Francis Gregway Shinskey: 2019 and Beyond

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"Virtually any arrangement of loops will operate satisfactorily in the steady state - but is the unsteady state that tests control performance" (G. Shinskey 1967)

"There is no substitute for process knowledge, and certainly none for common sense" (G. Shinskey, 1994)

Abstract

The purpose of this paper is honour F. G. Shinskey, arguably the greatest contributor to Process Control for the Chemical Processing Industries and, in the process, to inspire the new upcoming generations of process control practitioners to keep his teachings close to their hearts. The paper will present several aspects of Shinskey's life, such as: His most important contributions, His awards, His family farm enterprise, His outspokenness with respect to the academic-industry gap, His musical skills and his paintings, and to narrate where his work and teaching brought him to; amongst other fascinating facts from his life that he was willing to share with this author.

In an age in which filling technical positions is becoming more difficult, engineering seems to have lost its luster (sadly). Interest in engineering from the new generations is waning and the few companies that are still looking for engineers are having a hard time finding them. Process Control expertise is also fading away. It is hoped that this presentation will inform new process control engineers to embrace Shinskey's contributions and instill in them an appreciation to work in the pursuit of a better world. Shinskey was always willing to share his findings and insights. He also encouraged academics and researchers to have a practical and approachable way to their inventions if they wanted to see them become part of the arsenal of tools available to process control engineers in the field. In this day and age, we have a proven engineering discipline; nowadays we need to leverage on the venues offered by the social media and the internet, in general, to carry on the message and timeless techniques Shinskey has gifted to us.

His essential bio

Shinskey was born in Tonawanda, New York on the 29th day of October 1931. He attended the Canisius High School in Buffalo, NY, where he graduated with honors at the age of 16. He graduated Magna Cum Laude as a Chemical Engineer from Notre Dame University (IN) in 1952. He served two tours of duty in Korea while on active service with the U.S. Navy and after working a few years for DuPont and Olin Chemicals, he went on to have a very prolific career at The Foxboro Company from 1960-1993. Although he consulted for more than 20 year, afterwards.

While working at Olin Chemicals in Niagara Falls in 1958, he married his secretary Elizabeth Barret, who sadly passed away on December 2018. Eight children were born from his marriage. In Shinskey's own words: "the youngest is a Ph.D. specializing in infant cognition in London

(UK), the other ones live in WV, CA, FL, NJ and two of them in RI, where he as his wife have chosen to spend their last days."

His entrepreneurship

In an e-mail, exchanged on February 16, 2018 for the purposes of this article Shinskey wrote: "I restored a historic (1775) house in Foxborough, and operated the property as a family farm, with a large vegetable garden, raising a steer, pigs, chickens, turkeys, geese, and ducks to feed us year-round. That lasted only as long as we had a houseful to feed."

His artistic inclination

Throughout his lifetime, Greg also had many artistic pursuits. "I was a church choir director and tenor for many years and retired as a church organist at age 80. I began landscape painting with oils, continuing with watercolors and now working with pastels, of which you have some examples." Greg was generous enough to share some of his outstanding art with the author. The Figure 1 shows a couple of his painting, now owned by the author.

Figure 1 - A couple of Shinskey's Paintings

The globetrotter

He wrote a book out of his travel logbook: "TO THE ENDS OF THE EARTH: Travels of an Engineer", which he hoped to get published but it was rejected by the publishers; nevertheless, he wanted to share his experiences as a world itinerant; so herein I quote from the preface: "Though I have written many books, I am not a novelist or journalist, nor well known outside my technical field. By way of introduction, my specialty is Process Control. It is the technology applied to the automatic control of processes in power plants, chemical plants, petroleum refineries, paper mills, etc. I will not bore you with any of the technology; it simply happens to be the vehicle which brought me to the adventures described here. While I am not particularly well-known in my home town, my name is recognized in such faraway places as Australia, Singapore, Venezuela, Finland, and South Africa. In responding to invitations to lecture all over the United States, Canada, and over forty other nations, I lived these adventures."

Having become a lead authority, he was invited to lecture in several famous places such as the Royal Society, the Royal Institute in London, and Oxford University.

