

## Welds, roll bonds and explosions: Clad plates in brief

Clad materials are commonly used in many industries as they combine the corrosion resistance of one metal with a strong yet inexpensive base metal. A variety of production techniques are available and each has its own merits. For a better understanding of the options, *Stainless Steel World Americas* spoke to Mr. Mike Blakely, Global Director Business Development at NobelClad.

Interview by David Sear



Mike Blakely is Global Director Business Development at NobelClad.



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**I understand there are three main ways to produce a clad plate material that can be formed into products like pipes, pressure vessels, heat exchangers, etc. What are they?**

The three main processes to produce clad are roll bonding, weld overlay and explosion welding.

**How do the production processes differ?**

Roll bonding is done by steel mills, where the metals are heated up to rolling temperatures and passed through a pair of rollers. As the metals are rolled together, the oxide layers are broken and bonding can occur. In the weld overlay process, fusion welding is used to deposit the top layer. Both the cladding and base metals are melted and in part mixed during this method of cladding. Many times, multiple passes are required to meet the chemistry requirements of the cladding layer. In the explosion welding process, two plates of material are welded together by an explosive force. The energy of the explosion driving the two metals together causes a weld to occur without significant melting or heat input.

**What are the relative merits of these processes?**

Roll bonding is performed by many steel mills around the globe. It is well accepted for applications where shear strength is less important and the heat of the rolling process won't damage the cladding metal. Many (but not all) of the world's flue gas desulfurization unit chimneys are produced from roll bond clad plate. Weld overlays are also simple to apply and regularly done by metal fabricators. Pressure vessel nozzles and manways are regularly clad with weld overlay. In some cases, weld overlay can clad tubesheets for heat exchangers or entire pressure vessels when forged ring construction is specified. Explosion

welding can be applied to a wider range of materials and across a greater thickness spectrum than either roll bond or weld overlay. In fact, it can clad materials like aluminium, titanium and other metals that are impossible with welding or rolling. Additionally, explosion welding does not affect the mechanical, electrical or corrosion properties of either layer. Explosion welding is used in refineries, chemical plants and other industries in pressure vessels and heat exchangers. It's interesting to note explosion welding also produces a number of different types of structural and electrical transition joints.

**Is it possible to identify the best technique?**

No. That depends on factors such as the application, materials required, materials availability, the requirements of the customer, cost considerations, etc. In some cases roll bonding is an inexpensive and fitting solution, usually when metals are very thin. However, roll bonding is less suited to plates which have to be subsequently formed into shape, such as for induction bends in piping systems or pressure vessel heads. I have heard anecdotal evidence of roll bonded plates having the clad layer disbond during the forming process. Weld overlay is highly flexible in terms of geometry. If you need to clad the id of a forged vessel connection, weld overlay may be the best or only way to do it effectively. Weld overlay is also widely used to restore the corrosion resistance between larger plates of roll bond or explosion welded clad in pressure vessel construction.

**What types of test or inspection procedures are available?**

Common testing performed on clad plates after production includes ultrasonic and some destructive mechanical testing. Ultrasonic testing can be used to identify





areas where there is no bond between the clad and base metal. These unbonded areas show up during testing much like a lamination in steel. Shear tests can demonstrate the integrity of the bond by measuring the amount of force required to shear a lug of clad off of a backing metal sample. Other types of testing for bond integrity or base metal property retention can be used to demonstrate certain aspects of the clad plate.

#### Is there a difference between explosion welded plates used for pressure vessels and say pipes?

In theory they are made the same way, but the alloys used may not be quite the same and the specifications can also differ. In both cases, bond integrity, available production volumes and size capabilities are key differentiators.

#### What pipe markets might be interesting for explosion clad products?

There are a number of traditional markets for roll bonded material where explosion clad products can compete well on price and delivery. Additionally, explosion clad products offer technological advantages for high pressure line pipes, where nickel based alloys such as 625 are often the material of choice given the process temperatures, pressures and sour conditions.

#### Speaking of pipes, can you help dispel the confusion caused by similar terms such as line pipe, lined pipe and clad line pipe?

Sure. Line pipe may be clad or not and is the term used in the upstream oil and gas industry to describe pipes which transport oil and gas from the field to storage or production facilities. Clad line pipe is a subset of the line pipe market where corrosion resistant alloys are required and cladding is selected. Do not confuse either of these with so-called lined pipe, which is pipe that has been fitted with an inner sleeve, or liner. This sleeve is normally used for corrosion resistance but there is no

actual metallurgical bond with the outer pipe. This means lined pipe, or indeed roll bonded pipe, is typically not suited for forming into bends or manifolds, etc.

#### Why is that a problem?

In many projects, items such as manifolds and induction bends are often the first items that need to be installed on the construction site, but in many cases are afterthoughts of the project team. So if you are producing a clad pipeline and need a manifold or induction bend with a corrosion-resistant inner surface, it's probably best to consider a production technique other than lining or roll bond for the clad plates to be made into those products.

#### Explosion welding sounds very dramatic. How is it possible to properly control the explosion?

Without control, the explosion welding process can be unreliable. But, if I use NobelClad as an example, we use an explosive which can be precisely and evenly spread out over the entire top surface of the clad layer. We also select the type and quantity of the explosive to exactly match the metals to be clad. On detonation, the detonation front moves from one side of the plate to the other, driving the plates together. The impact creates a metallurgical weld between the clad layer and the base layer which is typically stronger than the weaker of the two materials being clad.

#### Finally, I've heard that a gap is left between the base layer and the clad layer before the explosion. Why is that and how is it achieved?

Correct. The gap is required for technical reasons. The gap gives the cladding metal an opportunity to accelerate into the base metal. Without this relative velocity, cladding would be impossible. The dimension of the gap and the methods we use to make sure the gap is exactly within our specifications are proprietary, so I cannot reveal any more.

All photos: NobelClad

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