Power Plant Boilers: A Chevy With the Hood Welded Shut

By Peter Baston

When I first met Steve Bennett, he was a senior engineer at Plant Bowen, a huge coal fired power production plant in the Georgia power hub of the Southern Company. He was responsible for maintaining the power boilers, the functional centerpiece of this utility that supplies the bulk of electricity to the southern United States, and that's exactly how he described the challenges he faced every year: like trying to maintain a Chevy with the hood welded shut. This simple metaphor started me on a multi-year engineering odyssey that eventually led to the only major innovation in boiler maintenance technology in the last 50 years.

Twice a year, the power plant is shut down for a "planned outage [1]" so that preventive maintenance can be performed to enable it to keep functioning and producing electrical power for the state of Georgia. Steve was responsible for the horde of 450+ workers who descended upon Plant Bowen for its biannual multi-million dollar checkup and repair.

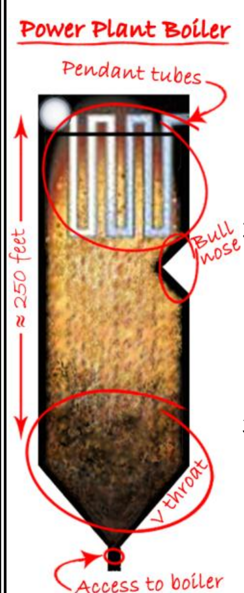
Plant Bowen's planned outages could be compared to your car's 30,000 mile service. However, as Steve pointed out, when your Chevy was designed by its manufacturer, facilitating the maintenance needed to keep it at the peak of its operability would have been a major design consideration— but that seemed not to have been the case when his power plant was designed. Hence his comparison to "a Chevy with the hood welded shut." An immense industry has grown up around malfunction in design — and millions of dollars and, sadly, many, many lives are wasted every single year because of it.

Power plants are multi billion dollar complex monsters that spread over many acres of land. Fossil fuel power plants like Steve's Plant Bowen convert the chemical energy stored in fossil fuels such as coal, fuel oil, natural gas or oil shale into first thermal energy (steam), then mechanical energy (the rotation of a turbine or generator), then, finally, electrical energy. Functionally, there are two major components of a power plant:

1. The turbine/generator that produces the electricity
2. The boiler that burns the fuel that produces the steam that drives the turbine/generator

The prime fuel for the boiler in Steve's Plant Bowen, as for some 1,500 other power plants in the U.S., is coal—anthracite or lignite, or subbituminous, bituminous, synthetic or waste coal. Coal fired plants produce about half the total electricity consumed in the U.S.

Steve's Wish List



1. I want to be able to do complete rapid interior inspection and repair of my boilers from the pendant tubes down to the V throat in my own time frame many times a year any time I have a lull in plant demand.
2. I want to be able to do this with an internal, integrated system that uses in-plant personnel and equipment, takes less than 48 hours to complete and immediately posts the results so I can plan and/or carry out rapid repairs as needed.
3. I want the results of inspections and repairs to be posted to a computer system so major issues and progress of repairs can be seen by power plant personnel at all levels as well as summarized and translated into non-technical terms to facilitate good risk management.

Steve's wish list seemed surprisingly simple. Listening to him, I was amazed that the trillion dollar support industry would simply ignore his logic, but eventually I would come to realize just how much money is made by growing problems rather than solving them. At the time, fueled by a few beers and laughs, I saw the wish list as an intriguing engineering challenge, one that promised both of us a multitude of new directions over many years.

***

At the time of this conversation, I was a senior Business Development Analyst for a company that provided power plants with support services. Armed with Steve's request list, I returned to our head office in Houston and prepared to make a presentation to our corporate staff on the major needs of one of our primary customers.

A well-run fossil fuel powered plant operates at about 45 percent efficiency; that is, about 45 percent of the potential chemical energy in the fuel actually

[1] Planned outages are scheduled far ahead, while "forced outages," which are unfortunately far more common, occur when the system fails unexpectedly.

emerges from the plant as electrical energy. Steve's work and calculations showed that he could increase his plant's efficiency rating by 5 to 10 percent if he could perform more and better preventive maintenance. This would result in direct cost savings to his utility amounting to $280 million over 5 years.

