25 YEARS OF DRIVING PUMP TECHNOLOGY—
THE CONTRIBUTION OF THE PUMP SYMPOSIUM

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INTRODUCTION

Good morning and welcome to the 24^{th} International Pump Users Symposium! By your presence here this week, you are tapping into a major powerhouse of the pump world. You have come here, because you know this to be the reliable way to learn about the current developments and emerging trends that may already be impacting your respective roles in this business (Figure 1).

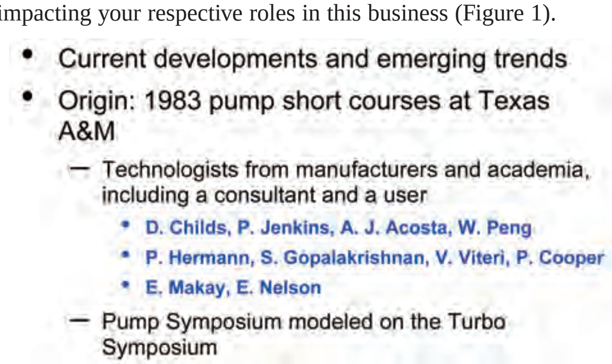

Figure 1. The Pump Symposium: A Technology Powerhouse.

How is it that this symposium is special enough for you to take valuable time out from your busy schedules to be here? Having been involved with this venerable institution since it began, I believe I can shed some light on how it has come to command your attention and respect.

HISTORICAL BACKGROUND

Twenty-five years ago—in 1983—a group of educators and technologists came together at Texas A&M's Turbomachinery Laboratory for a three day "short" course on centrifugal pumps. It was organized by Professor Bill Peng. They focused on the latest developments in pump technology and how they were affecting design, construction, performance, and reliability, namely, cavitation, rotordynamics, seals, maintenance and troubleshooting. Speakers were professors Dara Childs, Pete Jenkins, Alan Acosta, and Bill Peng—and Mr. Ed Nelson, and me. Dennis Bowman of Pacific Pumps was one of the "students" and so was Dr. Paul Hermann of Sundstrand – himself a premier pump technologist. He and four others of us, including Dr's. Gopalakrishnan and Elemer Makay, then participated in a "Blue Ribbon Panel on Pump Design and Application." Lab director, Professor Pete Jenkins, taking advantage of the presence of this group of accomplished pump technologists, corralled them into an advisory committee that would help organize the first pump symposium. The lab had already sponsored the 12^{th} annual Turbomachinery Symposium, and this had moved forward the application of technology in that field. We would operate on the same time-honored and successful model, which promised similar benefits to attendees of this new spin-off called the Pump Symposium. This was the unique, synergistic interaction of academics, manufacturers, consultants, and users that characterized the program of short courses, tutorials, discussion groups, a large product show, and technologically informative lectures.

PS-1

So, the first Pump Symposium was held at the Shamrock Hilton here in Houston the following spring in 1984. Through 2008, there would be 23 more of these "PSs" under the distinguished leadership of Professor Dara Childs. The 25^{th} Pump Symposium will take place next year in 2009, none having taken place in 2006. My address today speaks of the 25 calendar years that the symposium has been in existence. However, next year's 25^{th} symposium happens 25 years after that first one in 1984, and that 25^{th} anniversary will be an occasion for the appropriate celebration. As you can see from the listing in Table 1 of lectures at that first symposium, communicating technology to the attendees was the mind of the advisory committee. This technology encompassed everything from maintenance to the latest developments in the fluid mechanics and rotordynamics of pumps. Notice the subjects: dynamic behavior, reverse flow, acoustic resonance, $NPSH_R$, seal mathematics, nozzle loads, inlet flow, maintenance, and troubleshooting. All were aimed at the same results you are seeking by your attendance here this week, namely, maximizing the reliability and maintainability of these machines, thereby ultimately driving up the profitability for both the user and the supplier. From this list, you would have to conclude that pump technology dominated that symposium—at least so far as the lectures were concerned. Indeed, technology transfer became a hallmark of this and all subsequent symposia (Figure 2). Technologists were drawn to this event, where they could support their own institutions, learn what others are doing, and transfer their knowledge literally to the pumping universe. So, technologists set the tone, especially in those early days. Indeed there was a feeling that they were "pushing" their own technologies. However, in those first discussion groups, users and consultants toughened by field experience immediately challenged the designer-technologists from the pump companies. Not only did this lead to a productive response by the designers in subsequent symposia, but it eventually led to user needs "pulling" the most relevant technologies. This remarkable synergism established the credibility of the symposium as a driver of pump technology.

