American Glovebox Society
ENCLOSURE
Summer 2020

Unique Challenges of Glovebox Fabrication:
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American Glovebox Society ENCLOSURE

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President's Message

By: Gary Partington

I am honored to serve as this year's AGS President. After a successful Conference in Boston, the AGS Board of Directors hit the ground running and enthusiastically started planning the 2020 Conference. Then, the unforeseeable occurred. With the COVID-19 pandemic, and the ensuing shelter in place orders, the last few months have changed both our personal and professional lives. As information shifts daily, we are all adjusting the way in which we do business.

After careful deliberation, the AGS Board of Directors made the difficult decision to cancel the July 2020 Conference. While we are disappointed that we will not have the opportunity to meet this year, the health and safety of our membership is paramount. We were able to reschedule our Nashville Conference for July 12-15, 2021 and we are excited that we will still get to experience the great City of Nashville. More details about the 2021 Conference will be released later this year.

The AGS Board of Directors will be meeting in the coming weeks and will discuss ways in which we can provide other opportunities to our members in lieu of this year's Conference. We will strive to provide educational and networking opportunities for our speakers, vendors, and members.

Additionally, we will continue our outreach to students and to other similar communities in an effort share knowledge and to grow our membership by promoting and advancing the science of glovebox and containment technology. We believe that gloveboxes serve an important function for many applications and the knowledge gained as a Society and industry over the years needs to be disseminated to the next generation of glovebox operators and designers.

The Society will also continue to publish guidelines and standards to use as references for a wide array of glovebox-related topics. New guidelines and standards are being produced constantly and your input is welcomed.

I would like to thank Tony Heinz our Past President for his leadership and to the entire Board of Directors, and to Dorothy and Crissy for their commitment to the Society and the membership.

While things continue to change, the AGS mission remains the same. AGS promotes safety and quality of glovebox systems; promotes communication; and disseminates knowledge in the field of glovebox technology. We will continue to meet these goals and support our membership. Soon, we will be together again, and in the meantime, stay healthy and safe.

Gary Partington ❖

The Enclosure

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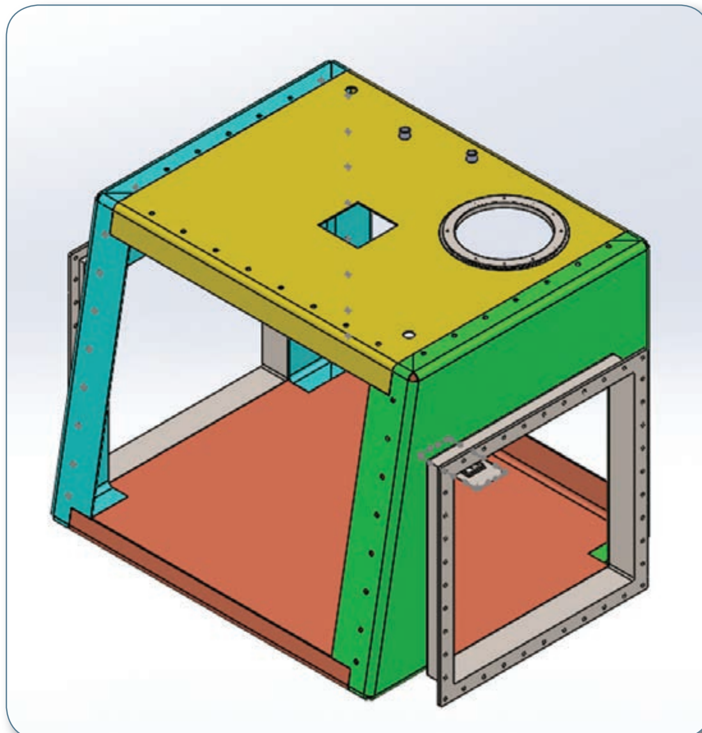
Unique Challenges of Glovebox Fabrication: How Manufacturing Evolves with Design

By: Natalie Morvay

Radiation was the theme for the 2019 AGS Conference in Boston and presentations covered topics ranging from design for internal equipment, processes and radiation shielding, to ergonomics for glovebox operators. Many factors such as these are taken into consideration when designing a glovebox shell. The resulting glovebox designs directly impact fabricators' abilities to manufacture them, conform to the requirements, and meet cost and schedule requirements. As a result of the multiple attributes that need to be considered, glovebox shells may have unique challenges that fabricators strive to overcome and this paper will dive into several of those difficulties and some possible solutions.

