952. He specialised in vehicle engineering under the guidance of Professor van Eldik Thieme, for whom he also did work as a teaching assistant. The first time Hans came in contact with the tyre shimmy phenomenon was during his six-month placement at Calspan, Buffalo, NY, in 1958, where he worked under the guidance of William F. Milliken and Leonard Segel. Back in Delft he graduated cum laude in 1959 on the dynamics of a vehicle. After graduation, Hans was drafted for military service and was stationed at the Frederik and Alexander barracks in The Hague. Because Delft is close to The Hague, Hans was now able to continue his experimental work on the wheel shimmy phenomenon at Delft.

In the meantime, Hans met his future wife Nettie Groenendijk in 1957. Nettie was the girl next door of his school friend, with whom Hans was always working on his motor scooter, outside, in front of the house. And Nettie always walked her dog, and that is how they met. In 1960, Hans and Nettie got engaged to be married. After having left military service in 1961, Hans started his work towards a doctoral degree at Delft, again under the supervision of Professor van Eldik Thieme. Having a fixed job with a steady income, Hans and Nettie decided to get married in 1962. The next year they moved to a brand new house in a brand new neighbourhood of Rotterdam, the Alexanderpolder, were in 1963 their son, Hans Jr, and in 1966 their daughter, Karine, were born.

Hans got his doctoral degree, cum laude, in 1966 on the thesis entitled 'The wheel shimmy phenomenon, a theoretical and experimental investigation with particular reference to the non-linear problem', with Professors de Pater and van Eldik Thieme as advisers. The next year, Hans was appointed reader in the vehicle engineering group of van Eldik Thieme at Delft. Later, in 1980, Hans was made a full professor and head of the vehicle engineering group at Delft. In 1971, Hans was visiting professor at the University of Michigan, Ann Arbor, MI, where he worked together with Leonard Segel. He moved there with the family for one year and enjoyed the warm summer and cold winter, and the American way of life. Back in Delft in 1972, Hans continued work in vehicle engineering and, in particular, in the field of tyre mechanics. Hans was one of the founders of the International Association for Vehicle System Dynamics (IAVSD), for which the first ideas about the organisation were formed during a conference in 1974 in Enschede, organised by Anton de Pater and Joost Kalker. Then in 1975, during an IUTAM symposium in Delft, the IAVSD plans became more concrete and the organisation was formally founded in a meeting of the scientific committee at the next conference in Vienna in 1977, with Sachs as president, Pacejka as secretary, Slibar as treasurer and Segel as one of the trustees. This conference in Vienna was named the 5th IAVSD conference because of the four preceding conferences. In parallel, they started thinking about setting up a specialised journal on the dynamics of vehicles. This journal, Vehicle System Dynamics, was established in 1972 with Herbert Sachs as editor in chief and Hans as associate editor. Then, from 1974 until 1990, Hans was editor in chief, first together with Sachs and later with Hedrick. In the meantime, Hans continued working with the car industry, among others Volvo and Toyota, and tyre manufacturers such as Bridgestone.

In his private life, he enjoyed tinkering and working around the house for maintenance and fixing things. In 1972, they bought a holiday cottage in northern Italy, around Lake Maggiore, where he enjoyed working in the garden and on the house. On the way to and from the cottage, he often visited relatives in Vienna. Besides reading his research literature he enjoyed reading general history. Furthermore, he was interested in performing arts such as theatre and classical concerts. He always enjoyed drawing, and at a later stage in life, he picked up artistic painting, where most of his paintings were portraits from family members.

The scientific contributions of Pacejka can be divided into the subjects of vehicle handling, the shimmy phenomenon, tyre modelling, motorcycles, the application of bond graph techniques, and vehicle control, separate or in combinations.

Building on his earlier work as a student, Pacejka made a contribution to the steady-state cornering conditions of a four-wheeled vehicle [1–7], which were summarised in an overview paper [8]. Later, the behaviour on an uneven road was considered [9]. A particular paper was written together with Koiter about the directional stability of a vehicle with locked wheels [10].

