

Key Learnings from Opening a New Coil Shop

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Introduction

The Hydro industry is one in which quality and reliability comes from technical experience.

Our industry is conservative by necessity and machines are expected to be extremely long lasting and reliable. This is particularly true of stator insulation. Our industry has evolved to the point where stator bars and coils are less designed, to simply give long life, but rather to designed to meet rigorous tests. All improvements have to be made by referencing to systems that have given long lives.

These aspects are important to keep in mind, particularly when setting up to produce in a new shop in a new location. Over the past three years Andritz Hydro has established a new high voltage winding shop based on known stator coil and bar technology, and today we would like to share some of the important things we have learned.

Discussion

Within Andritz we have had long experience making resin rich stator coils and bars.

Traditionally, we have made press cured coils in our past factory in Canada, Autoclave cured bars in our second factory in Canada, press cured stator bars and coils in multiple locations.

Within the last three years Andritz had decided that re-establishing the coil capabilities and consolidating the bar capabilities close to engineering in Peterborough would help us serve our North American customers better.

Overall, we built a modern insulation factory with good, modern equipment. We then commissioned our equipment and had successfully performed internal and external qualification testing to the most rigorous of standards in our industry.

We demonstrated fully that we could comply with all modern insulation requirements!

Over the course of doing this work we re-validated, what we likely already knew.

Key learning #1: Making quality insulation products for the industry is almost an “art form”. There is the technology and the knowhow, but the real quality lies in the low level details!

Some areas of importance;

- How taping layers are started and stopped
- How strands lay when spreading coils and bars
- Getting transposition correct and well insulated (both coils and bars)
- Getting the correct and repeatable shape
- Keeping the coil and bar accurately located in space when manufacturing
- Achieving correct mica tape input and tape tension
- Grading length accuracy, overlap distances and layering

While occasionally we struggle with most of these things, as I presume other manufacturers

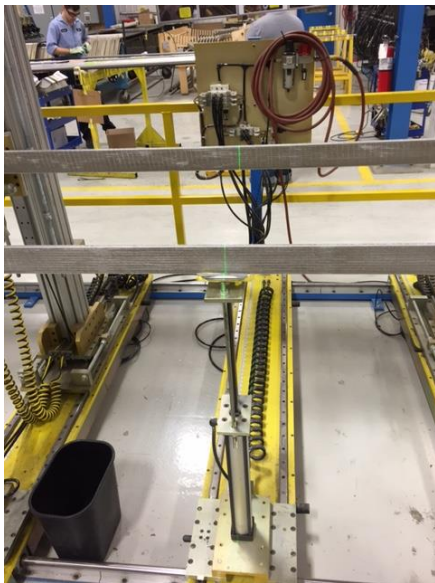
do also, the learning is that there is one of these issues that potentially can cause many related issues. Shape control and consistency, trumps all other details!

Shape, is as important to manufacturing coils as it is to making a good winding.

For the Andritz Peterborough process, the centerline between the two first bends is our reference for manufacturing. The accuracy of this centerline is extremely important to achieve a perfect result. Within the processing there can be two main causes of in-accuracy;

1. Actual shape variation of the part
2. Need to transfer centerline marks between stations due to overtaping.

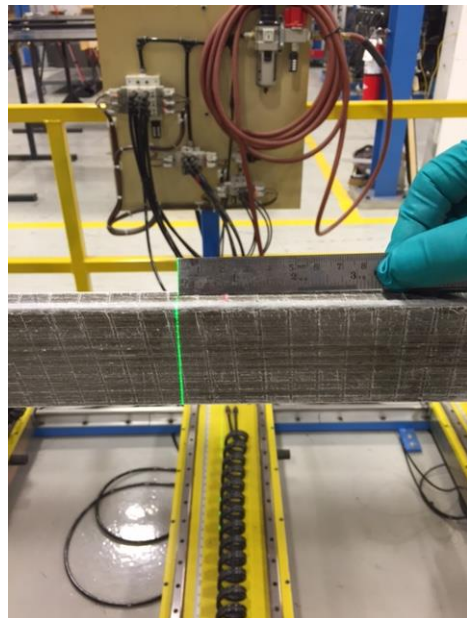
While this sounds like a simple thing to do, in practice it is harder than it sounds. The centerline of importance is precise center of each leg between the first two bends.



Coil set-up at tapping by Centerline

The first place where centerline accuracy is important is at ground wall taping. On the taping machine centerline is used for locating coils and bars in the machine. From the first coils or bars a program is made based on the exact geometry of the product and this program is therefore repeated for each piece.

If the shape varies, the quality of the tape lay, starts to decrease at the bend area. To ensure quality of taping and pressing, a tight tolerance must be achieved. Any deviation beyond this starts to cause taping issues in the bend that can have a detrimental effect on accelerated life testing.