The awards

Shinskey's contribution to process control and engineering has been recognized several times, probably not at many as he should have had, probably due to his critical observations of the role of the academic institutions contribution to the preparation of engineers for the real plant challenges. Nonetheless, these are some of the awards he received:

ISA Applications Award (1977) for advances in pH control, ISA Education Award (1983), ISA Founder's Award (1988) for his time domain approach to process control, ISA Fellow (1990), ISA R.N. Pond Award (2003) for best paper of the year, ISA's Life Achievement Award (2008). Computing Practice Award from the AIChE (1992), Benjamin H. Bristol Fellowship, awarded by The Foxboro Company (1982), Sir Harold Hartley Medal, IMC, U.K. (1995), Nordic Process Control Award (1998), Control Engineering Practice Award, AACC (2000), Process Automation Hall of Fame (Control magazine, 2001).

In addition, he holds 17 U.S. Patents for inventions such as "Deadtime simulators for process control apparatus", "Fractionator control systems material balance computer and feedback control", and "Method an apparatus for characterizing and compensating for non-linear components".

The magician-engineer

According to Ed Bristol, Jim Douglas (U. of Massachusetts) spoke highly of Shinskey: "He walks into a room, puts on his black cape and pointed hat, waves his wand at the process and the damn thing works!". The author could not have put it better. His expertise and know-how are nothing short of magic.

Shinskey pioneered the control theory in the time-domain. This occurred after a request to give a course in process control to a heterogeneous group of professionals who would have difficulty following the Laplace domain and frequency domain theories. Those notes eventually became the first edition of his Process-Control Systems book published in 1967. Throughout the years, he expanded and improved this book into three additional editions, with the most recent version published in 1996, by McGraw-Hill in a "Chinese translation of internationally renowned textbooks in information technology and electrical engineering". His books were also translated to Spanish, Italian, Japanese, Romanian, and Russian.

In his time, Shinskey authored well over one hundred papers. His first: "For Gas-Phase Reactors… Design for Control of Temperature", was published in Chemical Engineering, October 5, 1959. And the latest: "Killing Model-Based Control Dead Time", published in Control Magazine in May 2013. If you tally that up, that is over half a century of invaluable contributions to the process control field in the form of articles that provide a wealth of information.

Figure 2 - PCS 4th. Edition in Chinese, 2014

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Some of Shinskey's contributions to process control (Not necessarily his inventions)

Shinskey's work in Distillation Control is probably one of his biggest contributions, having written two editions of his DC (1977 and 1982), which happens to perfectly align with this morning's session: Honoring the Contributions of Greg Shinskey: A Jubilee of Advances in Distillation Control.

"Critique of Chemical Process Control Theory" written by Alan Foss in 1973 where he stated that "the central issue to be resolved by the theories of process control is the determination of process control structure", probably, inspired Shinskey to research the subject. In 1983 he presented his Distillation Control methodology to illustrate his proposition on how to address control strategy design problem.

Based on that paper and the collaborations with Shinskey the methodology could be summarized as follows: First, understanding that a model is a simplified and reduced version of the reality, find a process mathematical model; it will open the possibility to better understanding the underlying behavior of the process and will allow for testing that may not even be possible on the actual process. Second, use Relative Gain Array as the principal means for pairing controlled and manipulated variables, supported by the simplification of the size of the multivariable problem provided by the dynamic response of the different process variables, e.g. flows and pressures have much faster dynamics than temperatures and compositions. Although relative gains (RG) can be estimated from plant testing, the availability of suitable differentiable models will allow the RG calculation using slopes instead of steady state gains, such as in

Shinskey's Distillation 4-components proposed method. Third, use partial decouplers, iff (If and only if) necessary. Fourth, apply feedforward to improve controls performance.

Shinskey's contribution spread wide and far among industries such as Heating Ventilation and Air Conditioning, Solar Energy Systems, Mineral Processing, Pulp and Paper, Fossil Power Generation, Oil and Gas, Oil refining, Petrochemical, and food industry. This demonstrates the universality and transversality of control theory and its application to chemical processes that Shinskey was able to exploit masterfully. There are many specific techniques that Shinskey either invented or developed, amongst them, Feedforward control as a high-performance controller (1963), Material Balance in Distillation Control (1963), Separation Factor in Distillation Control (1965), Inferential control (1968), External Reset (1971), Optimizing Control Performance (minimum Integrated Error) by minimizing P, I and Controller output (1972), Values of process control (1974), Development of the Bristol's RG (1967), Override controls (1967).

