# SIGURD SKOGESTAD. CV

Norwegian citizen. Born: 14 Aug. 1955 in Flekkefjord, Norway.

## Education

* 1978: M.S. (*Siv.ing.*) in Chemical Engineering at NTNU, Trondheim
* 1987: Ph.D. in Chemical Engineering at California Institute of Technology (Caltech).

## Positions

* 1979: Military Service at Norwegian Defence Research Center (FFI).
* 1980-83: Research engineer at Norsk Hydro's Research Center in Porsgrunn, Norway.
* 1983-87: Ph. D. student and Research Assistant at California Institute of Technology
* 1987- present : Professor in Chemical Engineering at NTNU (Dept. Head 1999-2009)
* 1994-95: Visiting Professor at University of California, Berkeley (Departments of Chemical Engineering and Mechanical Engineering).
* 2001-02: Visiting Professor at University of California, Santa Barbara (5 months).

## Supervision

* 37 completed PhD theses as main supervisor. Currently supervising 6 PhDs and 1 postdoc
* 160 completed MS theses as main supervisor.

## Publications

* About 200 international journal publications and 300 conference publications
* H-index (ISI): 39 (2015).
* H-index (Google scholar): 55 (2015)
* Author of 2 international text books. (1) S. Skogestad and I. Postlethwaite, ``Multivariable feedback control - analysis and design,'' Wiley (1996); *2nd Edition* (2005). (2) S. Skogestad, ``Chemical and energy process engineering'', CRC Press (2009).
* No. of citations to book Multivariable Feedback control: 6174 (Google scholar, 2015)

## Awards and Honors

* *Innstilling* awarded for the *Siv.ing.* degree (result communicated to Norwegian King), 1979.
* *Fullbright Fellowship* (travel grant) awarded for graduate studies at Caltech, 1983.
* *Utdanningsstipend* awarded from Univ. of Trondheim for graduate studies at Caltech, 1983.
* Elected member to *The Norwegian Academy of Technical Sciences* (NTVA), 1988.
* *Ted Peterson Best Paper Award* by the CAST division of AIChE (The American Institute of Chemical Engineers), 1989.
* *George S. Axelby Outstanding Paper Award* by the Control System Society of IEEE (The Institute of Electrical and Electronic Engineers), 1990.
* Elected member to *Det Kongelige Norske Vitenskapers Selskab*, 1991.
* *O. Hugo Schuck Best Paper Award* by the American Automatic Control Council, 1992.
* Best paper award for paper published in 2004 in Computers and chemical engineering (2006)
* Member of IFAC Technical Board, 2008-2014.
* Elected member of [Process Automation Hall of Fame,](http://www.nt.ntnu.no/users/skoge/publications/2011/hall-of-fame) , Delaware, USA, 23 May 2011
* Elected Fellow of American Institute of Chemical Engineers (AIChE), 2012.
* Elected Fellow of International Federation of Automatic Control (IFAC), 2014.
* Elected member to *The Norwegian Academy of Science and Letters*, Oslo, 2015.
* Honorary member of *Norwegian Society of Automatic Control,* 2015.

## Invited plenary lectures. recent

* "Feedback: the simple and best solution", Invited interactive Web-CAST lecture (American Institute of Chemical Engineers' Division for Computing and Systems Technology), Feb. 2006.
* ``The dos and don'ts of distillation column control'', *Symposium Distillation and Absorbtion 2006*, London, UK, Sept. 2006.
* ``Self-optimizing Control: Simple Implementation of Optimal Operation'', 27th Benelux Meeting on Systems and Control, 18-20 March 2008, Heeze, Netherlands.
* ``Feedback: Still the best and simplest solution'', 4th IEEE conference of industrial electronics and applications (ICIEA), 25-27 May 2009, Xi'an, China.
* "A systematic approach to plantwide control". Invited plenary talk at ICCAS, Seoul, Oct 2011.
* "Optimal PI-Control and Verification of the SIMC Tuning Rule", Invited plenary talk at IFAC Conference PID'12, Brescia, Italy, March 2012.
* "Economic plantwide control". Invited plenary talk at AMIDIQ, San Jose del Cabo, Mexico, 01 May 2012.
* "Optimality of PID control for process control applications", Invited plenary lecture at the 5th International Symposium on Advanced Control of Industrial Processes (ADCONIP 2014), Hiroshima, Japan, May 2014.
* "Economic plantwide control", Invited plenary lecture at Chinese Process Control Conference, Nanchang, China, 01 Aug. 2015

