Summary of Professor Majozi's lecture: Research is what I am doing when I don't know what I am doing

Process integration as a discipline is relatively young, having been introduced in the late nineteen-seventies to optimise energy use in major chemical industries. Evidently its introduction was spurred by the energy crisis experienced at that time. It is based on conceptual analysis that is supported by deep insights, rather than mathematical modelling as traditionally encountered in chemical engineering. These insights allow us to probe into the process and gain understanding which would otherwise be lost in the interplay of mathematical equations characterised by thousands of variables and parameters. The sad reality though, is that there are a myriad of practical problems the nature of which militates against the capabilities of this approach. Embedded in all of these complex problems is one common feature: they inherently cannot be reduced to two dimensions.

Traditional process integration can safely be applied in situations where the problem at hand can be analysed in two dimensions without any loss of exactness or accuracy. My research, since 1997, has focused on problems that refuse to be confined to two dimensions. Paramount among these is the optimum scheduling, synthesis and design of batch chemical processes with a view to minimising energy use and water consumption.

Unlike continuous chemical processes, batch processes cannot attain a steady-state that is time invariable. Suppressing time reduces the dimensionality of the problem, which invariably reduces the complexity of the subsequent analysis. Treating time as an important independent variable is the main source of our challenges in batch process optimization. This implies that one has to establish a solid framework for capturing the effects of time before addressing water and energy optimization. In 2001 my research group at the University of Pretoria developed a continuous-time mathematical framework based on the so called state-sequence-network recipe representation which outperformed other published methods in terms of CPU time, as a result of the drastic reduction in binary dimensions. Using this framework as a basis we have developed techniques for wastewater minimization in batch plants in media that involve single and multiple contaminants. This contribution has been further extended to address effluent problems in processes wherein water features as a major ingredient in the final product, as encountered in some pharmaceutical operations. Consequently, a near-zero effluent optimization framework has been developed and adopted by a multinational pharmaceuticals facility. The same framework has also been used to take advantage of a unique feature in batch chemical plants, namely idleness of some of the processing units. This novel concept is aimed at eliminating the necessity of dedicated storage, thereby reducing capital cost investment in both processing units and plant space.

In collaboration with our colleagues in Hungary, we have recently developed a graph-theoretic technique for scheduling batch plants that does not require any involvement of binary variables. This approach, which has been published in one of the leading chemical engineering journals, is currently the only one of its kind in the published literature. For years I told my students 'there can be no scheduling method without binary variables'. Thank God Almighty, I have proved myself wrong in my own lifetime.

Recipients of the South Africa Medal (gold) who attended the 2008 award ceremony. From left to right: Prof Pieter S. Steyn (2004), Prof Patrick G. Eriksson (2008), Dr C.K. (Bob) Brain (1997) and Prof Michael Wingfield (2005), with Dr Ian Raper, President of the Association