

## Sanjay Kumar Biswas (1945–2013)

Sanjay Kumar Biswas, a distinguished tribologist and educator, passed away on 28 April 2013 in Bangalore at the age of 67. With a background of doctoral and postdoctoral work in plasticity, he pioneered many fundamental approaches to studying two moving surfaces that are in contact with each other. This scientific exploration led him to undertake research in many branches of science and engineering ranging from mechanics, materials and chemistry to nanoscience and bioengineering.

Biswas was born on 9 June 1945 in Kolkata. After graduation in mechanical engineering in 1966 from the Indian Institute of Technology Kharagpur, he moved to the United Kingdom for higher studies. He obtained his Master's degree from University of Strathclyde in 1969 and Ph D from University of Birmingham in 1972. At the suggestion of Prof. Satish Dhawan, he joined the Indian Institute of Science (IISc), Bangalore in 1976. Since then, he has served IISc in various capacities, including Chair of Mechanical Engineering and Dean of Engineering.

The tribology laboratory in IISc had humble beginnings in the hands of Biswas. It is fondly recalled that he was so excited when the purchase department informed him that a new machine, a journal bearing test rig, had arrived on campus that he towed the instrument in a trolley for 2 km from the stores to his laboratory along with his lab members. It was this enthusiasm that helped the field flourish and made his laboratory thrive as a major multidisciplinary focal point in IISc. His legacy in tribology is vibrant even today and his contributions are known around the world.

Tribology is concerned with contact between two surfaces that are in relative motion. Exploring all aspects of tribology led Biswas to several fronts in the field, including contact mechanics, surface roughness, single-point abrasion tests, nano-indentation, nano-tribology and cutting fluids. Since all practical surfaces are rough, it meant looking at how individual asperities – the smallest elements of roughness – interacted with one another. This naturally drew Biswas to the mechanics of materials at nanometre scale and his research moved to nanotri-

ology, being a pioneer, exactly knew when to explore a new research topic, develop it, contribute to its understanding in a nontrivial way, and then leave the field open for others to explore. In his endeavours he collaborated with researchers in different disciplines ranging from mechanics, materials and physics to chemistry and biology.



The early work of Biswas and his students on aluminium silicon alloys went on for many years and this work is cited even today. What started as simple curiosity-driven research developed into a major engineering application when modern car-makers turned to aluminium alloys for their engine cylinders. The accumulated knowledge in the wear mechanisms of aluminium alloys provided the groundwork for big automobile companies to design aluminium engines. Similarly, well before technology missions became fashionable, he ventured into the world of ceramics and coatings in collaboration with the industry and academic colleagues from materials engineering. With his ability to integrate other people's expertise with his own background in continuum mechanics and plasticity, these multi-institutional programmes were able to translate laboratory ideas into the real world of engineering tests. The practical experience of applied research that these projects gave the numerous participating students and research staff was truly exceptional in a university environment.

The dynamism and resourcefulness of Biswas is evident from the fact that he managed to procure a scanning electron microscope in 1988 for his laboratory

when it was a rare piece of equipment in IISc and India. One of the strong points of his mentoring was making his students develop their own instruments from scratch. This led to many innovations. The pin-on-disc wear-testing machine is one such example. An innovative approach to measure the wear through change in height of the pin rather than its weight led to continuous monitoring of the wear process. This design is popular today and can be found in many engineering colleges across the nation. Other instruments included the high-temperature scratch tester, reciprocating scratch tester, rail wear test rig, erosion test rig and many other machines that formed the basis for tribological studies. He made sure that the instruments were designed to solve problems of direct relevance to the industries that were involved in building as well as marketing some of the instruments. Biswas realized that testing at the macroscopic scale was only part of the story and he embarked on an ambitious foray into nanotribology in an attempt to unravel a molecular understanding of lubrication at contact. In close collaboration with major Indian oil companies, innovative designs were used to develop simple hardness testers for the nano-indentation machine, a surface force apparatus that allowed measuring forces between real engineering surfaces, atomic force microscopy and an *in situ* Raman tribometer to track molecular changes in lubricants. Developing such instruments was a challenge, but Biswas was a man who never gave up and made sure that these instruments were designed, developed and built locally by his students.

One of the notable points in Biswas was the freedom he gave to his students. He made sure that he passed on his enthusiasm and optimism to them. If a student decided to choose a path that was not taken by anyone before, he would not stop the student from doing so; rather he would encourage the student with unhindered backing. It requires quite a bit of courage to have such an open mind. His guidance was built on one simple rule: 'Look deeper into the results and it will get interesting.' This push that he gave students to think deeply into a subject prompted many of his students to pursue research careers. It is worth noting that

three of his doctoral students became faculty at IISc.

In addition to being an active researcher, Biswas was also an able administrator who knew how to excite people around him to take new initiatives, and then step aside when things were on the right track, only to move on to another initiative. Within the last five years, he played a pivotal role in increasing the student intake, bringing undergraduate programme into IISc, establishing IIScPress, initiating the bioengineering programme, connecting clinicians and hospitals with IISc, liaising with the Indian Institute of Management Bangalore, and starting biodesign activity at the national level.

Biswas began his bioengineering research in the last few years, focusing on the mechanics of cells. His vast experience and expertise were brought to bear in exploring the mechanical properties of bacterial cell walls using atomic force microscopy, and investigating mechano-transduction of cancer cell adhesion. Just as he was able to connect disparate fields, he was also adept at connecting people from different disciplines. Over the last three years, he brought together faculty from many different departments to create a bioengineering group in IISc. Furthermore, he connected medical doctors with IISc faculty. He had envisioned bringing about a radical change in bioen-

gineering and biodesign in India. After his retirement from IISc in 2010, he occupied a prestigious Department of Biotechnology Chair to work at the Translational Health Sciences and Technology Institute in Gurgaon. He wanted to set up a National Biodesign Alliance to connect major research universities and upcoming colleges with hospitals and industries.

The enthusiasm and passion of Biswas were not limited to what he did at IISc. He started and ran for many years a journal entitled *Bulletin of Sciences* to popularize science. He took part in several social activities, including taking a clear anti-nuclear stand and lending support to people who helped the poor and the deprived sections of the society. He also founded the All India Progressive Forum.

A truly remarkable trait in Biswas was his eternal optimism. A glass was not just half full for him; it was overflowing. He was a man of many interests and he lived a full life. He enjoyed music of many genres. He was a connoisseur of food. He loved to travel and trek in various parts of the world. He knew a lot about south Indian temple architecture and rituals and wrote about them in the newspapers. He loved history and literature. Ever friendly and supportive, Biswas and his zest for life brought out the best in people who interacted with him.

There was so much more that was to come from him to enrich the lives of the people he worked with, but he left them suddenly on Sunday, 28 April 2013. One is reminded of the immortal lines of Mir Saqib:

‘ज़माना बड़े शौक से सुन रहा था;  
हम ही सो गये दासताँ कहते कहते।’

which can be translated as

‘The world was listening to me in rapt attention;  
It was I who slept off while narrating the story.’

These words befit Sanjay Kumar Biswas who was agile in his scientific and other pursuits until the very end. He is sorely missed by his family, friends, students and colleagues, all of whom celebrate a life well lived.

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