The Use of Large and Heavy Walled Pipes for the Oil and Gas Industry

The selection of a wall thickness is never due to chance in the industry. During the design phase, the characteristics of the wall thickness must be carefully studied and determined to avoid any complications, avoiding unnecessary costs.

Why is it so important to determine wall thickness for pipelines?

Undersea pipelines are known to have wall thicknesses up to 75mm (2.953”). So why would you need that much steel for an oil and gas pipeline?

Figure 1 - Compound bevel made with a high speed beveling bench PROTEM BB3-16

Pipes are subjected to high mechanical, thermal and chemical temperatures or pressures, depending on the type of fluid they transport, especially at depths of over 2km (1.24 miles). The working conditions pipes are subjected to must be calculated by design engineers and have the result be in accordance with applicable codes.

If there are no codes or standards that specifically apply to the oil and gas production facilities, the design engineer may select one of the industry codes or standards as the basis of design. The design and operation for the gathering, transmission, and distribution pipeline systems are usually governed by codes, standards, and regulations. The design engineer must verify whether the particular country in which the project is located has regulations, codes, and standards that apply to facilities and/or pipelines.

Once the inner diameter (ID) of the piping segment has been determined, the pipe wall thickness must be calculated. There are many factors that affect the pipe wall thickness requirement, which include:

- The maximum and working pressures
- Maximum and working temperatures
- Chemical properties of the fluid
- The fluid velocity
- The pipe material and grade
- The safety factor or code design application

Wall thickness Pipe Formula

The basic formula for determining pipe wall thickness is the general hoop stress formula for thin wall cylinders, which is stated as:

$$t = \frac{Pd_o}{2(H_s + P)},$$

Where:
H_s= hoop stress in pipe wall, psi,
t= pipe wall thickness, in.,
L= length of pipe, ft,
P= internal pressure of the pipe, psi,
d_o= outside diameter of pipe, in.

As an example, an undersea gas pipeline will use pipes made from 39 millimeters (roughly 1.54 inches) of high-quality material with additional plastic coatings. The pressure would be considerable at 2km (1.24 miles) depths (on the order of 20 MPa or 200 atmospheres). The pipe would need to be thick enough to withstand these very high pressures.

We saw that the depth is an important issue to determine the wall thickness of tubes. Another parameter must be taken into account, the installation method. Different methods such as J-Lay, S-Lay, Reel Lay, may cause fatigue in the pipe sections. Correct wall thickness must be determined in consideration of consequences.

The material grade specified for pipes with wall thickness less than 30mm (1.181”) is usually X-60, or X-65 for high pressure pipelines or deep water applications. Higher grades can be selected in special cases. Lower grades such as X-42, X-52, or X-56 can be selected in shallow water or for low-pressure, large diameter pipelines to reduce material cost.

When wall thickness increases on the parts to be welded and exceeds 20mm (.787”), the quantity of weld metal that needs to be deposited in the weld bead also increases in similar proportions. For avoiding welding operations that are too long and too costly from a labor and consumables point of view, preparations for welding joints with thicknesses of over 20mm (.787”) are made using bevels that enable the total volume of the bevel to be reduced.

How to Bevel Heavy Walled Pipes?

When wall thicknesses increase on the parts to be welded, the quantity of weld metal that needs to be deposited in the weld bead also increases in similar proportions. For avoiding welding operations that are too long and too costly from a labor and consumables point of view, preparations for welding joints with thicknesses of over 20mm (.787”) are made using bevels that enable the total volume of the bevel to be reduced.