The most common struggle when fabricating glovebox shells is large sealing surfaces. It becomes more difficult to maintain flatness tolerances as openings in glovebox shells become larger. When window openings are larger, more material and more structure is removed from the shell itself, making it difficult to maintain an adequately flat surface. One way to prevent excessive distortion on large sealing surfaces is to design the mechanical layout such that large seam welds are not on or near sealing surfaces. Heat input generated during welding causes the material to pull in the direction of the seam; so, when planning a shell layout, it is best to avoid long shell seam welds near sealing surfaces where it will cause the material to pull or shrink excessively. One example of a shell layout with large openings relative to the shell size is shown in a side by side comparison of the production parts and solid model.

Production Shell Weldment



Solid Model of Shell Layout

In this case, longer seams run along top and bottom on the sides where large window openings are not present. Seams near the openings are less that 3 inches of weld and supported during welding to prevent distortion.

Another common struggle for fabricators is related to material selection. Where some projects use 3/16 in. thick material, others require different levels of radiation shielding, which can mean a non-cladded glovebox shell up to 5/8 inch thick. As thicker material is required, greater press break tonnage is required. For a quick comparison, a 3/16-inch shell requires ~ 17 tons per foot whereas a 5/8-inch shell requires ~ 65 tons per foot. That's almost 4 times the amount of force required. The major limitation related to this challenge is equipment and having the capacity to form thicker plate.

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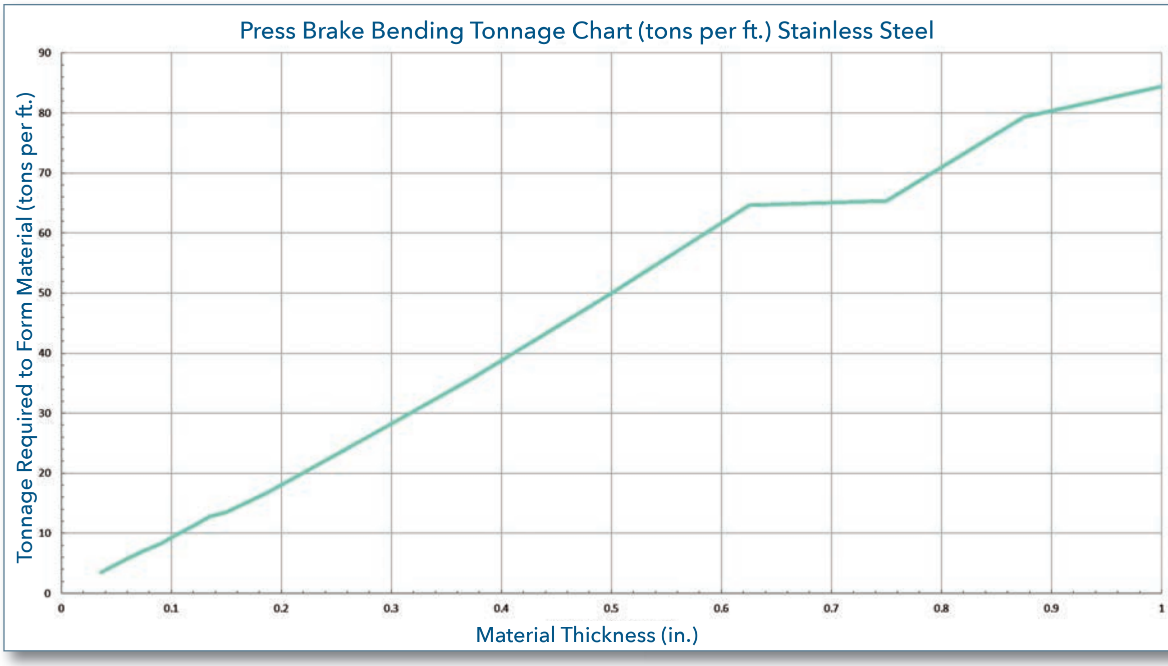

