The GFR's Maurice Couette Prize

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The name of Couette has been adopted by the scientific community in France and throughout the world to designate the shear flows that are normally created between two walls moving in opposite directions parallel to one another, the type of cell between two rotating concentric cylinders that he built and the pipe entry corrections that he introduced and calculated. The typically rheological scientific approach adopted by Maurice Couette, and the professor, researcher and man of culture that he was fully justify the GFR's decision to call its grand prix, which was created in 1993 (under the chairmanship of J-M. Piau), the Maurice Couette prize.

Figure 1. Maurice Couette (1858-1943)

The photograph represents Maurice Couette carrying out a cathetometer observation at the Faculty of Angers.

According to his family, Maurice Couette could not conceive of a measurement being made without taking all the necessary precautions beforehand. He would insist on the experimenter's work top being well organised, with the instruments and the experimenter himself being properly installed.

1. His life

Maurice Marie Alfred Couette (Fig. 1) was born in Tours on 9 January 1858, and died in Angers on 18 August 1943. His father, Alfred Ernest Couette, was a cloth merchant who had been born in Tours in 1825. Maurice Couette was an only child. He was educated by the Frères des Ecoles Chrétiennes in Tours, obtaining his baccalaureat in humanities in June 1874 and in science in September of the same year in Poitiers. He then studied further maths at Tours and physical science at the Angers Free Faculty of Science, which had just opened in 1875. In 1877 and 1879 he obtained the corresponding bachelor's degrees delivered by the Faculty of Science of Poitiers. After a year working as a lecturer in Angers, he joined the 12th Artillery Regiment at Vincennes to do a year's voluntary military service.

He settled in Paris in 1881 and registered at the Sorbonne, attending lectures in physical science preparing for the *agregation* (an advanced teaching diploma) while at the same time working as an examiner at the Collège Stanislas and giving private lessons in mathematics. He later worked as a physics teacher at Arcueil and at the Ecole Sainte-Geneviève in Paris.

In 1886, he married Jeanne Jenny, the daughter of a cavalry officer who had died in combat in 1870 She had been educated at the Légion d'Honneur school. The Couettes began a life of hard work, in accordance with the religious principles they had learnt during their childhood. Of their 8 children, 5 reached adulthood and gave them 21 grandchildren.

It was in 1887 that Couette joined the Sorbonne's Physics Research Laboratory to prepare a doctorate in science under the supervision of Gabriel Lippmann. After occupying a chair of Mathematical Physics, Lippmann had just succeeded Jamin to the chair of Experimental Physics and been elected to the Academy of Science. He was to receive the Nobel prize in 1908 for his work on photographic reproduction of colour by the interference method.
Couette also benefited at the Faculty of Science from the presence of Joseph Boussinesq, a largely self-taught mathematician whose work focussed mainly on hydraulics and the strength of materials. He had been elected to the Academy of Science and held the chair of Physical and Experimental Mechanics in 1886.
It was while preparing this doctorate and still working as examiner at Stanislas and Sainte-Geneviève that Couette made his decisive, lasting scientific contributions to the behaviour and stability of flowing liquids. The manuscript of Couette's thesis, entitled "Studies on the Friction of Liquids", was handed to Gabriel Lippmann in May 1889. It was officially registered at the Faculty of Science in November 1889 and printed in March 1890. Couette defended his thesis on 30 May 1890.

Shortly afterwards, in September 1890, Maurice Couette's life took a major turn when he obtained a position as professor of physics at the Catholic University of Angers (now known as the U.C.O.). This fulfilled his deepest dreams, but the position was neither well-paid nor likely to offer him any significant means of research. With his wife's encouragement, he therefore left for Angers, where he was to spend 43 years teaching mechanics, electricity, optics, thermodynamics and even meteorology at the Free Faculty of Science and School of Agriculture. Because of the precarious financial situation of the U.C.O., he had to teach at the School of Commerce and in secondary schools, especially during the First World War, in order to make ends meet.