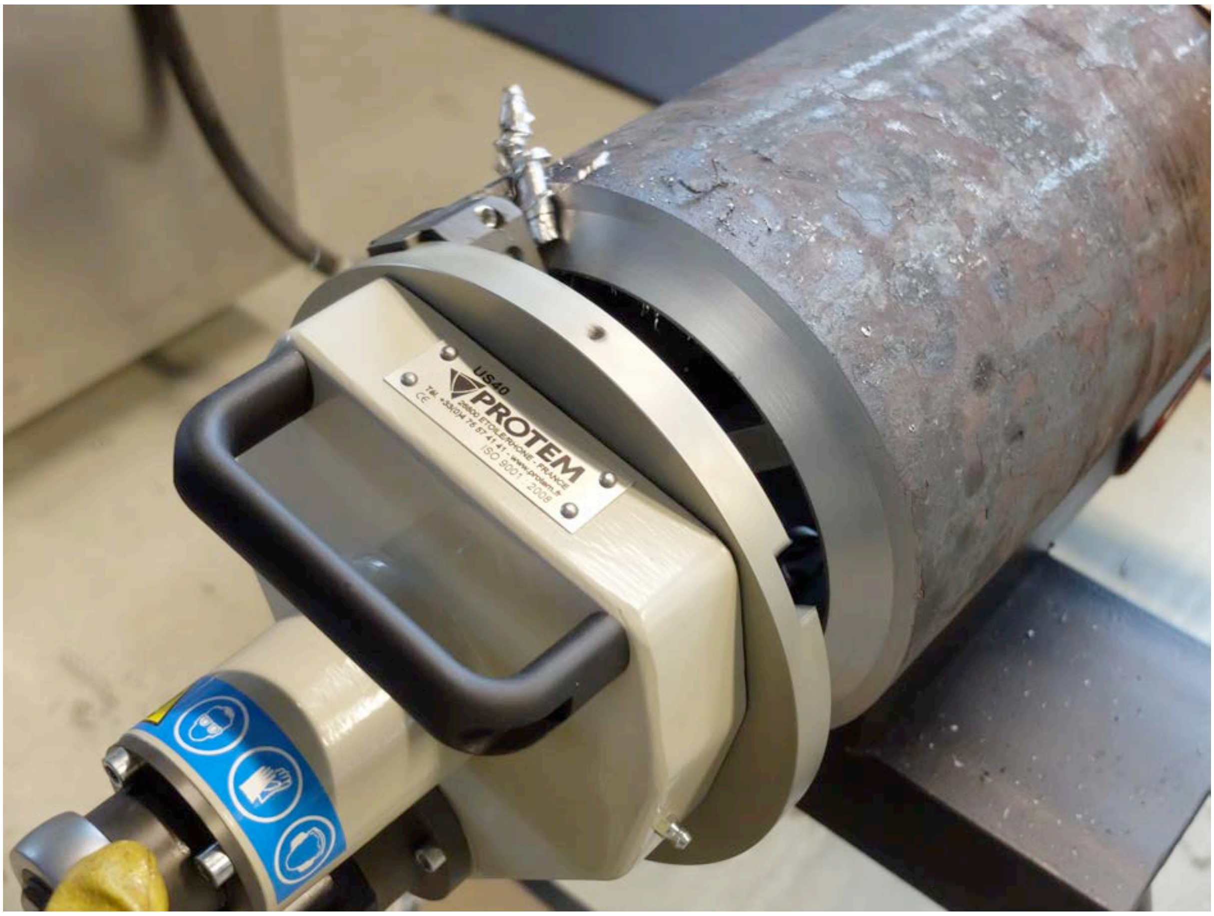

Figure 2 - Pipe Beveler with axial stroke PROTEM US40

1. Double Angle V Grooves (or Compound V Grooves):

The first solution for reducing the size of the bevel is to make a change in the groove angle. An initial angle of 30° or 37.5° (up to 45°) is combined with a second angle, generally between 5° and 15°. The first 30° or 37.5° angle must be kept to avoid the groove becoming too narrow and preventing the welder from making the root pass.

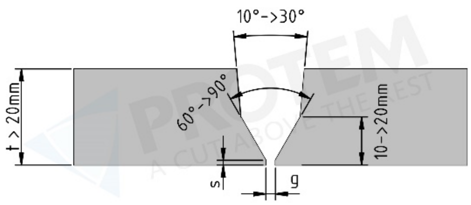

Figure 3 - Compound bevel, V shaped

Just like single V grooves, these preparations require a land from 0.5 mm to 1.5mm (.020 to .059”) wide and an opening between the parts (g) between 0.5 and 1mm (.020 and .039”). The hot pass for the land is usually done using the 141 process, and filling operations using the 13x or 111 processes.

For example, in comparison with a 30° single angle bevel (grey zone plus red zone), a V bevel with a double angle of 30°/5° (grey zone) gives an economy of about 20% in terms of weld metal for a part 20mm (.787”) thick.

Figure 4 - Material saving for a compound bevel on a wall thickness of 20 mm

The potential savings in terms of bevel volume increase in proportion to the wall thickness of the pipe to be welded. Consequently, savings will be over 35% on a 30 mm (1.181") thick pipe.