Material Thickness and Press Break Tonnage Chart

One way to combat this challenge is to add relief cuts when making the mechanical layout for the shell. As there is less material, there is less force required to form plate. Although helpful, there are other drawbacks to this. When removing large pieces of the shell in order to form the parts, they have to be replaced and welded back in at a later time.

Corners in a 5/8-inch thick shell is the most complex part to form into shape. Not only is it difficult to properly form the pieces, but it is difficult to make the sides of them come together and line up for welders to have an even fit up. One way to prevent issues in the corners is to machine them out of raw billet and then weld those into the glovebox shell.

A major benefit to this alternative fabrication technique is that there is less welding required in the corners and fabricators do not have to manipulate the shell to properly fit up.

Assembling and sealing one glovebox shell is an accomplishment, but to assemble multiple boxes together and seal as a lineup is an entire challenge of its own. In order to achieve this, it is important to ensure the mating flanges are flat and perpendicular to the shells they are welded to. Meeting tight tolerances on flatness and perpendicularity with conventional welding techniques can be done, however, it is difficult. One way to ensure flatness and perpendicularity is the

Examples of Relief Cuts from a 5/8-inch Thick Shell

Relief Cut Fill Piece Fit Up Example (Above)
Machined Corner Example (Right)

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Glove Integrity Testing or leak testing, how often should it be done?

Glove leak testing to monitor the integrity of glovebox & isolator gloves is often only done periodically. This practice is normally based on the thought that it takes too long. Years ago with old rudimentary leak test devices taking up a lot of space and only allowing very few gloves to be tested at one time, leak testing all gloves on a line use to take hours.

A specialty company by the name of MK Metalfree Corp. has changed the way glove leak testing is performed and made it possible to test all gloves on even large lines in less than 30 minutes in a cost effective manner. All test data and results are electronically recorded with no required operator intervention all backed with a full 21CFR Part 11 compliant audit trail.

MK provides the most comprehensive Glove Integrity Testing Systems made. All specific industry standards and customer requirements are implemented and validated. Proven glove recipes are provided. IQ, OQ, and PQ implementation is available to ensure the validity of the test results, ensuring customer and regulator satisfaction.

Photo: MK Versuchsanlagen

Let MK help your organization improve its glove safety to minimize the risk for your operators and products. Since a glove breach can either contaminate an operator or a product batch, which, in turn could shut down your operations; Mitigate that risk by choosing MK Metalfree Inc. as your quality partner to track and maintain your glovebox and isolator glove integrity.