## Some other activities

* Member of four editorial boards for major journals
* Editor of Automatica (1996-2002
* Founding chair of the Nordic Process Control Working group (1994-1998) + chair 2014-16
* Board member of Norwegian Academy of Technical Sciences (NTVA) (1992- 1999)
* Head of NTNU/SINTEF's strong point center in process systems engineering (PROST) (1994)
* Chair of NTHs fund (1996 - 2002)
* Member of the Norwegian research council expert network (1998-2002)
* Member of the Jury for Norsk Hydro's Birkeland Award, 1999-2002
* Chair of the International Federation of Automatic Control (IFAC) coordinating committee on *Process and Power Systems (CC6)* and member of the IFAC Technical Board, 2008-2014
* Member European Union control council (EUCA) (2007-2013)
* Chair of National Committee for following up International Evaluation of Chemistry Research in Norway (2009-2010)
* Chair of Nordic Process Control Workshop, Trondheim-Bodo, January 2015 (about 70 participants)
* Chair of National Organizing Committee, *11th IFAC Symposium on Dynamics and Control of Process Systems, including Biosystems (DYCOPS-CAB 2016)*, Trondheim, Norway, 06-08 June 2016 (about 250 particiants expected).
* 2015: Director of SUBPRO (Center for research-based innovation subsea production and processing at NTNU). 30% position. Budget is about 35 million NOK per year (2015-2023).

**Sigurd Skogestad. ERC Ten year track record**

**Scientific profile and development**

Following my MS degree in chemical engineering at NTNU in 1978, I embarked on an industrial research career at the Norsk Hydro Research Center in Porsgrunn (the top Norwegian industrial research center at the time). I worked on a range of interesting projects, especially related to physical data, thermodynamics and simulation. Because of my excellent grades from my MS studies, I was encouraged by NTNU to qualify for an academic position, and NTNU funded my PhD studies at Caltech (1983-87). At Caltech, I worked on robust control applied to chemical processes and I was very lucky to work closely with possibly the two top individuals in the automatic control field, namely Manfred Morari (advisor) and John Doyle. The focus of robust control field is to develop control theory that is applicable for uncertain systems, where the models may be poor. The main “trick” is to make use of the power of feedback, and this has since then been the main reoccurring them in my research. During my time at Caltech, I also got intrigued by the issue of control structures and hierarchical decomposition, which makes it possible to operate extremely complicated process plants using only local controllers and local information. I have continued this line of research in various fashions, since I came back to Trondheim in 1987 and started my present position as professor of chemical engineering at NTNU.

I have been working a bit against the tide over the last 20 years, because most of the academic control work has focused on centralized solutions assuming that good models are available, for example, using model predictive control (MPC). There are several reasons for this. First, increasing computing power has allowed for increasingly more complex centralized solutions. Second, centralized control solutions are easier to handle mathematically. Third, and maybe the most important, an optimal centralized solution is always better, in terms of any mathematical performance measure, than a decentralized solution. However, this assumes that the problem is clearly defined and that a model is available. For man-made systems, the main (fundamental) disadvantage with a centralized model-based solution is that it requires a clear mathematical formulation of the problem to be solved. Gathering this information, especially the dynamic model, is very costly for large-scale systems. Therefore, in practice, a centralized solution is best for small-scale systems or for larger systems that can carry the economic cost of developing a centralized model-based solution, for example, for oil refineries, petrochemical plants and for mass produced items, like cars. My research has been to go in the opposite directions, and try to understand how the existing decentralized solutions work. The two main principles they make use of are hierarchical (vertical) decomposition in time and horizontal decomposition in space. Of these, the hierarchical time scale separation is the most important. It allows for operation of very complex systems using simple controllers (algorithms). Actually, until very recently (before MPC), this was the only way real systems were operated, but the understanding of the underlying principles of hierarchical systems is still poor. The layers mainly interact by the slower upper layer (master) sending commands (setpoints) to the faster lower layer (slave). To reduce the load for coordination by the master, the faster “slave” layer should operate autonomously over as long a time scale as possible. This is done by making use of “self-optimization”, where the action by the “slave” to a disturbance, goes in the direction where the “master” would optimally like the system to go. They key here is to select the right variables to control. In management systems these are often referred to as “key performance indicators” (KPIs).