After two weeks I tracked down and got in front of our major corporate players and gave my presentation based around the following points:

1. Our business was brutally competitive and pricing negotiations with our best customers were developing into an antagonistic haggle every two years.
2. Our entire industry was regarded by its customers as performing worse than poorly.
3. Most planned outages only resulted in less than 40 percent of the needed work being accomplished due to the compressed schedules, changing requirements, and logistics failures.
4. The support logistics required us to supply over 30 fully loaded 18-wheelers and 200 men in a short time frame and, worse, most of our bigger customers required these services at the same time.
5. The steel staging that was required to envelope the boiler interior for multiple access levels was built from the ground or V throat up and so arrived last at the boiler roof pendant tubes. This was totally the reverse of the power companies' needs, as their priorities are from the top pendant down to the bull nose and hardly ever the V throat.
6. The only way into these huge, cavernous 250 x 150 x 250 foot tall boilers was through tiny access ports below the V throats, and this made it excruciatingly difficult to introduce the many hundreds of men and tons of material needed to perform maintenance. This inability to easily access the boiler for maintenance is what led Steve to compare it to the engine of a "Chevy with the hood welded shut."
7. Most of the equipment was rented, old and obsolete, which led to multiple logistic nightmares.
8. As a result of the way these outages were planned and carried out, the worker accident and death rate was worse than horrendous. Temperatures inside the boilers were commonly over 100 degrees and the working conditions were filthy, dark and hazardous, with slag and debris continually falling from the walls.
9. Labor costs were rising and at the same time personnel who would do this type of work were getting scarcer and scarcer, and as a result our wage burdens were skyrocketing. Attempts to control our labor costs by using unskilled, often undocumented, workers had caused the accident and death rates to increase rapidly.
10. Although this business was adding hundreds of millions of dollars to our company's bottom line, there were much better ways to solve our customers' problems.

At this stage some of the faces in the room were getting darker and darker, especially the CFO and CEO (who had never been to a power plant, let alone inside a boiler). Being an optimistic type, I nonetheless proceeded to lay out what later euphemistically became known in the industry as "Pete and Steve's Magic Carpet" or, as I'm going to refer to it, PSMC.

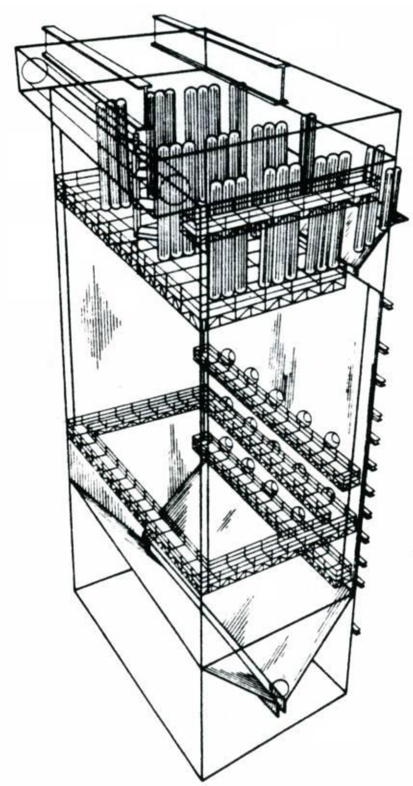
This was Phase One of PSMC:

PSMC Phase I: Develop and Implement a Workable Platform System

1. Develop a platform that spans the entire boiler width and can be assembled by in-plant personnel (no more than eight workers needed) safely and cleanly in less than 8 hours.
2. Engineer the platform so that it can safely carry all the non-destructive testing (NDT), inspection and repair personnel and equipment, as well as sufficient lighting to illuminate the whole boiler.
3. Include a mechanism that allows the platform to ride up and down the boiler just like an elevator and be rapidly deployed at the top of the boiler first.
4. Engineer the platform to protect personnel from the safety hazards documented through years of accidents using the older systems.
5. Engineer the platform so that the entire system, including the lift system, can be contained on a 48-foot trailer that could be rapidly deployed to any number of power plants within a day or parked on site, depending on each power company's requirements.
6. Enable the insertion of additional platforms, unfolding like origami, to access multiple levels.