Coil with centerline offset



Tape stressed due to offset centerline

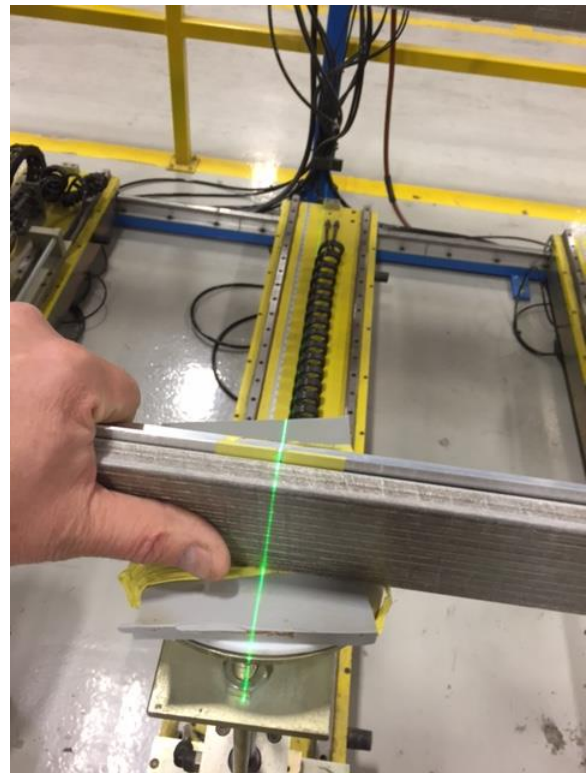
A similar tight tolerance is required in the pressing area. Deviations in axial position can result in mis-matched fit between the actual product and the press tooling in the bend area. This, if mis-positioned enough, can result in significant voids due to lack of compression in the other bend areas.



Lack of bend compression and pinch in tape due to mis-match between bar and tooling

This learning has taught us that spending time in set up, is most important, as the tooling and operators on all shifts must be able to closely replicate the shape for each coil and bar.

Improved methods of centerline marking and re-marking, such as dummy gauges or gauges applied during taping have been implemented to ensure consistency of initial centerline marking and later transfers, have made significant quality improvements.



Coil centered on machine with centerline gauge



Bar with excellent fit to tooling in press

Key learning #2: For a new shop, in a new location, the loading ramp-up should be planned and carefully controlled. While we have had experience in setting up new locations before, there was difference when this shop was set up. All the people working in the shop were new. While we had knowledgeable leadership in the shop, at the beginning the inexperience in shop labour was compensated by the leadership being able to closely watch and guide all the workers daily. The number of workers at the beginning was about 15 with two experienced managers, engineers. This ratio worked well.

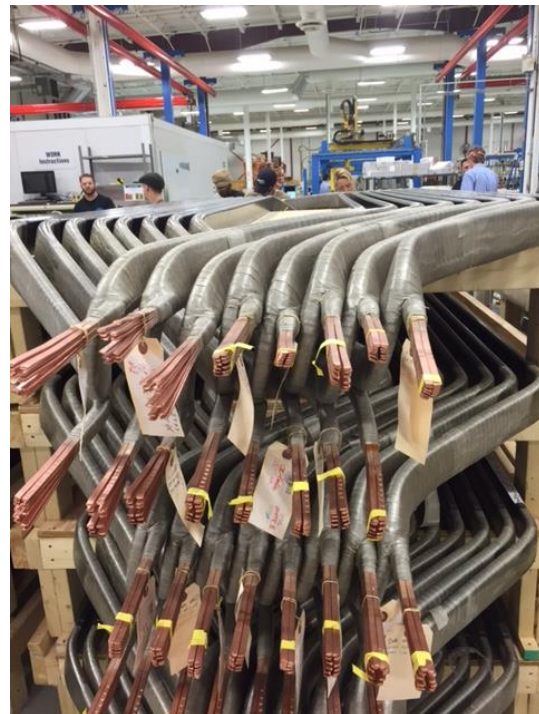
Within a one year period we were very successful in the market place and work ramped up too quickly. Over a 5 month period the

number of workers quadrupled, but there were no extra experienced supervisors.

In a manufacturing environment where the details are most important this overall situation leads to issues and rework.

The problems seen as a result were mostly things that could be reworked, but the extra work, and replacement coils and bars needed to fulfil contracts put extreme pressure on delivery dates.

This is where, working with a company such as Andritz, that has depth, has huge advantages! Once the issues were well identified, support was provided. Technical experts from our Weiz factory and management provided more technical expertise. Quality team members, helped with training, and provide extra hands to watch the operations.



Shape issues based on new workers and lack of detailed oversight



Coil and Bar shape improved, with workers properly trained and supervised.

Overall it is clear that this kind of support is uniquely available in larger companies that would not be the case for smaller suppliers.

Key Learning #3: While having issues in the shop causes problems for customers and for Andritz. Turning away work also causes issues for the industry. A second advantage of larger companies is that usually it is possible for every order to develop a secondary manufacturing plan (Plan B). It is clear from experience that for every supplier, sometimes things don't go per plan. Issues arise, causing scheduling problems, such as;

- supply of raw materials
- A potential quality issue such as failing to meet a test.
- Equipment failure.
- Schedule variations.

- Needing to fit a customer's work in that has had an emergency breakdown.

We clearly do our best to not let customers down, so having alternate plans for manufacturing clearly can relieve schedule pain, for both the customer and for Andritz. It is clear that schedule should never come ahead of quality! Short cuts to schedule may fly in the face of attention to all the details.

Andritz has done significant work to initiate harmonization among locations and designs allowing manufacturing to be more portable even though it may mean manufacturing a job that was intended to be made with resin rich technology with VPI and vice-versa. Also, Andritz Hydro has alternate internal coil suppliers such as our Brazil factory, if needed.



Stator Bar provided for North American customer by Austrian Bar Shop



Coils for a North American customer supplied
by Andritz Hydro Brazil

Conclusions

The experience that customers want when dealing with suppliers is gained by doing and learning. Setting up a new shop is something that has provided Andritz people with more experience, due to learning. Sometimes the hard way...

We have gone through growing pains and improved significantly as a result of the key learnings about manufacturing insulation.

1. By paying particular attention to the details in manufacturing.
2. By managing a ramp up.
3. By leveraging the greater Andritz resources and working closely with other Andritz manufacturing facilities in order to help serve our customers.

Ultimately the advantages to the user of dealing with suppliers with significant resources is that these learnings can happen and the resources needed to solve issues are somewhere within the organization, so that ultimately even if issues arise they can be solved.