Table 1. PS-1 (1984) Lectures and Special Papers.

1. PREDICTING AND IMPROVING THE DYNAMIC BEHAVIOR OF MULTISTAGE HIGH PERFORMANCE PUMPS, Bolleter, Frei, and Florjancic
2. CONTROL OF BACKFLOW T THE INLETS OF CENTRIFUGAL PUMPS AND INDUCERS, Sloteman, Cooper, Dussourd
3. ACOUSTIC RESONANCE PHENOMENA IN HIGH ENERGY VARIABLE SPEED CENTRIFUGAL PUMPS, Schwartz and Nelson
4. DOES IMPELLER AFFECT NPSHR? Konno and Yamada
5. IMPROVED MECHANICAL SEAL DESIGN THROUGH MATHEMATICAL MODELLING, Salant and Key
6. HORIZONTAL PROCESS PUMP MODIFICATIONS TO COMPLY WITH API-610 SIXTH EDITION FORCES AND MOMENTS, Steiger
7. AIR MODEL TESTING TO DETERMINE ENTRANCE FLOW FIELDS, Silvaggio and Spring
8. EXPERIMENTAL DETERMINATION OF THE REVERSE FLOW ONSET IN A CENTRIFUGAL IMPELLER, Barrand et al
9. MAINTENANCE AND TROUBLE SHOOTING OF SINGLE-STAGE CENTRIFUGAL PUMPS, Nelson
10. CHANGES IN HYDRAULIC COMPONENT GEOMETRIES INCREASED POWER PLANT AVAILABILITY AND REDUCED MAINTENANCE COSTS: CASE HISTORIES, Makay and Barrett
11. A MAP OF THE FOREST ... UNDERSTANDING PUMP SUCTION BEHAVIOR: WHERE TO WE GO FROM HERE? Karassik
12. SYMMETRICAL SEAL DESIGN: A SEALING CONCEPT FOR TODAY, Netzel

- Technologists came to PS-1
  - They transferred their knowledge
  - They learned from others
- Technologists set the tone of PS-1
  - Seen by some as "pushing" their own technologies
  - Later, user needs began "pulling" technologies
- Users and consultants challenged manufacturers
  - Field experience informed the designers
  - Designers responded in later pump symposia

Figure 2. PS-1 (1984) Technology Transfer.

TECHNOLOGY IMPROVEMENT

Let's take a look back over the 25-year life of the Pump Symposium and decide to what extent this has been true. First we need to ask what the state of pump technology was when PS-1 was held in 1984. Users came with problems to be solved. They told many stories about field problems they were having with pump operation. Their plight was best represented by Ed Nelson, manager of maintenance services for Amoco Oil Company at Texas City—an engineer who later was awarded the Henry R. Worthington medal for achievement in the pump field (Figure 3). As you probably noticed, he was the lone user among the lecturers. He personified the user's position, which led to the addition of the word "users" to the name of the Pump Symposium in 1988. At one of his presentations—most likely in the discussion group that he coordinated in 1984—I remember that Ed's message to his fellow pump users at the time went something like this: "Folks, here is a pump performance curve (Figure 4). You have them for the pumps under your responsibility. The best advice I can give you is to take this piece of paper and fold it in half. Next, look at the right side of the fold. Now, be sure that you operate the pump only on that half of the curve. That half is truly the performance curve. The manufacturer is misleading you by even showing the useless left-hand portion." Nobody could argue with Ed that most of the time the pump would be quite safe by following this policy. But what if you needed a lower flow rate than his policy dictated? He might have answered that you should get a smaller pump or add a bypass valve. This challenged the technologists from the pump manufacturers to learn enough to provide answers. They already knew that some pumps would work even at zero flow (i.e., shut-off); yet other pumps could have problems even to the right of Ed Nelson's fold line. Just three years earlier, in 1981, Warren Fraser of Worthington had published a paper identifying recirculation as the culprit, and a year later Mr. Hallam of Amoco had tied the problem to the suction specific speed capability of the pump. However, there was already a ray of light on the problem—in the PS-1 lecture by energy consultant Dr. Elemer Makay, who was already well known as a solver of utility pump operational problems. He also became a Henry R. Worthington medalist (Figure 5).