Related to the handling are his contributions to the understanding of the shimmy phenomenon, leading to his dissertation [11,12]. Some later additions and the application to an aircraft landing gear can be found in [13–16].

These two subjects cannot be studied without a proper model for the tyre forces, so this was a central part of Pacejka's research. Simple physical models were presented in [17–22]. The real breakthrough in his tyre mechanics research was in 1984 when Hans was working together with Egbert Bakker on a phenomenological tyre force model based on experimental data: this was the birth of the so-called Magic Formula [23,24]. The first sketches for the Magic Formula can be seen in Figure 2. Later extensions were reported in [25,26], eventually culminating in the MF-Swift model [27,28]. This is now the most widely used class of models in vehicle dynamic simulations. Further work on tyre models is reported in [29–35]. An important review paper was written together with Sharp [36,37].

Besides the analysis of multi-track vehicles, the dynamics of motorcycles was studied. With Koenen, a model for a motorcycle running straight ahead at a constant speed or cornering a curve of a constant radius was developed [38–40]. This model could predict the stability of the various vibration modes of the vehicle. A rider robot was developed with Ruijs [41]. Tyre models especially for motorcycles were considered in [42].

Pacejka developed an interest in bond graph modelling of dynamical systems, see [43–47]. A multibody dynamics program for vehicle dynamics applications was developed by Verheul [48].

Later in his career, the interest moved towards control applied to vehicles. A first paper appeared on driver modelling with Kageyama [49]. Another topic was the development of an original type of active suspension system [50,51], called the Delft Active Suspension, for which a patent was awarded [51].

Pacejka supervised nine dissertations in Delft and one at the University of Twente. Koenen [52] made a model of a motorcycle for the steady-state straight-running and cornering and the linearised equations about these trim conditions and analysed the vibration modes and their stability. Bos in Twente [53] applied bond graph techniques to the modelling of a motorcycle. Gong [54] made an in-plane model of a tyre consisting of a ring on an elastic foundation. Higuchi [55] studied the transient dynamics of tyres at finite wheel

