Hardbanding, as with most endeavours, has evolved over time. As few as 10 to 12 years ago, hardbandings comprised of tungsten carbide in a soft steel matrix were used extensively for tool joints, because many wellbores were shallow, straight and not cased. As deeper, deviated and cased wellbores became the norm, tungsten carbide was practically eliminated as a hardbanding alloy because it wore through the casings in a matter of minutes or hours. Chromium carbide and boron bearing alloys were substituted for the tungsten carbide, but those alloys contained numerous stress cracks that occurred during the hardbanding process and later proved to be disastrous downhole. They were also difficult to re-apply over themselves in the field, leading to porosity, and spalling. In many cases, these chromium carbide and boron alloy hardbandings have to be removed before re-application can take place, driving up re-application costs.

ROBERT F. MILLER, HARDBANDING SOLUTIONS, EXPLAINS HOW TO ACHIEVE OPTIMAL TOOL JOINT PROTECTION THROUGH HARDBANDING SELECTION.
costs by up to 400%. Today chromium carbide and boron bearing hardbanding alloys have been replaced by non-cracking alloys such as Tuffband® NC and Duraband® NC which rely on judicious control over the type and amount of carbides involved in the wear resistance of the hardbanding and casing.

Selecting the right hardbanding for today’s drill string needs is not the same as it was 10 years ago. Today’s wellsbores demand alloys that perform in a variety of hostile environments including highly abrasive formations, H₂S, deviated and horizontal directional holes, extended reach, and geothermal considerations. In addition, the hardbanding alloys must be ‘casing friendly’, which simply means that they should not unduly wear the casing, which precludes using any alloy containing tungsten carbide. But selecting the appropriate ‘casing friendly’ alloy is only part of the successful equation for maintaining tool joint integrity and longevity. Drilling conditions today are very demanding and drill pipe is being called upon to do more than ever before, such as: drilling faster, deeper, more deviated and even horizontal well bores. In its simplest form, hardbanding selection rests upon three main support legs:

- Alloy selection.
- Procedures and applicator field support.
- Innovation.

A weakness of any one of the three legs will only lead to costly mistakes, safety issues, downhole problems, downtime, and unproductive drilling operations. It is the intent of this article to present a sound, logical approach to selecting a hardbanding system that incorporates each of these three support legs.

**Alloy selection**

With a multitude of hardbanding products to choose from, narrowing the field appears to be a daunting and intimidating task but it does not have to be if a few rules are kept in mind:

- Choose a non-cracking hardbanding.
- Ensure that welding procedures are explicit, clearly described, up to date, available in multiple languages, cover all aspects of the hardbanding process, and are endorsed by a notable third party such as Fearnley Procter or T.H. Hill.
- When it is time for re-application, the identity of the hardbanding applied to the tool joints should be known.

If there is only one hardbanding alloy attribute that is absolutely required for sound tool joint integrity management it has to be ‘non-cracking.’ In the past, many alloys cracked because of their metallurgical structure and were the root of many downhole problems and re-application failures. Cracks are a haven for debris that interferes with the welding arc, which can often lead to excessive porosity, cracking, voids, spalling and poor weld appearance. While many hardbanding products on the market today publicise non-cracking attributes, Duraband NC and Tuffband NC guarantee them. When properly applied in accordance with the Hardbanding Solutions Hardbanding Manual, deposits are free of any cracks as determined by magnetic particle inspection (MPI) or visual inspection. This does not apply to re-applications over hardbandings that traditionally crack. If a previous worn hardband is cracked, many times the crack will re-appear in the re-application hardbanding. It may be rejected as a re-application candidate if the cracks are transverse to the drill pipe line centre line. If they are parallel to the drill pipe centre line, they may be determined as satisfactory if not too deep or wide. Subsequent re-applications with Tuffband NC or Duraband NC will generally not contain any cracks.

**Procedures**

While a specific hardband alloy may appear to be the perfect selection for an operator’s tool joints, it is almost useless without a good hardbanding procedure manual. The manual should cover all aspects of initial application and re-application procedures required. Invariably there will be issues with some re-applications, so the procedure manual should spell out the responsibilities of all parties involved and in addition, address the conditions for rejection and their ultimate final solutions.