I already had a clear idea in my head of how the system could be engineered and manufactured, and I knew it could be done quickly and inexpensively. I pointed out that this would enable our company to sell long-term multi-million dollar contracts to our customers, at ten times the margins of the contracts we were booking under our old systems. More importantly in my opinion, for the first time we would be able to provide our customers with supreme service that really benefited them. And we would drastically reduce the work site accident and death rate.

PSMC Phase I: Conceptual Design



Oblivious to my pending doom, I kept going to sketch out the next two phases of PSMC.

PSMC Phase II: Develop Information Systems for Preventive Maintenance Management

1. Develop laser measuring and data collection systems to diagnose the condition and needs of the boiler.
2. Develop a data storage system linked to SCADA[2] so that the total scans of the boiler performed by the diagnostic system could be transmitted to a central repository for further analysis and permanent storage.
3. Develop sonic cleaning systems that could be mounted on the platform and receive instruction from the central data repository so work could begin on one section while scans were still being conducted elsewhere.
4. Work with boiler manufacturers to incorporate automated segments of the diagnostic and cleaning systems into the boiler designs.

PSMC Phase III: Develop Models to Capture Best Practices Tied to Operational Efficiency

1. Develop intelligent off-site parametric data modeling that would work in conjunction with the power plants' own SCADA operating systems to identify best practices and make them replicable.
2. Target demonstrable operational efficiencies of above 60 percent, which had never been achieved anywhere in the world. (Later I wrote an article that spelled out in greater detail the full potential of Phase III and which you can read at http://www.ideapete.com/AATG.html.)

My close to them was that at every level from Phase I to III, the profit margins would increase by factors of five to 10. Also, as we increased the sophistication of the system, the skill sets of the crews would increase, the highly skilled crews would be smaller and the smaller crews could be rapidly assembled and deployed to any part of North America or the world with a complete system in 24 hours. Our entire business model would go from "low tech, poor results" to "high tech, great results."

After about ten minutes of stunned silence, the vitriol that poured across the table was awesome to behold. The main crux was this was a totally moronic idea and didn't I realize that we currently had our customers captive and as a result could screw them for any amount of money we wanted? The idea of providing a customer with an actual long term solution was insane, abject heresy and worse than stupid. In short, we were a permanent, parasitic virus in our customers' systems that they had to pay continually and could never get rid of.

Naturally, within four hours my exit from the company was expedited and so I duly made the trip to Georgia to let Steve in on the results of his requests. Sadly, he wasn't surprised. We did make a pact that if I could ever make the system work, I would get in touch with him. We spent a nice weekend celebrating the failure of my presentation and dreaming of what could be, then parted company.

***

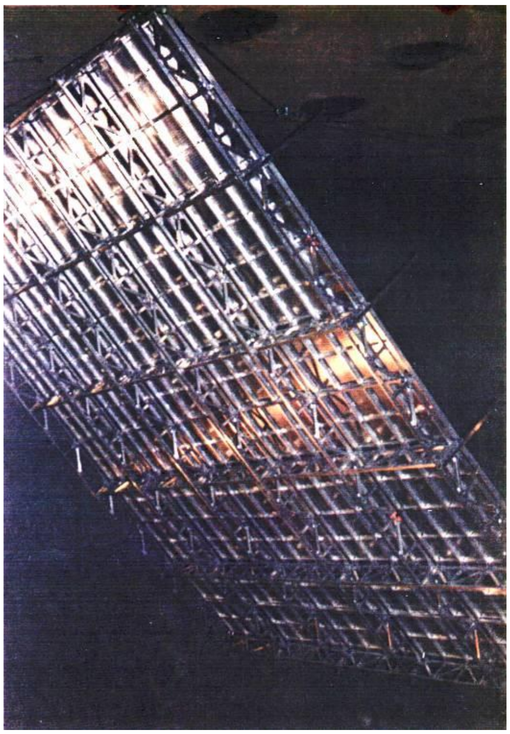
The tale has a bittersweet ending. Here's the sweet part: I went off and developed Phase I of the magic carpet on a shoestring. It flew like a dream and was placed into use at Plant Bowen and at several other power company plants across the U.S.

Here's the bitter part: The Monkradle Boiler Access System was so successful that my small underfunded company attracted the attention of the big players

[2] SCADA: **S**upervisory **C**ontrol **A**nd **D**ata **A**cquisition, a computer system for collecting and analyzing real time data.