Unique Challenges of Glovebox Fabrication: How Manufacturing Evolves with Design

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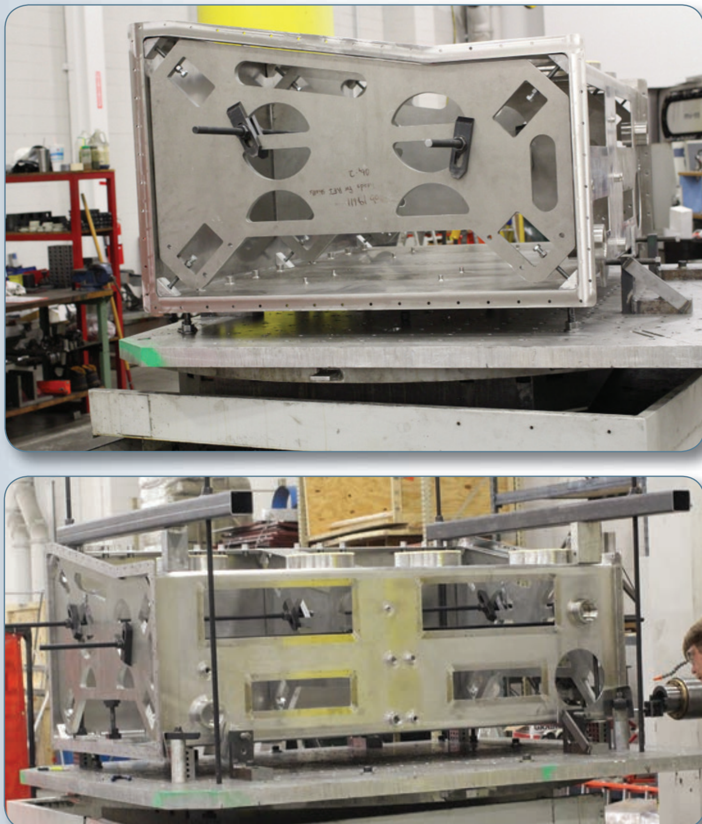
use of post-weld machining. Fabricators can weld thicker flanges onto the end of glovebox shells and then machine flat, parallel to the other side, and perpendicular to the bottom or top.



Glovebox Shell Being Post-Weld Machined

This technique does not negate the fact that flanges have to be welded on to shells reasonably flat and perpendicular. Only so much material can be removed to meet the requirements and maintain minimum thickness requirements.

Another suitable way to maintain flatness on end flanges for enclosures is stiffening structures. This can be achieved with a bolt on stiffener design or one that is incorporated into design and welded to the shell. These structures are most helpful when it comes to shells with large panels.

There is a tendency for large wall panels to bubble. Long seam weld lengths and the weight of the material causes it to bubble. Stiffeners provide a structure suitable to maintain shape while maintaining containment; thus, making large lineup sealing achievable.

A persistent challenge in glovebox fabrication is excessive distortion as a result of containment boundary welds. In order to get a containment quality weld, there must be complete joint penetration, which means the weld melts through from one side of the base material to the other side. If not well-planned, excessive distortion can ruin an enclosure and make it irreparable for sealing.

Example of Welded-On Stiffener Structure

One way to prevent excessive distortion during welding is to design the mechanical layout so there are no long shell seams. Sometimes it is unavoidable due to size and material availability, but it is important to lay out a glovebox shell as symmetrically as possible and with as short of seams as possible. In order to evenly distribute shrinking during welding, it is important to make the shell layout such that the sides and ends have as much symmetry as practical and as few seams as allowable. If there is a concentration of heat in one section of the shell, the material will pull that direction and create a parallelogram rather than a square box.

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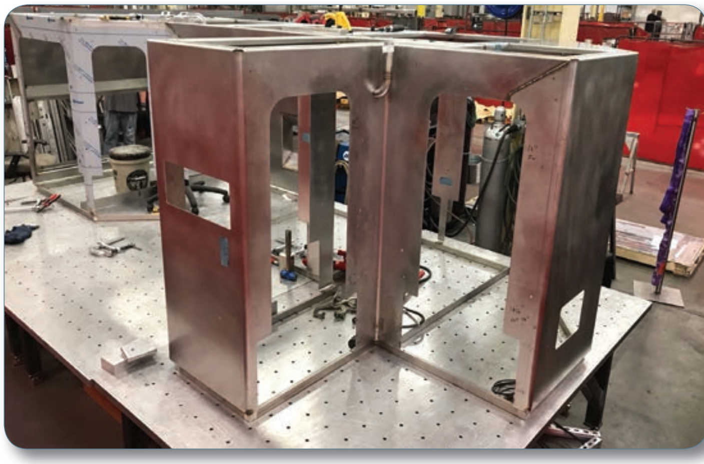
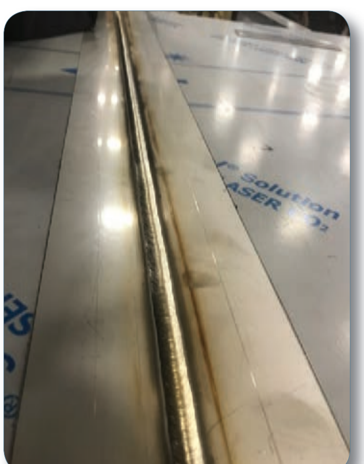
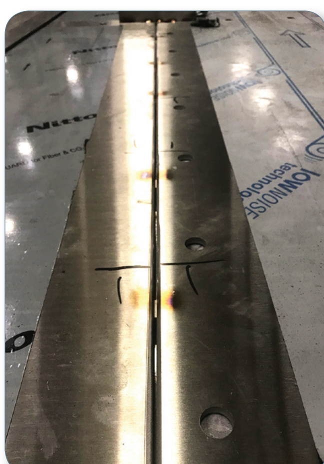