In addition to the general hardbanding procedure manual, special procedures may be required for unusual hardbanding conditions, such as sour gas or troublesome, worn hardbandings from other providers. Hardbanding Solutions has developed a number of special procedures:

- Re-applications for eccentric wear.
- Re-applications over worn tungsten carbide hardbanding on the tool joint tapered section.
- Re-applications utilising a double layer hardbanding of Tuffband NC or Duraband NC.
- Re-application hardbanding for H₂S environments.
Hardbanding for Wear Knots™.

Re-application for low temperature inside diameters known as CoolBand™.

Initial and re-application of Ultraband NC for non-magnetic drill collars.

Initial and re-application of Duraband NC on completion tubing.

Too often, when ordering new pipe, tool joint hardbanding is unintentionally given little attention assuming that the re-application hardbands can be chosen later and without consequences. The reality is that a great deal of consideration should be given to the initial hardband application to minimise any problems in later re-applications. Re-applications are almost always more critical than initial applications because of the in-service wear and tear on the tool joint and potential incompatibility of various combinations of hardbanding types.

Support

There is nothing worse than purchasing a product or service, only to find that there is not sufficient and reliable technical support. To avoid this situation, Hardbanding Solutions organised and installed a worldwide entity called Hardbanding Solutions Technical Centers to address any problems that might arise. The Technical Centers are strategically located across the world’s time zones in regions where the oil and gas industry is active.

Each Technical Center is supported by product information, data sheets, product distribution, and technical articles, which are routinely updated. Not only are the centres a hub for information, they routinely supply field training, inspection services, and certifications for the application and re-application of products and procedures. In most cases these services are supplied cost-free to the applicator or pipe owner.

Innovation

The third leg in the desired vendor criteria is ‘innovation,’ which means R&D in response to the changing needs of the oilfield.

The Hardbanding Solutions technical staff members are working to find ways and means to improve upon existing products for welder appeal, wear resistance and operational qualities. But it goes much deeper than that. Here are a few examples:

- HB bag/wrap: Immediately after hardbanding, the weld deposit requires slow cooling from high welding temperatures. Various devices such as cans, glass wool, and thermal blankets have been used with varying degrees of success. Hardbanding Solutions designed and developed a stainless-lined thermal blanket that is lightweight, compact, durable, and is easily slipped over tool joints or heavy weight centre wear pads and fastened in place with Velcro straps.

- Hardband gauge: Various individual rulers, calipers, and gauges are used in the hardbanding and inspection process. The need for a single gauge that would provide most of the functions required was recognised and the Postle Hardband gauge was developed accordingly. The gauge can be used to measure specific welding parameters as well as finished dimensions of the hardbanding.

- Ultraband®: Non-magnetic drill collars are crucial to deviated drilling procedures. It was common practice to hardband these tubulars with 310 stainless steel. However, 310 stainless provides very little wear resistance, therefore Ultraband NC, a non-cracking hardbanding alloy for non-magnetic drill collar applications was developed. Ultraband NC is designed to outwear typical 310 stainless hardbanding, which had been used in the past, by a ratio of 4 to 1.

- Fatigue testing: In addition to introducing Ultraband NC, the company has been heavily engaged in fatigue testing of Duraband NC and Tuffband NC with surprising results. This is still an ongoing project and will be reported on later this year.

- CoolBand®: Field testing is now underway for a new hardbanding procedure that will reduce production costs and labour while enhancing the hardbanding and base material properties. Low preheats help ensure that the inside diameter of the tool joint is kept below 400 °F (204 °C). Water cooling of the tool joint while hardbanding is also an option to ensure a low temperature of the inside diameter beneath the hardbanding. Some applicators have chosen the CoolBand® procedure to protect the internal plastic coating in the tool joint while hardbanding.

- Corrosion testing: Corrosion studies of Duraband NC are being launched to aid those involved in sour gas and other operations in hostile environments.

Innovations and technical developments, such as those above, are vital to the drilling industry and to the overall knowledge and expertise in the field of hardbanding.

Summary

Choosing a hardbanding material is not about simply selecting an alloy to apply onto tool joints. It is about selecting well-engineered alloy(s), definitive and detailed procedures, a well-executed support team, and a progressive structured R&D programme.

Hardbandings should not be selected strictly by the alloy chemistry, but by the procedures used and the innovation that has been undertaken as well; the three legs of stability. Doing so will promote confidence and security that the drill pipe will receive the utmost in care for many years to come.

References

1. Fearnley Procter Group, Aberdeen, Scotland.
2. T.H. Hill, Houston, TX.
3. Wear Knot is a trademark of RDT, Beasley, TX.