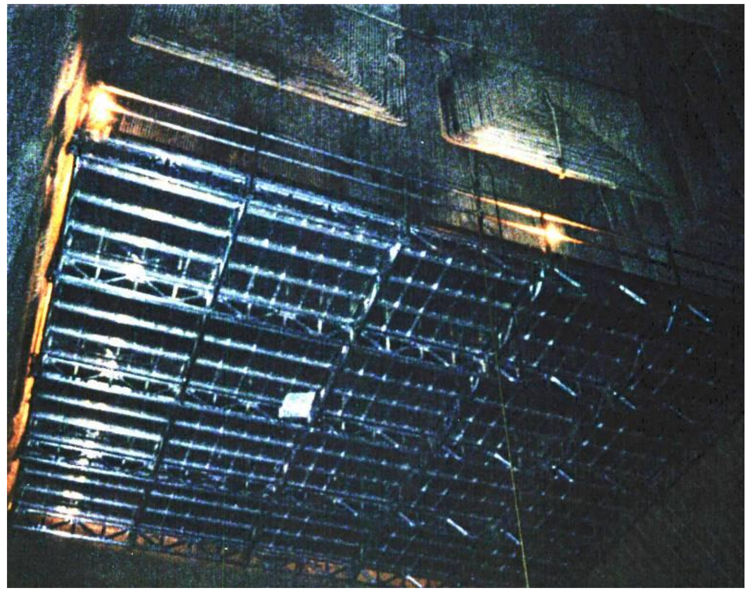
in the market. One would think such attention would be a good thing, but, again, my optimism proved misplaced. Within four years, a barrage of broken purchase contracts, critical suppliers being bought out and cutting off deliveries, lawsuits, and outright sabotage drove Monkradle out of business.

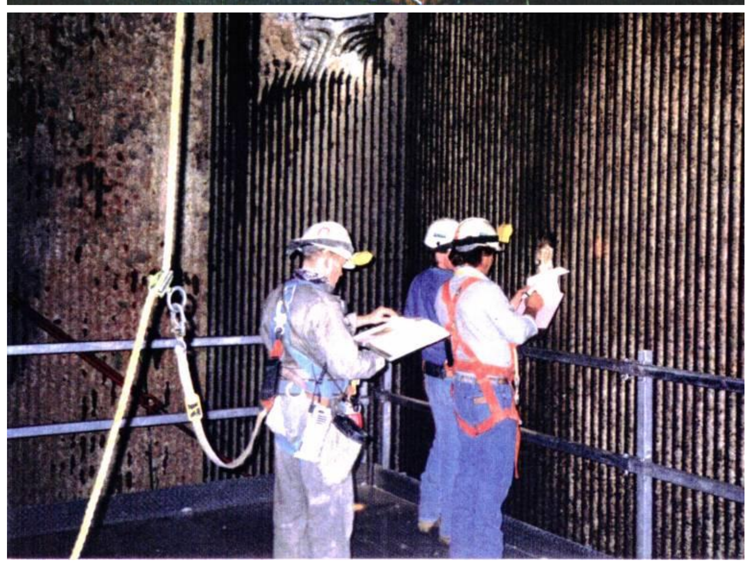
Let's go back to the sweet part. The Magic Monkradle Carpet did get a chance to fly in many boilers. It was the most awesome sight I have ever seen, and a true compliment to American and (in my case)



Rhodesian ingenuity. She was truly beautiful and got rave reviews from everyone who worked with her. The most heartwarming comment came a few years after our company ceased to operate, when I was discussing how she had been created with a Canadian power company plant manager who said: "Yes, it did not fly as far as it could have, but as a result of where it did fly, there are more than 200 people who were able to spend Christmas with their families, who are alive today because it flew—and that is beyond price." I slept really well that night.

The story of Pete and Steve's Magic Carpet is 15 years old, but nothing much has changed in the power industry since that time—except, of course, the cost of fuel and the demand for electricity. You hear all this talk today about energy conservation and the wonderful things that can and should be done to solve "the energy problem." But the biggest problem is the inefficiency that requires roughly three units of potential energy to enter the plant to deliver one unit of actual energy to the customer. The most advanced power plants are delivered with promises of 60 percent efficiency; by the time they have been





under-maintained for 30 years, they may be operating at 30 percent. More energy is lost through leaky transmission lines and inefficient delivery to the end user, but we won't talk about that now.