Glovebox Shell with Minimal Shell Seams (Includes previous Image)

The example provided is an enclosure shell with unique flat patterns and minimal weld seams. As shown, the corners have 45-degree seams. This slight change can take a total weld length from 12 inches down to 8.5 inches. For complex weldments, small adjustments to flat patterns can make a significant difference.

Fabricators typically use aluminum barring during welding to prevent shrinkage. There have been recent developments in welding equipment that make a significant difference in heat applied to a full penetration weld. Heat Input is the energy put into the part during welding; it is calculated using travel speed, voltage, and amperage. New equipment being developed such as TIP TIG has provided a way to achieve full penetration welds in a fraction of the time.



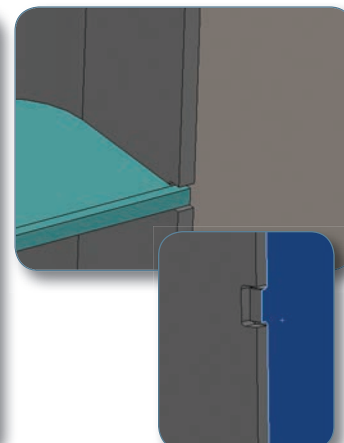


TIP TIG Equipment Set Up (Includes next image)

TIP TIG is different from typical manual TIG welding because it is a hot wire process whereas manual TIG welding is not. In manual TIG welding, filler metal is maintained at room temperature and energy from the arc is used to melt both the base metal and weld wire. This slows down the process and creates a greater probability of defects in the weld. TIP TIG equipment sends a hotwire current to the filler metal, preventing the weld bead from cooling upon deposit and putting up to 40% of the energy in through the filler. This provides a quality weld and minimizes chance of lack of fusion.

On certain weld seams, full penetration can be achieved in a single pass.

For other enclosure applications that do not require the full penetration welding for containment purposes, other weld fit up designs are effective in preventing excessive distortion. Slot and tab weld design has become increasingly common. With precision cutting equipment available, fabricators are able to take advantage of tight-fitting parts to weld.



Left: Image of Glovebox Shell with Slots Cut, Middle and Right: Solidworks Image of Slot and Tab Fit Up

The example provided is a pharmaceutical enclosure that is not required to maintain containment, but to hold pressure. The slot and tab design on this shell provides tight fit up for fabricators. This is beneficial for a couple reasons, one, it provides a guide for fabricators during fit up. Two, it maintains a tight fit so when welding proceeds, the parts hold each other in place. This is not commonly used on gloveboxes, but has been effective for pharmaceutical applications that do not require radiation shielding.

The final challenge this article addresses is fabricating large, complex weldments. These are weldments that cannot be welded as a single shell; but more, an assembly of shell weldments to produce one containment boundary. Walk in enclosures are a good example of these. These can be assembled with bolted and gasketed surfaces or field-welded. The greatest challenge with these assemblies is welding and machining flanges in a way that they will come together with the other shell weldments and line up properly to assemble and seal.