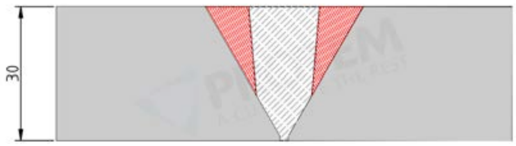

Figure 5 - Material saving for a compound bevel on a wall thickness of 20 mm

2. Single and Double Angle J Grooves

The second solution for drastically reducing the volume of the bevel and, consequently, the amount of weld metal in the 'J' groove preparation. Single angle 'J' grooves are comprised of an angle that is normally between 5° and 20°, a groove radius (r) and an increase in the land (e). The latter element makes the root pass easier to do by giving the welder better access to the land.

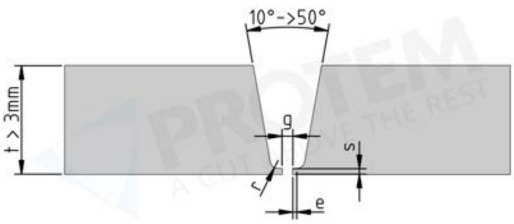

Figure 6 - J bevel

For cases with very thick walls, compound angle 'J' grooves can be made. Normally, the first angle is made at 20° and the second at 5°.

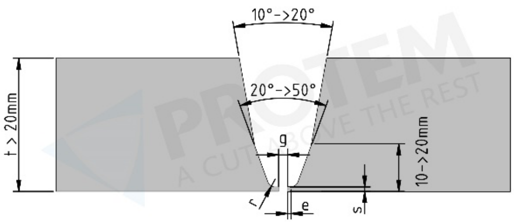

Figure 7 - J compound bevel

J or compound J grooves are usually welded with either a very small or a zero opening (g) between the parts.

From the point of view of geometry, bevels must be perfect to avoid cracking and other problems. As well as providing the accuracy to be guaranteed for this type of preparation, the machine used must also be capable of machining thick-walled pipes rapidly, in order to meet the production speeds required by manufacturers.

3. Narrow Gap Preparation

A variation on this type of bevel is narrow-gap preparation, which is used more and more in the oil industry due to the increase in pipe wall thicknesses and the high production rates to be maintained. The technique generally consists of making a single or compound angle 'J' bevel, with an opening as narrow as possible. This provides a very substantial reduction in the amount of weld metal used and an increase in productivity due to the decrease in welding times. For thicknesses of over 50mm (1.968"), the productivity factor can be over five times higher than on a weld made with a traditional bevel.

Even so, a large number of constraints are to be found in the use of this technique. Two of them have a direct impact on the weld preparation process:

Firstly, bevel geometry and the opening between the parts must be controlled with the utmost accuracy. This is because the opening between the parts does not give the welder access to the bevel root. As a result, the whole weld, including the root pass, must be done using an automatic process. Automatic processes cannot accept any faults in alignment or irregularities in land width, contrary to the welder who is capable of adjusting the position of his torch for compensating any geometric faults in the groove.

The grade of the materials to be welded represents the second factor that must be taken into account. Every type of material possesses different shrinkage characteristics. Therefore, bevel geometry (the opening angle) must be studied beforehand for each different grade. The higher the shrinkage level of a material after welding, the more the angle has to be open, so as to prevent any cracks from appearing during solidification. A variation of a few tenths of a degree in the angle is liable to have a direct impact on the occurrence or absence of cracking, especially when welding nickel-based alloys. These types of constraints require long and costly preliminary studies. Therefore, they need to be accompanied by a perfectly controlled bevel machining process. The description of the welding procedure (DMOS) resulting from preliminary studies requires lands to be accurate to one millimeter (.039"), for angles to be accurate to one degree and for the parts to be welded to be aligned perfectly so as to avoid any possible welding defects. Therefore, the equipment used for making the bevel must be capable of guaranteeing reliable repeat preparations under all conditions.

Different Ways to Perform a Bevel with Heavy Wall Thicknesses

1. Pipe Facing Machines:

Several techniques exist for producing a bevel. The most often used method for **wall thicknesses of less than 50mm (1.968")** is a frontal facing process. For the Oil and Gas Industry we are using Pipe Facing Machines.

Figure 8 - Application example: Producing a bevel at the end of a pipe, on-site, for an onshore pipeline

The PROTEM PFM - HSB can achieve perfect weld preparations on pipes with wall thickness up to 2”.

For wall thicknesses over 50mm (1.968”), there is another approach to create bevels. Instead of performing the bevel with frontal machining, we create bevels or compound bevels by using a copying cam. Radial movement is controlled by using a copying cam which allows the machinist to easily perform beveling jobs on wall thicknesses up to 4” wall pipe. The tool holder is equipped with carbide tips.