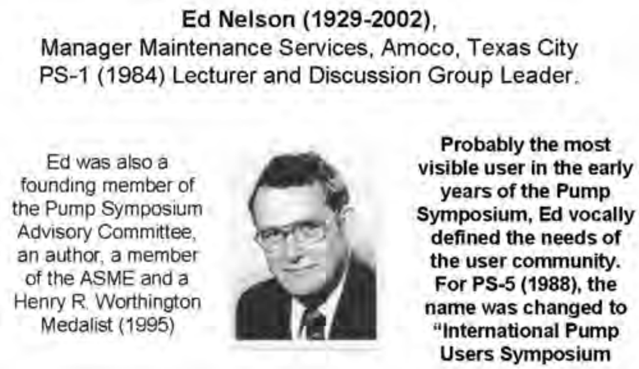

Figure 3. Pump Operation and Maintenance.

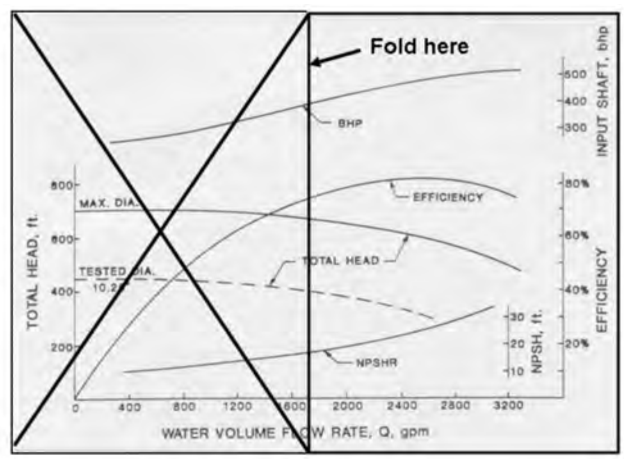

Figure 4. Ed Nelson on Minimum Flow.

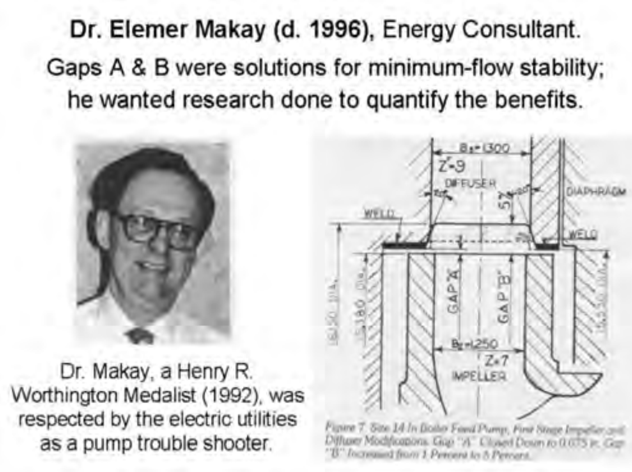

Figure 5. Power Plant Availability. Gap Modifications (PS-1). (Figure Courtesy of Makay and Barrett, 1984, Turbomachinery Laboratory)

He and user James Barrett demonstrated that proper values of the gaps at the impeller OD would lead to much more reliable operation—even in Ed Nelson's forbidden zone. On a host of high-energy pumps around the country, he demonstrated that increasing Gap "B"—namely, the radial gap between the impeller blade trailing edges and the leading edges of the diffuser vanes or volute cut-water—would greatly reduce potentially destructive pressure pulsations. These pulsations were arising from the interactions of the respective pressure fields of these blades and vanes. Further, he showed that a smaller radial gap—called Gap "A"—between the impeller and diffuser side walls would enable smoother operation at low flow in the presence of what Fraser called "discharge recirculation." A small Gap "A" essentially removed the instabilities and thrust problems that could result if erratic diffuser backflows were allowed to enter the spaces adjacent to the impeller shrouds. Yet, Dr. Makay said each case was unique, and, that research would be needed to quantify the appropriate sizes and benefits of these gap modifications.

The next step that addressed Ed Nelson's challenge is illustrated by Dr. Gopalakrishnan's response to this minimum flow problem (Figure 6). Gopal fundamentally examined the problem in a landmark lecture that he gave at PS-5 in 1988. He said that the minimum flow rate Q_{min} of the pump would be less than Fraser's recirculation flow Q_{recirc} by a series of k-factors, each of which should be less than or equal to 1.0. k_1 expressed the key effect of power density (or energy level), which influences the magnitude of potentially damaging pressure pulsations and vibrations. k_2 was the specific gravity of the pumpage, to which the fluid pressure rise and pressure pulsations within the pump are directly proportional for a given head. k_3 allowed for NPSH-margin, (as Fraser's Q_{recirc} already depended on the impeller eye geometry that is connected with its suction specific speed capability). More NPSH reduces the volume of vapor within the impeller that can interact violently with suction recirculation and so magnify the resulting erratic pressure fluctuations. k_4 was the intermittency or fraction of time that the pump was running at the minimum flow condition at which these potentially destructive phenomena can exist; and k5 depended on how robust the mechanical design of the pump is in resisting the resulting fluctuating forces. This theory, while not the final answer, went a long way toward quantifying the minimum flow problem in the minds of both users and manufacturers. This is a prime example of the synergistic role played by the Pump Symposium in driving relevant technology.