Shinskey on Energy Conservation – the entropy crusader

Let me begin by clarifying that entropy is NEITHER disorder NOR chaos (Lambert, 2002). Entropy is NOT a driving force, it is an index that measures the energy dispersion within the system and its surroundings; i.e. the distribution of energy among a large number of molecular motions relatable to quantized states. Shinskey has made clear that "energy conservation" is a misnomer, energy is always conserved, but that even if the energy flowing IN and OUT of a process remains equal, its QUALITY deteriorates; to the extent of becoming unusable.

Shinskey wrote (1978, pp.251)" Distillation is a classic example of a process using energy to create order. Typically, the products of a distillation column are in the same physical state as its feed and have the same energy content. Therefore, the energy use in the process simply passes through, increasing its entropy to reduce the of the products". Recalling a conversation where the author asked Shinskey if a highly entropic system would be more difficult to control, he replied "yes". No mathematical proof but an experience-driven statement. Although it was a loose comment, it has a lot of implications when it comes to the possibility of designing and building a process that might be uncontrollable. Process design and control should have the same standing during the design phases of a plant, something Shinskey was also an advocate of.

In the mid-'70s Shinskey became an "entropy crusader". From that period came his proposals, and recommendations, of how controls can be used to save energy and facilitate operation, amongst them, those for Distillation Control: Floating-Pressure Control, Heat-Pump Systems, Compressor-Expander Systems, Regenerative Heat Recovery (Feed Preheat with Bottoms product), Double-Effect Operation (Thermal Integration), and Coupling Unrelated Columns (Energy Integration).

The University-Industry gap

Shinskey was outspoken about the academic-industry gap throughout most of his career. Starting with his 1971 "To teach creativity" writing where he criticized the higher education institutions for their lack of contact with the real world and the consequent continuous proposition of solutions to problems that don't exist in the real life. In 1994, in "A critique of Education in Process Control" he decried the "tendency toward "dumb down" in all areas of

education", and on his 2002 "Process Control: As Taught vs as Practiced" he questioned investigation solutions that "has led to research results left unused by industry and graduates left unprepared for industrial assignments", in the same paper he also criticized the study of control loops without nonminimum phase dynamics, overemphasis of setpoint response, the near exclusion of load regulation, and the omission of dynamics in the loop disturbance path.

Is the University-Industry gap closing?

On May 1st, 2018 the following message was posted in the AIChE Engage – Discussion Central:

"Chemical Engineering schools follow a fundamental knowledge approach in educating their students … and I agree that this is the core mission of schools and I see the value in that … The problem is the gap between the fundamental knowledge that fresh grads have and the operational knowledge needed by the industry …"

I have seen strong resistance in academia towards incorporating some kind of operational knowledge/training on systems, equipment, and instrumentation that might accelerate the assimilation of young engineers into industrial operation environments post hiring … I have been teaching chemical engineering topics at the "operational level" for the past two years and I can see the value to the industry in this approach … The question is what does it take to convince "academia" to introduce a "healthy dose" of "operational training" that does not compromise the core mission of "fundamental knowledge-based education" for their engineering students?

Ammar Alkhawaldeh, PhD"

The post received 24 replies in a couple of weeks. So, the academy-operational knowledge divide is still an issue…

His legacy for the New Generations of Process Control Practitioners

Proven Process Control engineering is still needed today. It will also be needed in the future. For newcomers, it is quite relevant as they will be in charge of maintaining control strategies that he/she may have neither designed or have been a part of the implementation or commissioning team. In process control, the logic is backwards: Controls are guilty until proven otherwise; if a unit operation stops working all the sudden, it is the controls fault, even if they have consistently worked fine for years. The process control engineer has to prove that is not the controls by finding out what has really caused the problem. That being said, the engineer will need to be prepared to understand and troubleshoot both, the controls and the process. There is no free lunch on this front!

Education will be required in one way or another, as there will always be the need for in-house expertise in process control. Shinskey's books and papers will always be a source of valuable information whenever there is a need for an ingenious and practical solution to a process control problem. Do not get me wrong, theory is great. Theory allows for the exploration of alternatives not yet seen in the field. But theory cannot be the be-all-end-all to the success of a Process Control Engineer. It must be realistic, and applicable to real life. Keep that in mind.

Based on the commonalities between Shinskey's and my own experiences, as he pointed out on several occasions, the recommendation would be to follow his footsteps. He saw himself as a practitioner who managed to balance theory and practice. He gathered theoretical knowledge from academics like Edgar H. Bristol (1936-) and enriched his hands-on experience from practitioners like Carroll J. Ryskamp (1930-2016), whom he called "Mr. Distillation".