Left: Two-Story Weldment Assembly Right: Mating Flanges

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To prevent mate up issues, fabricators can do post weld match-marking and machining of holes. This is a time-consuming, challenging process, but it is the best way to ensure proper assembly and provides the best chance for leak prevention.

Enclosure designs evolve as applications and processes change and along with that, fabrication techniques also change. These are some of the most current, consistent fabrication challenges in enclosure building, along with various solutions. Although the list can be continuous, the most critical aspects of an enclosure remain to be containment and sealing. There are various ways to achieve these, but it can require a combination of fabrication techniques in order to be successful. ❖

Thoughts from Newman

By: John T. Newman, P.E.

The Insurmountable Design Problem

Life is filled with problems. We all have them, big and small, some are easy to solve, but then some are not so easy. Some can be insurmountable, or seem so. You know, like how to design a toilet to properly flush with only 1.6 gallons of water or a coffee carafe that can pour without dribbling all over the counter. Then there are all the classics, like the perpetual motion machine, anti-gravity machine, or time travel. All of which, I believe, may eventually be solved, well except maybe the toilet one.

I have spent most of my life in the quest for solutions of insurmountable problems. I am referring specifically to machine design problems, not life or money problems, all of which I am generally clueless. Being a design engineer, responsible for creating custom equipment for things that have "never been done before", I have learned that somehow there is always a way to solve the problem. "If there is a will, there is a way", as I always say. Although our capitalistic society does put some restraint on this problem-solving capability, so I can add to the metaphor, "Every problem has a solution, it's just a matter of time and money". There is nothing more stressful than trying to force creativity on a schedule and budget. Especially when the table beaters get into the picture, the people with the checkbook, who only care about when and how much.

One ridiculous idea combined with another stupid one can make an elegant solution.

I love it when I get handed a specification for my next design project and it has a bunch of blank spots or boxes with labels stating magic happens here. Oh, and it was also awarded at the lowest price and the best delivery possible. But then of course, my job performance is rated on how well the said project does, budget and schedule, for the company to make a profit and survive as a sustainable business. No pressure there, just get'r done, right?

OK, so what now? This is the crucial decision point, is it time to run for the hills? Admitting defeat before you start is not exactly the most honorable thing to do. I, like most people, have a family that depends on my steady paycheck, so running for the hills is really never an option. First thing, don't panic, and remember, if there is a will there is a way. Just keep repeating that for a while. Then smile, pretend like you know what you are doing and tell your boss "don't worry, everything will be fine".

I have a system that I use for starting a design project that will nurture the creative process. Creativity exists in all of us, and it's this ability to create something new, something that has never been done before, that separates us from the animals. For some people, this creative ability runs stronger than others, but I truly believe that we all have it, it's just a matter of knowing how to use it. Here is how it goes:

The first step is to input or load all of the project information into your brain. This means to read all of the specifications and project data, multiple times, and get it all into your head. It's ok to fall asleep over it, drool on it, but importantly, don't worry about the problem solutions just yet. Just get everything input. Also, this is a good time to write down any questions or concerns that you have and send them to the customer for them to answer. This will help you understand where all of the problems will be. Then go do something else. Work on another project, do anything, just don't work on the one you just input. This allows things to bake, like in the oven, only it's your subconscious mind doing the baking. For those who don't know, the subconscious is by far the most powerful processor in the human brain, and it will work on solving problems without you even knowing about it. Good sleep, especially REM sleep, will help the brain work as well, and is very important for the creative process.

After a few days it's now time to get going on the design. Hopefully the customer has provided feedback to your questions and things are now getting a little clearer on how to proceed.