In spite of his many teaching commitments, he continued his varied theoretical and experimental scientific activity, looking for example at the osmotic theory of batteries (3 articles in the Journal de Physique in 1900). He was a member of the French Physics Society until his retirement in 1933, supervised the doctoral thesis of Fernand Charron (his successor at Angers) on the "Influence of air in the friction of solids" (Paris 1911) and published many scientific articles and analyses in the journal "La Science Catholique".
Over 300 personalities joined the family to express their esteem for Maurice Couette at his funeral in 1943.

2. His work

Couette's name is familiar to any scientist interested in physics and fluid mechanics. His work has been cited in all physics manuals since the beginning of the 20th century. It has also long been recognised in engineering, in particular hydraulics and heat engineering. But his career was less well known. It was mentioned by Donnelly (1991) and described by Piau *et al* (1994) after his apparatus, found at the U.C.O., was presented at the International Congress on Polymer Rheometry organised in May 1993 at the Royal Abbey of Fontevraud not far from Angers, with the support of the EEC (Fig. 2). The importance and impact of the work he accomplished in such a short period (1887 to May 1889) appear all the more remarkable as a consequence.

The true scope of his ground-breaking work in the field of rheology deserves to be recognised. Indeed, Couette conducted remarkable theoretical and experimental work on different types of flow and flow stability: around oscillating bodies, in pipes and between cylinders. He designed and used the first truly operational continuously rotating concentric cylinder apparatus and measured the viscosity of water and air with remarkable accuracy. He identified the conditions of validity of the Navier equations and demonstrated unstable regimes.