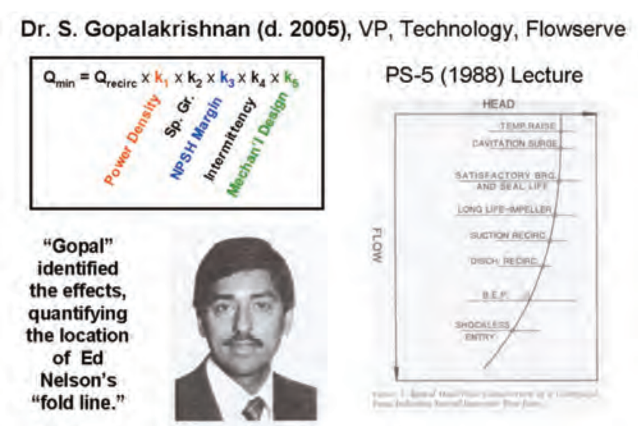

Figure 6. A New Method for Computing Minimum Flow (PS-5). (Figure Courtesy of Gopalakrishnan, 1988, Turbomachinery Laboratory)

I'd like to give you one more example of how pump technologists have addressed needs that have been enunciated at the Pump Symposium. This time, however, the challenger was not a user but rather a distinguished pump engineer who represented a venerable pump manufacturer. Igor Karassik, who was the first recipient of the Henry R. Worthington medal, had such a broad vision and understanding of pumps from concept to application that he was widely accepted as a spokesman for virtually everyone involved with pumps (Figure 7). During his lifetime, he wrote over 600 articles about pumps and the systems in which they are deployed.

Figure 7. A Map of the Forest… Understanding Pump Suction Behavior: Where Do We Go from Here?

In a special paper at PS-1, he described the imprecision of the various methods for assessing the true suction performance of centrifugal pumps. So much about pump performance and reliability depends on the NPSH required by the pump to:

- Meet head performance,
- Run smoothly in the system in which it is installed, and
- Resist cavitation damage for a prescribed period of time under widely differing operational profiles.

Knowing incipient cavitation has to do with the existence of bubbles in the liquid, he questioned how one determines the corresponding NPSH and even then how important that might be in the life of the pump involved. He challenged the engineers of the future to come up with practical answers to these questions.

I believe Igor would be pleased with the way two lectures from PS-21—a generation later—have clarified our knowledge of pump suction behavior. First is the effect of the system on pump suction behavior. Bruno Schiavello showed how a distorted inlet flow pattern produced suction recirculation and vibration in a field installation (Figure 8). All three pumps in this system were affected—at otherwise acceptable flow rate and NPSH available. Modification of the inlet bell upstream of the pump impeller removed the distortion, enabling this pumping system to operate smoothly. Thus, a full understanding of suction behavior requires that the possibility of suction recirculation be taken into account. Here the technologist's knowledge was successfully applied to the benefit of the user, which is an object of this symposium.

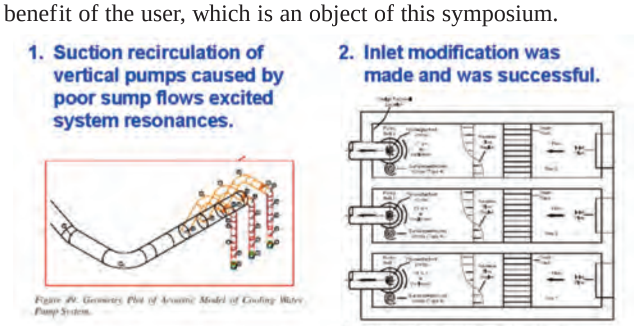

Figure 8. Pump/System Interaction: Suction Recirculation. Given as a Lecture at PS-21 (2004). (Courtesy of Schiavello, et al., 2004, Turbomachinery Laboratory)

In fact, here at PS-24, you can experience how far today's engineers have come in meeting Igor Karassik's challenge. You can attend the tutorial on "Pump Cavitation—Various NPSHR Criteria, NPSHA Margins, Impeller Life Expectancy." The instructors are

Bruno Schiavello and Frank Visser. This is only one of eight equally informative tutorials being presented this week.