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The design process starts off like walking around in a room full of fog and you keep running into things as you walk around. As the project proceeds, the fog eventually starts to clear and you can now see things clearly and walk around without running into things. Now is the time to start translating all of the written requirements into hard design concepts. Remember all of those math word problems in school? Same thing here. Read the specifications again, but this time write down and/or sketch out the ideas that come to mind during this process. Look for the known and easy things and try to separate the problems or issues that don't have the obvious solutions that will need work to solve.

Sometimes it can help to start with a similar past project as a base to build on. It doesn't always work, but it can really save some time over completely starting from scratch. Try to layout the overall machine concept with all of the knowns or things that you know will work. This will help you get going and help you not to dwell too long trying to think through everything. Sometimes it is easy to slip into the "try to solve it all in your head syndrome". This can be difficult and will cause you to dwell for days without making any real progress on the project. The trick is to "just start" with what you know and begin building the design. Lay out, or draw the things you do know and this will help you to visualize the design and get the ideas flowing. Just be careful not to "paint yourself into a corner" and leave room in your design to allow for the unknowns in the problem areas.

As the layout process progresses, try to locate the problem areas that you don't have solutions. The so-called insurmountable problems are starting to appear. Remember all the "magic happens here" things? This is when the progress can slow down, and it can get awkward waiting for the solutions to pop out of the subconscious. Management doesn't really understand why things are taking so long and the pressure can begin to build. You start thinking that maybe running for the hills really was the better option.

The creative process is kind of an unpredictable thing. The subconscious mind is very powerful but it is not very controllable. Ideas always seem to come at odd times, like when you are in the shower, driving down the freeway, lying in bed sleeping / dreaming, or doing other things besides working on the design. One time, I literally fixed my stereo receiver in a dream. I had taken it apart one day to look at it and saw nothing wrong. About a week or so later, in a dream I visualized a small microchip that had a hole blown in the top of it. I woke up and immediately took apart my stereo and there it was, plain as day, the blown microchip. I figure that I had seen it the first time, but it took my subconscious mind to recognize it and present it to me in a dream. Just tell your boss you are waiting for a dream to happen, and surly he/she will understand, right?

There are things that you can do to help speed up the process. It helps to clearly define what the actual problem is that you are trying to solve, and then the solution sometimes becomes easy. Bounce ideas off someone and talk it through with a coworker. Just the process of explaining it to someone else can inspire a solution. Brain storming is another very useful tool. Get together a group of people and present the problem to them and ask for ideas. People will start randomly tossing out ideas, some will seem stupid, but don't discount anything. Many times, what seems stupid at first can evolve into a viable solution. One ridiculous idea combined with another stupid one can make an elegant solution. When you get stuck on a problem, "sleep on it". I find that after a long day of working on a design, I get wishy washy and can't decide on what to do for a problem. It's time to give it up for the day, go home and get some sleep. When you come in the next day, the answer you were dwelling on will be crystal clear.

I have basic criteria that I generally use for my designs. Besides creating a working design, it has to have symmetry, be elegant, and be as simple as possible. Most importantly, the simple solution is always the best. I like to follow the principles of Occam's Razor, which can be summarized as follows: "Among competing hypotheses, the one with the fewest assumptions should be selected." In other words, it basically states to strive for the simple solution for the problem. I learned it before I even heard of this Occam fellow, as the KISS theory, "Keep It Simple Stupid". In machine design, the simpler it is, the easier it can be manufactured, has a higher possibility of actually working, and overall is way superior than something complicated. Every complex machine is really just a combination of simple machines, (i.e. ,lever, screw, pulley.) But you got to love it when the boss always say's, that's so simple, why did it take so long? They never understand that sometimes it takes a lot of work to arrive at the simplest solutions.

These days, solutions can be inspired from the internet. Just start searching with a good internet search engine and look for things that can inspire a good idea. Try different wordings, as sometimes it takes a few tries to arrive at the proper terminology to get the desired results. I like to click the images button to get all the pictures from my search results. This helps you to zero in on something viable for the application. I also have an excellent book "MECHANISMS AND MECHANICAL DEVICES SOURCEBOOK" that I regularly consult when looking for design ideas.