Despite their low efficiency, coal fired power plants still produce 50 percent of the power consumed in the U.S. Although coal is under siege because of its pollutant discharges and because of its reliance on a mining industry itself under attack for its worker fatalities and environmental impacts, the fact of the matter is that the U.S. is stuck with its coal fired plants for at least the near if not the foreseeable future. One reason for this is that fuel accounts for 50 percent of the operating cost of a power plant, and the cheapest fuel is still coal, of which the U.S. has a lot. You can buy 100-year contracts in coal. Today, less than 5 percent of power is generated by renewables. Getting 50 to 100 percent more power out of existing fossil fuel plants would have far greater immediate impact on reducing our use of fossil fuels than doubling the number of renewable fuel plants.

Many of our coal fired plants are old by any standard, but, still, maintenance is the first area tapped for cost-cutting. Every few months, there is an explosion, which often could have been prevented by better maintenance. The cost of this catastrophic event is covered by insurance, however, while the cost of preventive maintenance (the hard costs of doing the maintenance plus the lost business due to the outage) just comes out of bottom line — as things stand now, there is no financial incentive to do maintenance, let alone do it better!

Eighty percent of the problems in these plants occur in the boiler, partially because burning coal is highly corrosive. Leaks in the tube cost 20 percent in efficiency at the hot water end (the tubes in the walls) and 60 percent at the super-heated pendant tubes. The typical plant schedules two planned outages a year to maintain its boiler and the tubes that carry the water/steam to the generator, but few plants accomplish everything they should at those times.

A complete planned maintenance is conventionally scheduled to last about six weeks. With two a year, the plant is out of operation 12 weeks, or 25 percent of the year. This maintenance is performed by outside contractors, who bring in their own equipment. The first and last two weeks go just to setting up and disassembling the scaffolding inside the boiler.

By contrast, the Monkradle platform took 12 hours to deploy or remove, allowing eight more days of actual maintenance, or a briefer outage. Phase II would have made the system semi-intelligent, so that the platform itself became a non-destructive testing system, scanning the walls as it was being raised. Not only would this have shaved more time off the outage, but it would have ensured that all the required maintenance was identified and triaged.

The fact is that the operational constraints imposed by maintenance needs and methods actually drive the business plan for this type of power plant. Yet, even today, maintainability is mentioned either not at all or as a footnote when boiler manufacturers promote their products. Power plants, like refineries and water systems, have been routinely using SCADA systems to monitor and control their operations since the 1990s, but their builders have not taken the logical next step of incorporating ubiquitous sensors to manage the plant itself. With today's sophisticated but inexpensive SCADA technology and parametric design modeling[3], it would be a simple matter to make a boiler "intelligent" — every component of the boiler itself could continually report its status through integrated digital feedback systems, including the steam tubes that compose the walls and the superheat pendant tubes whose failure is the cause of most catastrophic boiler explosions.

So where could we go from here? The patent on the Monkradle Boiler Access System has been released to the public domain. After all, that was only Phase I. We knew all along that the largest gains in efficiency would have been realized with the implementation of PSMC Phase II and III, which would have effectively retrofitted an existing plant to make it intelligent. These were large undertakings 15 years ago, but today the technology to develop them is well within reach of the smallest utility operator. And the architecture and design is still valid and still available through my new company, IDEAS.

The bottom line is this: the full implementation of "Pete and Steve's Magic Carpet" could allow a coal-fired plant to sell 30 to 100 percent more electricity with no more fuel than it is using now, at a capital investment cost of roughly 30 percent of the fee for one year of maintenance by an outside contractor. The Chevy could be freed of its welded hood forever.

*Peter Baston is CEO and Senior Partner at IDEAS Business Technology Integration, a Boulder, CO consulting firm that shows companies how to **really** use technology. He has over 30 years experience in the design, construction and maintenance of power plants on three continents. You can reach him at pete@ideapete.com and read more of his articles at www.ideapete.com.*

[3] Parametric models are dynamic multi-dimensional virtual surrogates of structures and their operations in their environment. The model incorporates the relationships between the workflow, the structure and its environment so that any alteration to one aspect of the model is reflected in all related aspects.