The second PS-21 lecture about suction behavior demonstrated how it can affect the life of an impeller due to cavitation damage. In Figure 9, you see a high-speed photograph of the sheet cavity that trails off the blade leading edge of a typical first stage pump impeller at its BEP. The available NPSH is about twice the NPSHR. Here, Don Sloteman demonstrates that incipient or inception NPSH, namely, that at which the first sign of a cavity occurs, is important for high energy pumps—both in theory and in practice. If the available NPSH exceeds this value, there will indeed be no cavitation damage in such pumps. In this regard, Igor would be relieved to hear that, in accord with his wide experience, the new theories about cavitation damage show that inception NPSH has no practical meaning for low-energy pumps, because they don't suffer such damage—even with a lot of vapor in the impeller passages. Such pumps need only the much lower 3-percent-head-drop NPSH—better known as NPSHR.

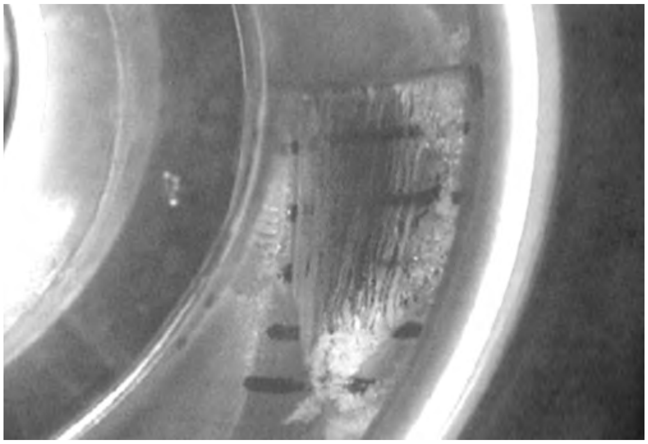

Figure 9. Demonstration of Cavitation Life Extension for Suction Stage Impellers in High Energy Pumps. Given as a Lecture at PS-21 (2004). (Courtesy of Sloteman, et al., 2004, Turbomachinery Laboratory)

The relation of the sheet cavity length (Figure 10) to cavitation damage was empirically established by Dr. Johann Gülich, another lecturer at these pump symposia. So, Don visually observed the cavity lengths at various NPSH-values on test, computing the estimated life of the impeller from these data by Gülich's method. Notice that he also successfully obtained the same data via CFD, a new tool that is becoming essential for economical development and accurate prediction of the performance of pumps nowadays. He goes on to say that by producing a new leading edge blade shape, he was able to reduce the inception NPSH below the available NPSH. Not surprisingly, he reports that at the time he wrote the paper the new design had already been in service for several years with no evidence of cavitation damage.

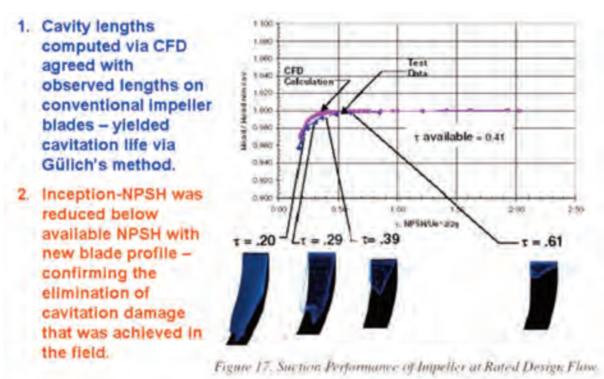

Figure 10. Cavitation Life. CFD Predicts NPSH-Performance. Given as a Lecture at PS-21 (2004). (Courtesy of Sloteman, et al., 2004, Turbomachinery Laboratory)

No doubt Igor Karassik would say that, in addition to this week's tutorial on the subject, these two lectures from the 2004 Pump Symposium are evidence that his successors have indeed met the goal he set for them—20 years earlier—for a better understanding of pump suction behavior.