Don't get frustrated and stuck in the "Can't Be Done Syndrome". Don't you just hate those people who always default to that answer? Turn it around and think positively, "how can I do this". Think of ways that it can be done, not

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Thoughts from Newman

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the reason that it can't. Look outside of the box, and try to think of things around the problem that can have the possibility of making the problem no longer a problem. The sky is the limit here and you can make that part any way that you want. Every problem has a solution, sometimes it is just not readily apparent. Perhaps the way to solve it is to change the requirement, or use an administrative solution. Here's an idea, get the customer to change the specification to something more workable that will still accomplish the same end result.

Have you ever heard of being "out on a limb"? Science and/or machine design is kind of like climbing a tree. As you climb up the tree, it is possible to unknowingly go out on a limb, preventing you from making it to the top of the tree. You will have to go back to the tree trunk, before you can ultimately make it to the top. In design, it means that you have gone far out the wrong way and need to go back to the beginning to look for a better path forward. Be aware of this principle, and realize that sometimes you may have to go back and start over in a new direction.

A custom design project always starts out with big ambitions. Sometimes people write these specifications with delusions of grandeur, which don't have any grasp of reality, or follow the general laws of physics. I love how someone will write a specification for a new machine or process for something that has never been done before, award it to the lowest bidder with the shortest schedule, and then at the end expect the machine to run like a finely tuned race car that has been through years of development and prototyping. Usually every custom design project always comes down to a compromise at the end, and some concessions must be given to the specification or else the project will never be completed.

You never know if or when the "eureka" moment will hit, but with a little perseverance, all of the problems will eventually get solved in some way or another and the project will get completed. It is truly amazing what can be accomplished when you are backed into a corner. But, be prepared, the problem-solving requirements will continue well past the design, through the construction and into the factory test. Here is when I like to say, "It separates the men from the boys". It's the end of the project, you have a machine that doesn't work, the customer is scheduled in a week for the factory test, and you have to figure out how to make the machine function, without rebuilding any major pieces or starting over. No pressure there! But you know, everything always seems to get worked out somehow. Although it never fails, all of the really good ideas come out, when you are looking at the finished piece of equipment. You know though, someday, just for fun, I am going to "Run for the hills". ❖

LESSONS LEARNED

By: Justin Dexter
Lessons Learned Committee Member

As I was talking to all of you at the end of last year's AGS conference in Boston, I realized that I had been in the glovebox industry twenty-five years! It was kind of a shock to realize that so much time has passed. As my father always told me "It seems like you blink and another year goes by". Many members of the AGS have been around a lot longer than me, and they are approaching retirement, or have already retired. It is always a happy and sad moment, when your friends retire. You are extremely happy for their next journey in life, but sad that they won't be around at another Conference or a Standards Development Committee meeting. The challenge is trying to get as much knowledge, stories, glovebox related experiences, and other information that comes with being in the industry for decades and disseminate it to others.

I have been very fortunate in my glovebox career to be surrounded by some amazing individuals in both the engineering and the manufacturing industries. I have learned many lessons in design and many more on the shop floor. I'll never forget my first drawing package I released to manufacturing back in '95. The lead mechanic and journeyman, just looked at me and shook his head, asking me "How do you plan to fabricate this piece of equipment?" Apparently, I didn't understand the basic function of a press brake. I learned from this and never made the mistake again.

We need to focus on Knowledge Capture and Knowledge Transfer from these savvy veterans to the younger generations. At the annual conference next year in Nashville, the Lessons Learned Committee will be discussing this topic and possibly have a breakout session to brainstorm knowledge transfer within the AGS and throughout the industry. I have a feeling we will be talking about this for years to come. If you would like to be a part of the Lessons Learned Committee, please contact the AGS office.

Please share any lessons learned, general knowledge, or best practices with the AGS and OPEXShare. By sharing your experiences, you could help others who might be struggling with a similar challenge.

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