Biological systems must be operated in a similar fashion, in particular, because biological systems have no means of performing the centralized optimization. Biological systems have developed structures and solutions by natural selection, and some of the principles that nature uses are yet to be discovered and understood mathematically. I see this as a fantastic research challenge.

The first main publication on self-optimizing control was in 1999, and over the last ten years, we have made good progress on the theoretical side, for example, see my work with Alstad and Yelchuru. Otherwise, the focus has been towards applications, for example, on offshore oil and gas, mainly because of the funding situation. One important area here has been stabilization of multiphase flow (where we have 3 patent applications), which I find very fascinating, and which an area where control really can make a difference. I have a keen interest towards biological systems, but my efforts in this direction have been minor, again mainly because of the funding situation.

**Publication record.**

I have had a steady publication output over the last 30 years, and many of my publications are highly cited. In particular, my text book on Multivariable feedback control (first edition 1996, second edition 2005) has over 6000 citations according to google scholar. The book is focused towards robust control, and in particular in understanding the inherent controllability of a system, that is, what fundamentally makes a system easy or difficult to control.

**Representative publications from the last ten years.**

1. V. Alstad and S. Skogestad, ``Null Space Method for Selecting Optimal Measurement Combinations as Controlled Variables'', *Ind.Eng.Chem.Res*, **46** (3), 846-853 (2007).
2. E. Storkaas and S. Skogestad, ``Controllability analysis of two-phase pipeline-riser systems at riser slugging conditions'', *Control Engineering Practice*, **15**, 567-581 (2007).
3. V. Alstad, S. Skogestad and E.S. Hori, ``Optimal measurement combinations as controlled variables'', *Journal of Process Control*, **19**, 138-148 (2009)
4. S. Skogestad, ``Feedback: Still the Simplest and Best Solution'', *Modeling, Identification and Control*, **30** (3), 149-155 (2009).
5. J. Jäschke and S. Skogestad, ``NCO tracking and self-optimizing control in the context of real-time optimization'', *Journal of Process Control*, **21** (10), 1407-1416 (2011).
6. H. Manum and S. Skogestad, ``Self-optimizing control with active set changes'', *Journal of Process Control*, **22** 873-883 (2012).
7. R. Yelchuru and S. Skogestad, ``Convex formulations for optimal selection of controlled variables and measurements using Mixed Integer Quadratic Programming'', *Journal of Process Control*, **22** 995-1007 (2012).
8. Sigurd Skogestad and Chriss Grimholt ''The SIMC Method for Smooth PID Controller Tuning'', Chapter 5 in: R. Vilanova, A. Visioli (eds.), *PID Control in the Third Millennium*, Advances in Industrial Control, DOI 10.1007/978-1-4471-2425-2-5, Springer-Verlag, London, 2012.
9. Sigurd Skogestad ''Plantwide Control'', Chapter 5.3.1 in: Process Systems Engineering. Part of *Ullmann's Encyclopedia of Industrial Chemistry*. Wiley, Weinheim, 2012. pp. 10-14.
10. Sigurd Skogestad ''Control structure selection'', In: Encyclopedia of Systems and Control, Baillieul, John, Samad, Tariq (Eds.), Springer, 2015. ISBN 978-1-4471-5057-2

See CV for awards etc.