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FRANZ GRASHOF AND THE GRASHOF NUMBER

C. J. SANDERS and J. P. HOLMAN

Southern Methodist University, Dallas, Texas, U.S.A.

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THE GRASHOF number is widely used in all types of free convection problems, but unlike other dimensionless groups in the fields of heat transfer and fluid mechanics, the man for whom the grouping was named is not familiar to workers in the field. Consequently, the historical and biographical information which follows is of interest in establishing proper links with the past.

Jakob [1] attributes the naming of the dimensionless group

$$Gr = \frac{\rho^2 g \beta \Delta T}{\mu^2}$$

to Groeber [2] but points out that Groeber gave no reason for selecting the name "Grashof number". A careful check of the free convection literature before and after 1921 indicates that Groeber did indeed coin the phrase because the grouping was nameless before that time. Even Davis [3] still left the group without name in 1922 but it is likely that he did not have access to Groeber's text. By the time that Colburn's [4] excellent historical discussion of convection heat transfer correlations appeared in 1933, the name Grashof number was well established but the man for whom the group was named was still a mystery, at least in the heat transfer literature.

Although we cannot be sure, it appears that the dimensionless group was named for Franz Grashof (1826–1893), a very famous German engineer in his time. A search of the biographical literature reveals no other person named Grashof who could be a candidate for the naming. The biographical information which follows is a translation of the information available from Poggendorff's [5] and Matschoss [6].

Franz Grashof was born July 11, 1826 in Dusseldorf, and died October 26, 1893 in Karlsruhe. His grandfather experienced the overthrow and rise of Prussia as a school master in Prenzlau, and in 1813, at the age of 43, he took the field as a second lieutenant in the militia along with his students. After the end of the war he was appointed provisional director of public instruction on the lower Rhine. Grashof's father taught ancient languages as senior assistant master at the Royal Classical School in Dusseldorf. His son, Franz Grashof, was attracted early to technical subjects in contrast to the family tradition in the pure arts. At 15 years of age he left school to work as a mechanic and then attended trade school in Hage and secondary school in Dusseldorf.

From 1844 until 1847 Franz Grashof studied mathematics, physics and machine design at the Berlin Royal Technical Institute. During the German peoples movement of 1848 he served in the military in Dusseldorf. As a result of this experience he decided to join the German navy. He enlisted on the sailing ship "Esmeralda" as a seaman and made a voyage which lasted over $2\frac{1}{2}$ years and took him as far as the Dutch Indies and Australia. On the voyage he realized, however, that he was not destined for a mere practical vocation. After a short stay at home he returned to Berlin in 1852 and continued his studies. In addition, he was assigned to conduct a lecture on applied mathematics at the school. In 1854 he became employed as a teacher of mathematics and mechanics at the Royal Technical Institute. At the same time he became the Director of the Bureau of Standards in the office in Berlin.

On the 12th of May 1856 at the 10th commemoration of the "Hutte", the renowned society of the pupils of the Royal Technical Institute, Grashof, along with Freidrich Karl Euler, was one of the leaders in founding the Society of German Engineers (*Vereines deutscher Ingenieure*, VDI). If the society was to endure it was decided that it must include the whole of Germany, and be the society of all German engineers. The true embodiment of the ideas of the Society became Franz Grashof. He had a well established reputation in the scientific world, participated as a Society director and was

assigned as editor of the periodical. As author, editor, corrector, and dispatcher he assumed an enormous load in the first year of development of the VDI.

In 1863 Redtenbacher died and Grashof's name was so esteemed that the technical university in Karlsruhe appointed him to be Redtenbacher's successor as superintendent of the engineering school. He also served as professor of applied mechanics and mechanical engineering and his lectures included strength of materials, hydraulics, and theory of heat in addition to part of the general engineering. Grashof gave up the editorship of the VDI periodical following his move to Karlsruhe; however, he remained as a director of the society, and in addition, he still carried on a very extensive writing activity. Grashof expected great things of the students, and clarity, certainty, and sharpness of expression distinguished his lectures. Grashof was known as a very earnest individual and even in troubled times he retained an atmosphere of genuine friendliness. He participated in charitable service activities and derived great personal satisfaction from these efforts. In spite of all his success, uninterrupted work and creativity he was known for his kind disposition and modest appearance.

Near the end of 1882 Grashof suffered a stroke, but recovered enough to resume his activity on a limited basis. In 1882 Grashof became a member of the standard calibration commission, and in 1887, a member of the governing body of the Physical-Technical Government Institute. In 1891 he suffered a second stroke and had to cease his activities. Two years later he died at the age of 67. The Society of German Engineers honored his memory by the erection of a Grashof monument in Karlsruhe and by the institution of the Grashof commemorative medal as the highest distinction that the society could bestow for merit in the engineering skills.

It is quite clear from this information that Franz Grashof had a major impact on the development of the engineering profession in Germany in the nineteenth century and merits the naming of the dimensionless group in his honor.

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EFFECTS OF TRANSPIRATION ON THE MHD FLOW NEAR AN OSCILLATING PLATE

HSING CHUANG

Department of Mechanical Engineering, University of Louisville, Louisville, Kentucky, U.S.A.

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NOMENCLATURE

- B. external magnetic field flux density normal to the plate;
- $\bar{B}$. dimensionless magnetic field flux density. $B(2\sigma/\rho\omega)^{\frac{1}{2}}$;
- S. speed of mass transfer normal to the plate. leakage speed;
- $\bar{S}$. dimensionless mass transfer speed. $S/(2\nu\omega)^{\frac{1}{2}}$;
- t. time;
- u. fluid velocity parallel to the plate;
- $\bar{u}$. dimensionless fluid velocity. u/U_0;
- U_0. maximum velocity of the oscillating plate;
- y. the coordinate normal to the plate. distance from the plate;
- η. dimensionless distance. $y(\omega/2\nu)^{\frac{1}{2}}$;
- λ. dimensionless parameter. equation (3);
- ν. kinematic viscosity of the fluid;
- σ. electrical conductivity of the fluid;
- ρ. density of the fluid;