TECHNOLOGY EVOLUTION

Similar stories chronicle all the main strands of pump technology as they evolved over the years of the symposium. Representative presentations are shown in Table 2; there were of course many more. In the interest of showing as many as you see in this table, some of these papers are not precisely located with respect to the exact dates when they were presented. Admittedly these presentations—mostly lectures—are among those that impressed me from my own involvement in the parade of these technologies, but they do reveal a common evolutionary thread going through all the symposia. As I have noted near the bottom of this table, we started out emphasizing *research and education*; that is, we pump technologists wanted to tell the listeners about our consuming interests and why our respective topics were important. That worked as long as all the topics of interest were covered in the symposium program. Moreover, many of these lectures were describing works in progress—such as new design and analysis concepts and computer codes. This was the case in the first few years of the symposium, and a great deal of archival and useful information appeared in the proceedings. However well intended, though, this approach at least had the appearance of being one-sided. The users were taking center stage, and the technologists had to *focus* on *developments* aimed more directly at the needs of the *user*. What we see today is more emphasis on the *application* or *implementation* of what was and still is being learned. This is not to say that education ceased to be important; in fact the ongoing Pump Symposium short courses and tutorials—tutorial titles shown in green here—illustrate the fact that *application* is a major aspect of education when understood in its largest sense. Indeed the symposium is overall an educational event sponsored by an educational institution.

Table 2. Pump Symposium Technology Evolution.

FIELD SOLUTIONS INSTALLATION MAINTENANCE RELIABILITY ECONOMICS	TROUBLE-SHOOTING: NELSON PS-1; GAPS A & B: MAKAY PS-1; ROTOR CRITICAL SPEEDS DIAGNOSIS AND SOLUTIONS: BOWMAN, REID, MARSCHER 7; HYDRAULICS-BASED FIELD SOLUTIONS: NELIK, SILVAGGIO, JOSEPH, ET AL 13; LIFE CYCLE COSTS: NETZEL 18; TRANSIENT THERMAL FEA – MULTISTG. CLEAR'S: KAISER ET AL 16; SUMP FIX FOR SUCTION RECIRC.: SCHIAVELLO 21
POSITIVE DISPL. & OTHER PUMPS	PD-SYSTEM ANALYSIS: SINGH PS-4; SLURRY WEAR: ADDIE ET AL 4; PD WEAR: VETTER 13; SPECIAL-PURPOSE PUMPS: SCHIAVELLO 14; MULTIPHASE SCREW PUMPS: PRANG, COOPER 21
PROCESS, API P's SEAL TECHN'GY SEALLESS PUMPS	SEAL MATH: SALANT & KEY PS-1; MAG-DR. CHEM.; API: BUSE 7; BEHNKE 9; MAG-BRG API: HANSON 9; DUAL GAS SEALS: ADAMS 12; DUAL SEALS: LAVELLE, KEY 12; INTEGRAL PUMP-MTR: SLOTEMAN 17; SEALS WITH WAVY SiC FACES FOR NGL PIPELINE APPLIC.: KEY ET AL 21
HIGH ENERGY P's VIBRATION ROTORDYNAMICS MECH. BEHAVIOR HYDRAULICS CAVITATION	HIGH-PERFORMANCE PUMP DYNAMICS: PS-1 FLORANCIC, BOLLETER; FORCES: BRENNEN PS-2; SUCTION: KARASSIK PS-1; MIN. FLOW: GOPAL 6; ROTOR-DYNAMICS CODE: 5 NIKOLAJSEN; VIBR'N: MARSCHER 15; FLOW-CURVE INSTABILITIES: HERGT 13; THUNDER HORSE INJECTION PUMP: MEUTER ET AL 20; CFD CAV'N PREDICTION: DUPONT 16; A VERY HIGH HEAD PUMP: McGUIRE 22; DEMO. OF CAVITATION LIFE: SLOTEMAN 21

RESEARCH & EDUCATION → USER-FOCUSED DEVELOPMENT → APPLICATION

	1984	1988	1992	1996	2000	2004	2008
Symposium	PS-1	PS-5	PS-9	PS-13	PS-17	PS-21	PS-24