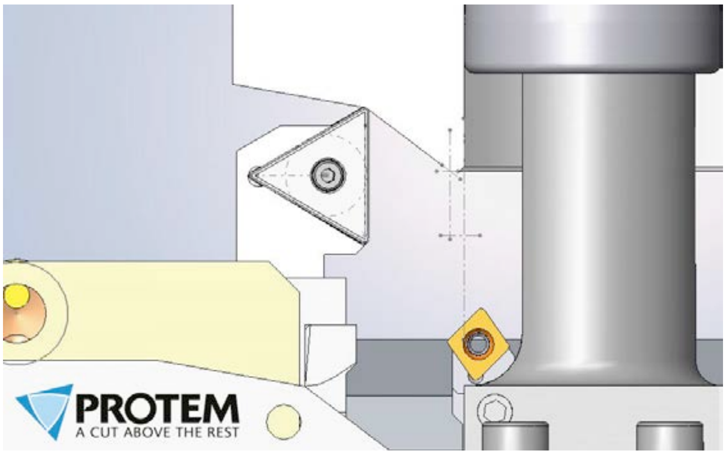

Figure 9 - Cam profile copying. The carriage is provided with a copying roller that follows the profile of the internal diameter of the tube.

PROTEM offers a high speed Pipe Facing Machine with an outside clamping system and copying carriage. The carriage mounted on the tool holder plate is driven with hydraulic radial movement. With this machine you can perform end preps from 6” to 14” with wall thicknesses up to 60mm (2.362”).

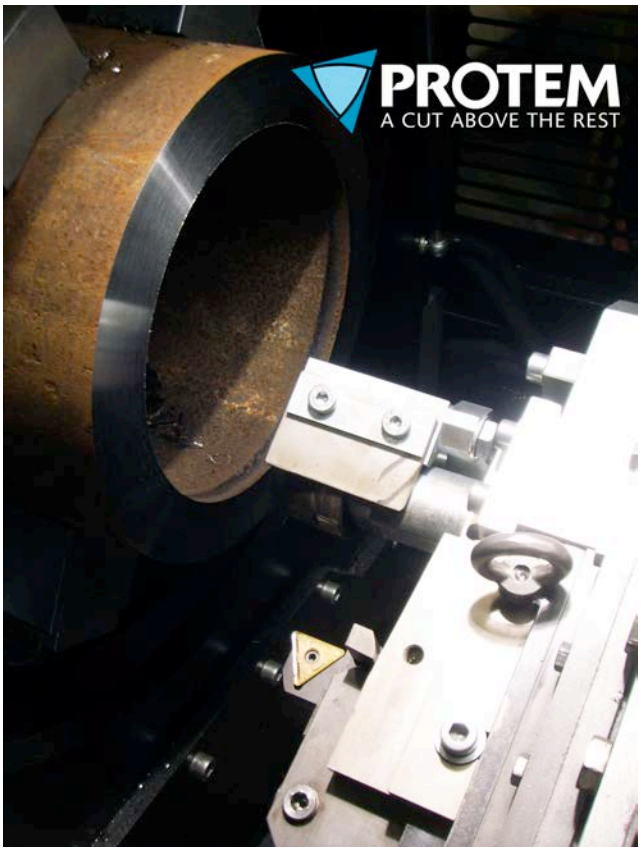

Figure 10 - PROTEM OHSB machine performing a bevel on a pipe with a heavy wall thickness

.

Another transportable machine, which performs custom bevels from 24” to 59” on wall thicknesses up to a 4” wall pipe, is the US600-R. This machine performs any type of weld preparation such as an I-bevel, J-bevel, V-bevel, compound bevel, etc. with accuracy and repeatability, on any type of material; carbon steel, stainless steel, alloy, Inconel, duplex or super duplex.

2. Copying carriage Technology

PROTEM has a full range of pipe cutting and beveling clamshell machines from 2” to 58”. This machine is made for construction, maintenance and dismantling projects. PROTEM TTNG machines can perform bevels on pipes with wall thickness up to 4”. The process steps for machining extreme wall thicknesses are as follows: Make a straight cut on the pipe. Set up a copying carriage to perform J-bevels or compound bevels.

Figure 11 - Figure 6- PROTEM clamshell TTNG1016. 32”-40” heavy wall thickness – Material : Austenitic stainless steel