Shinskey always invoked Cyril Northcote Parkinson's law: "The time required to do a job will be equal the time allowed to do it" So make sure that you set reasonable limits to the delivery of your work, otherwise the work will never be finished, and the managers will not see the value of your contribution as process control engineer.

On Artificial Intelligence and other tools

The author wrote an expert system based on backward reasoning back in 1987. An expert in the field, a knowledge engineer and a computer programmer were required to build an expert system. To avoid all the risks associated to dividing the work among people from different disciplines, Shinskey himself wrote a Distillation Expert System back in the mid 80's. The author used Shinskey's tool: it provided help into getting to know what it takes to design distillation control strategies. Yet, there were cases where the software application could not be used as the column specifications would not fit the models and/or assumptions made in the expert system, it other words, even if it had the essence of Shinskey's expert knowledge of the subject it was not a substitution of him, by any stretch of the imagination. As a matter of fact, it was only when the fundamentals of distillation column design, operation and the understanding or underlying principles behind the expert system were grasped, that the use of the expert system became more "normal" to this author. Bottom line, a tool is not a substitution for either experience or knowledge.

In 2018 this author took an eleven weeks course on "Machine Learning and Data Mining"; software tools have remarkably improved over the past 30 years, however, the same "limitations" apply: "No magic (except for Shinskey's!), No free lunch". The data has to be either collected or extracted from a historian for what the purpose of the application is, the data has to be adequately selected, which can take 70% to 80% of the project time, the data mining algorithms must be understood, the resulting models need to be monitored and recalibrated, etc. All these is to give a clear message to the new generations of process control engineers: Tools are tools, and are not substitution for human expertise. Theory-Praxis Feedback in the learning process is priceless.

On persistence

The author's work with Shinskey for over 25 years, gave him the opportunity to learn from the man himself. At one facility, after years of the continued operation of a successful application of his material-balance controls on two heat-integrated distillation columns (Nino, 2011), the author was told by the primary contact at the facility, that nobody at that plant thought that it would work! No sure if he ever received that type of comment from any customer.

Shinskey firmly believes, as the author does, and as any process control engineer must know: There are lots of value and benefits to be accrued by applying sound process control strategies to the chemical processing plants. As far as Distillation Control is concerned: Shinskey

told the author during the execution of a sidestream drawoff distillation column project: "Give material-balance controls a chance".

The moral of the story is: If you have a solid design, backed by strong engineering fundamentals, the trends on the DCS will speak on your behalf. All you need is the opportunity from the right person to prove the benefits or process control. Sadly enough, this is more often than not the hardest piece of the puzzle to solve. Finding a believer, in a position of authority is difficult. For this reason, persistence is a must-have in the Process Control Engineer toolbox.

References

Felton B. (2008) "Innovating, educating, writing, earn Life Achievement Award for Greg Shinskey", Intech Magazine, August.

Lambert F. L. (2002) "Disorder—A Cracked Crutch for Supporting Entropy Discussions", Journal of Chemical Education, Vol. 79 No. 2, February

McMillan, G. and S. Nino (2017) "The greatest source of process control knowledge", Control Magazine, October

Shinskey, F. G. (1967) *Process-Control Systems*, McGraw-Hill Inc., NY.

Shinskey, F. G. (1978) *Energy Conservation Through Control Systems*, Academic Press, New York (NY)

Shinskey F. G. (1979) "Entropic and Anti-Entropic Processes and the Future of Technology", Energy, Man and Civilization – Report on an Engineering Foundation Conference. Engineering Foundation, NY.

Shinskey, F. G. (1971) "To teach creativity", Instrumentation Technology, pp.34-38, October

Shinskey F. G. (1983) "From process knowledge to computer control: A methodology", Pacific Area Chem. Eng. Congress, Seoul, Korea, May 5-8

Shinskey F. G. (1994) "Process Control: Where have we been, where are we going", South Africa IMC symposium, Durban, June.

Shinskey F. G. (1994) "A Critique of Education in Process Control", IASTED Conference on Computers in Industry, Cairo, December

Shinskey F. G. (2002) "Process Control: As Taught vs as Practiced," Industrial & Engineering Chemistry Research, 2002, vol. 41, no. 16, pp. 3745-3750