As an example of what I'm trying to convey here, I think we have time to take a look at the seal technologies that I have conveniently—but not totally accurately—shown as being only in the more general category of process pumps. The lecture by Dr. Richard Salant and Bill Key on the mathematical modeling of mechanical seals was a fitting introduction to the fundamentals of the subject and set the tone for all the seal work that would be presented at future symposia. Indeed this was *research and education* for those trying to get the basic understanding of the subject that would propel the industry technological development. Next, to address the needs of users seeking to reduce or eliminate emissions, sealless pumps came along, including the magnetic-drive chemical pump paper by Fred Buse and the API sealless pump by Paul Behnke. Lloyd Hanson produced a sealless pump with magnetic bearings. Some of these papers were not practical enough for the users, and the seal technologists took the challenge and did a lot of new work. Representative of this initiative are the dual gas seals paper by Bill Adams, and another paper on dual seals by Ken Lavelle and Bill Key. This kind of *user-focused development* was successful in restoring mechanical seals to favor; although, sealless pumps continued to occupy a niche. In fact, a later sealless development that piqued the imagination of the zero emissions users was Don Sloteman's axial-field integral motor pump lecture at PS-17 in 2000. Finally, at PS-21 in 2004, we see Bill Key's *application* of the more sophisticated seal technology that had become available by that time. He was addressing a challenging NGL pumping service with seals having wavy faces, which provided a hydrodynamic lifting force and—together with other advanced features—enhanced seal life and reliability.

FEATURES AND TRENDS

Besides illustrating the trend from research through application, this seal technology story reveals another feature of these pump symposia. They can be a crucible in which promising new technologies are proven and applied—and sometimes de-emphasized. In his PS-17 lecture, Sloteman provided a significant perspective on the give and take of these two technologies (Figure 11). First, he saw the increase in the number of symposium papers on sealless pumps in the 1990 to 1992 time frame as a measure of the heightened interest in this promising answer to user concerns relating to government regulations about emissions.

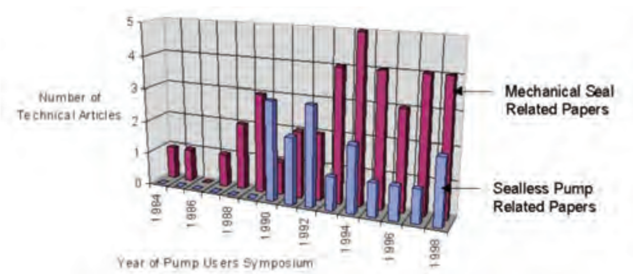

Figure 11. Pump Symposia: A Crucible for New Technologies. Sealless Pumps Made a Strong Debut but Declined to Find a Niche When Challenged by Improved Seal Technology. Given as a Lecture at PS-17 (2000). (Courtesy of Sloteman and Piercey, 2000, Turbomachinery Laboratory)

However, beginning in 1993, the seal industry responded with a dramatic and sustained increase in the number of papers on the improvements they were making to ensure reliability in meeting these regulations. The symposium evidently provided the impetus and platform for the shift back to mechanical seals while maintaining sealless technology for certain critical applications. Both technologies were addressed continually in the short courses, tutorials, and discussion groups and were well displayed in the symposium's product shows.

Moreover, the trends from research to application—as often kept on track by this "crucible" aspect—were accompanied by yet another trend. Most veteran participants could see an underlying shift in the emphasis of the Pump Symposium over the parade of its quarter-century existence. Market forces were in play all during this period, beginning with the buildup of the industrial infrastructure—largely in the developed countries. In those early days, accomplished technologists such as those I mentioned before were active participants in their respective environments and in the symposium. In the 1990's, this build-up virtually ended. As business slowed, the pump industry underwent a massive consolidation. Many of these people left or simply retired. There was not enough business to support technology development. New pumps and new pump ideas that had been "pushed" as part of the earlier research-engineers' vision were now on the back burner. The emphasis shifted to field maintenance, repairs, upgrades, and—at best—building and installing established pump designs (Figure 12).

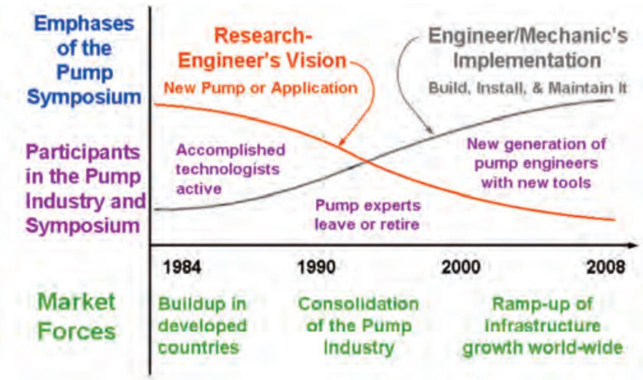

Figure 12. The Emphases of the Pump Symposium and the Influence of Market Forces.