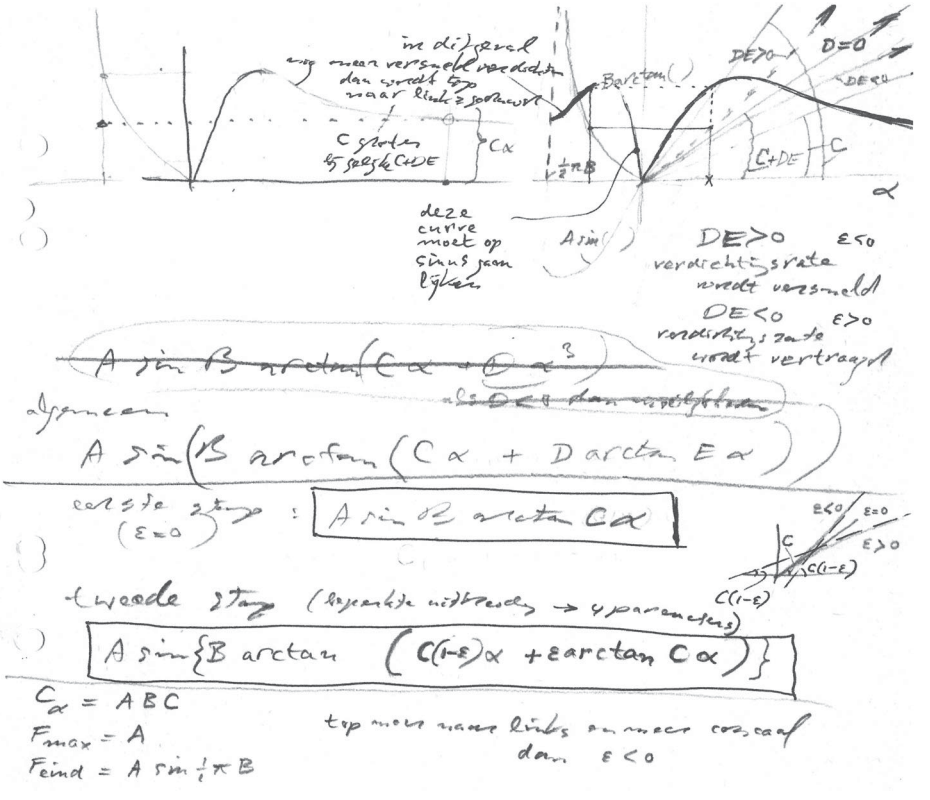

Figure 2. The birth of the magic formula. Source: E. Bakker.

slips using a stretched string model. Zegelaar [56] modelled in-plane tyre behaviour with a flexible-ring model and a rigid-ring model to gain computational efficiency. Maurice [57] modelled the short-wavelength response of tyres. Besselink [58] returned to the wheel shimmy phenomenon, this time for aircraft. Three dissertations were control-oriented and were supervised together with Professor Bosgra. One was on active and semi-active suspension systems by Venhovens [59], another by Pasterkamp [60] on the identification of the friction coefficient from the tyre forces in the non-linear regime, and the third by Smakman [61] on an integrated controller. All models in these studies were at least partially validated by experiments.

In 1996, Hans left Delft University of Technology with early retirement. The vehicle dynamics group at Delft gradually dissolved, and most of the tyre and vehicle dynamics work was then continued at Eindhoven University of Technology. In the meantime, Hans started working on a book. The first edition of the book, entitled 'Tyre and Vehicle Dynamics' was published in 2002 [62], and it was immediately recognised as a standard work and the definitive book on tyre mechanics. During the years, the book saw a number of revisions and reprints [63,64] (Figure 3). After retirement, Hans continued his advisory position within TNO until 2006, when he decided that it was enough.

Through the years, Hans received a number of prestigious awards and recognitions for his scientific work. In 1989, an honorary doctorate from the KTH (Royal Institute of Technology) in Stockholm, Sweden, was awarded, in 2004, he became an honorary member

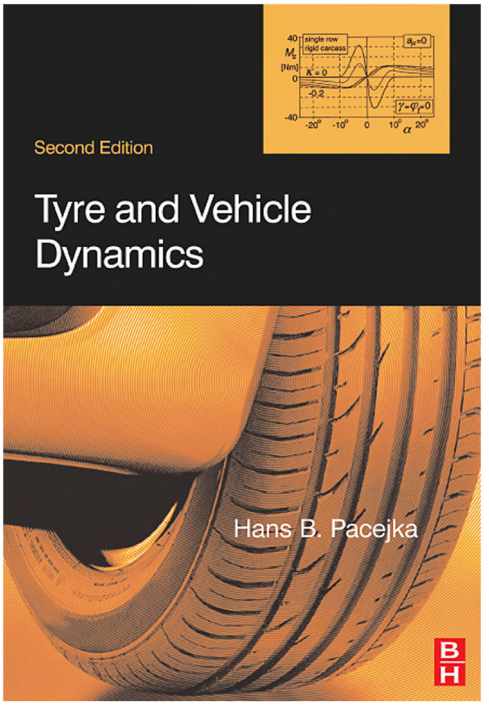

Figure 3. Cover of the 2nd edition of 'Tyre and Vehicle Dynamics' by Hans B. Pacejka [63].

of the IAVSD, and in 2013, Hans was awarded the Tire Society distinguished technical achievement award and subsequently in 2015, the Tire Technology International lifetime achievement award.

As a teacher and professor, he has always been modest, approachable and helpful. His students and colleagues appreciated him as a tremendous source of inspiration for their studies and research. We will remember him with deep gratitude and great respect, and wish his family and friends much fortitude.

Acknowledgements

We thank Mrs Nettie Pacejka-Groenendijk for providing us details about the life and times of her husband.

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