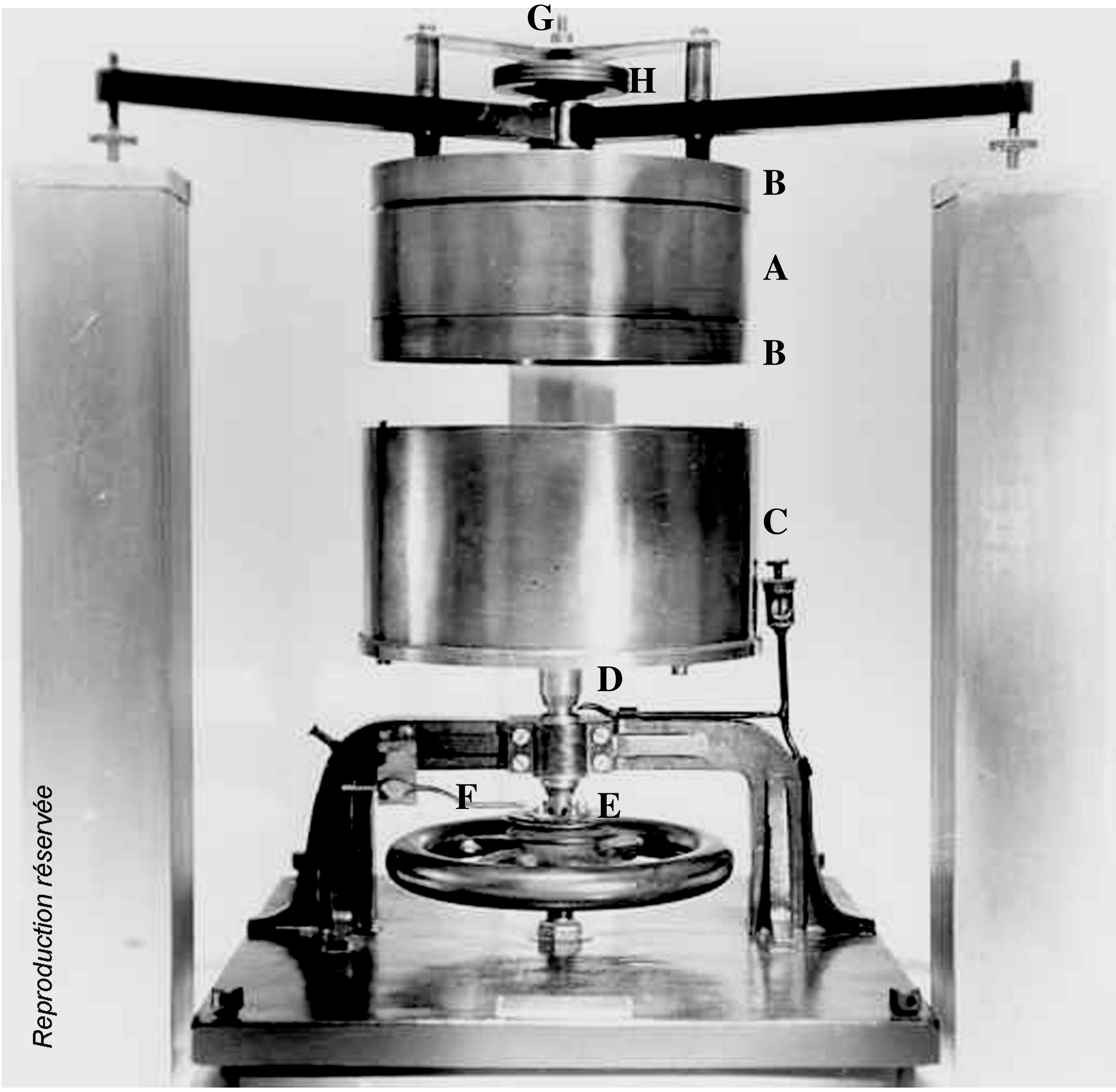

Figure 2. Maurice Couette's concentric cylinder apparatus (viscometer) (1888)

The inner cylinder A, 144 mm in diameter, equipped with guard cylinders B on either side, has been taken out of the rotating outer cylinder C for the photograph. The centre line of the outer cylinder was guided by a lubricated bearing D equipped with a fly wheel and driven by pulley E, a belt and electric motor. Brush F was used to detect the passage of insulating sectors and measure the rotation speed. Friction torques were measured along the centre line of the inner cylinder by means of torsion wires G or an Atwood machine H, depending on their value.

He also focussed on pipe flows, introducing and calculating the essential (so-called Couette) entry corrections and examining the transition to turbulence. He took into account in flow rate formulas the slip length b= μ/E (μ being the viscosity and E the wall friction coefficient) defined by Navier. He discussed the notions of slip at the wall and concluded that there was no slip with the material-wall pairs used. He tested various fluids (water, rapeseed oil, air, mercury) and compared the influence of various wall materials and treatments (glass, copper, tin, varnish, silver paint, grease, paraffin) on flow.

The friction and slip of complex fluids controlled by the structure of the wall interface are still highly pertinent issues for rheologists today.

Couette was also interested in the relations between the viscosity of a fluid (defined as the internal friction coefficient, according to the custom of the period), its other physical properties and its chemical structure, at different shear gradient values.

3. A pioneer of rheology

Maurice Couette's contribution is thus extremely topical and his approach is a forerunner of that used in modern rheology, of which he is truly a pioneer. His major publications are listed below. Detailed comments may be found in Piau *et al* (1994) and in Piau and Piau (2005).

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Abstract: The GFR Maurice Couette Award. This paper gives a brief survey of the life and work of Maurice Couette, whose name is associated with a type of flow, of rheometer, and with a correction method for end effects in capillary flows. Couette's experimental and theoretical work on oscillatory, pipe and cylindrical flows and on transitions to turbulence was accomplished in a relatively short period (1887-May 1889). He was in particular the first to succeed in building a concentric cylinder constant speed rheometer and obtaining significant data sets, giving accurate viscosity values, and to correctly identify the laminar-turbulent transition for air and for water. His interest in Navier constitutive equations, in viscosity measurements at different velocity gradient values, and his discussion on wall slip and friction of complex fluids, using several fluids and wall materials, are highly relevant subjects in present-day rheology. These outstanding scientific contributions and this pioneering work, in keeping with a modern rheology approach, fully justify the naming of the GFR award, founded in 1993, the Maurice Couette Award.