Into this gloom—mainly in the past decade—came the unexpected ramp-up of infrastructure growth across the world. By this time, a new generation of pump engineers was on board. The manufacturers had become lean and mean. Now, the design engineer might also have demanding project responsibility. In this environment these engineers began "pulling" in the technologies they needed to get the job done more efficiently, accurately, and at reduced cost. Serendipitously, they have found new tools available to them. Some of these are in the form of advanced commercial computer codes for rotordynamics, FEA and CFD. These are the fruit of the developmental labors of the preceeding generation of technologists. The industry has entered a new era in which much of the earlier research and development is being implemented in practical ways by the engineers and mechanics who design, build, install, and maintain the equipment. The symposium has reflected this shift in emphasis. The original vision has in fact begun to bear fruit in unintended and exciting ways.

Referring back to Table 2, allow me to illustrate this metamorphosis for the case of those technologies that I previously identified there as applying to high-energy pumps. Pioneering work in vibration, rotordynamics, and the array of "mechanical behaviors," as well as hydraulics (or fluid dynamics) and cavitation led to impressive applications in later years. There we see lectures on pump dynamics, and some evidenced the development of codes for use in design. Similarly we learned how flow patterns relate to performance curve instabilities. The educational aspect continued, Bill Marscher's vibration tutorials also appearing there—not to mention his short courses, which are ongoing. Then came pumps that were designed using the advanced commercial codes—both FEA and CFD—which had by then become available and which have enabled rapid and efficient designing and performance prediction of today's machines.

The way these particular technologies are now utilized in the pump industry is typical of the role that probably all technologies have played in shaping the structure of the Pump Symposium as it is today. As seen in Figure 13, early on, reporting of the research and development of the computer codes was part of the "education" emphasis. Here again, however, education in the larger sense has always been a major objective of the symposium—as we see from yesterday's list of seven short courses and the array of eight tutorials coming up today and tomorrow. The message of Figure 13 is simply that yesterday's codes have today become proven commercial tools that enable a new generation of engineers to design and build the new machines and the upgrades for today's market. The tools themselves no longer occupy center stage. They are taken for granted and utilized in a new and efficent manner that eliminates much of the extensive hardware iteration and laboratory testing of an earlier generation. The issues for today's pump engineers are no longer the tools, the ideas behind them, nor their development. Many of today's engineers are users, who now have these tools. As users have always done at these symposia, today's engineers are also telling *their* stories within the expanding format of multiple case histories and discussion groups. There are 14 case histories and 12 discussion groups being held in this week's symposium—a structure well suited to fulfilling the PS-24 motto of "practical reliability improvement."

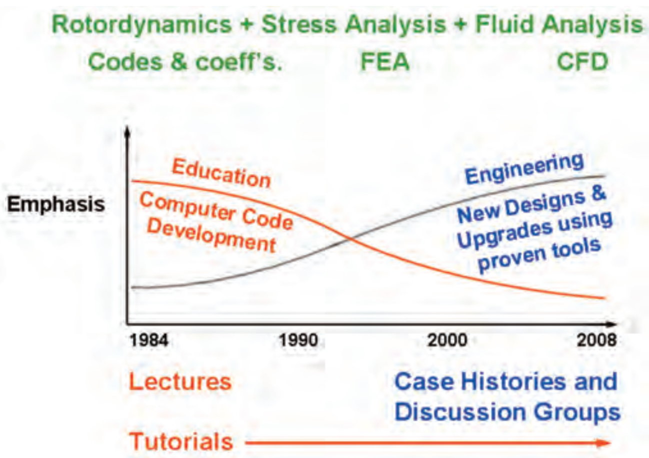

Figure 13. Technologies and Symposium Structure.

CONCLUSIONS

In conclusion, the Pump Symposium is well known globally as a forum where users, suppliers, and educators interact synergistically for the benefit of the participants and the industry in general.

Over the quarter century of its existence, the symposium has been a major player in the development and application of pump technologies:

- From the vision of many, including research and development,
- Through teaching, learning, and implementation of this vision,
- Resiliently responding to market and industry trends, and
- Equipping a new generation of pump experts.

For 25 successive calendar years, the pump symposium has addressed and balanced the developments and requirements of the pump field:

- Responding to market trends and user needs,
- Promoting reliability and economies in all phases from design and construction through installation and maintenance,
- Thereby driving the technology of the pump industry.

On this last point, some would take the contrary position, namely, that *technology has driven the symposium*. I cannot agree, nor am I content to let the matter rest in the uncertainty of an indecisive chicken-or-egg limbo. As a pump technologist, my own career has been spearheaded, encouraged, and expanded—literally enhanced—through my association with this venerable institution of participants from all walks of life within our industry. May it be the same for you this week.

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