

Composite Metallic Forging

The present invention relates to a composite metallic forging for use in producing a threaded tubular connector for attachment to a variety of oilfield products, and to processes for manufacturing such connectors from compound metallic forgings. The invention is applicable to threaded tubular connectors for attachment to oilfield products including drill collars and pipes, tubings and casings of all kinds, but is particularly applicable to tool joints.

10 In the drilling of bore holes through underground formations for the purposes of locating and recovering oil and gas and for the forming of mining blast holes and the creation of water wells, the normal procedure is to locate a drilling bit at the bottom of a "drill string" and rotate the bit to disintegrate and fracture the formation being drilled. The drill string comprises a long string of tubular members formed of a tough steel alloy with relatively thick walls and heavy, tough, threaded end-sections. The tubular members comprising a drill string are commonly referred to as "drill-pipe", and the threaded end-sections on the drill pipe are commonly referred to as "tool joints". Each section of drill pipe normally runs from 25 to 35 feet in length and has secured thereon a male tool joint member and female tool joint member having threaded portions located thereon accordingly. Most applications of tool joints to drill pipe are achieved through some technique of welding such as flash welding, friction welding or inertia welding.

30 Although generally made of tough low alloy steel, materials may be selected to provide desirable characteristics in the particular application of the drill string desired. For example, when drilling in corrosive environments, a corrosion resistant alloy

may be selected for a tool joint member. Alternatively when an extremely long string of drill pipe is used, the metallic content of the tool joint or other threaded tubular connectors may be selected to provide extra strength due to the heavy weight of the drill string being supported by the connector. Such material selection may considerably increase the cost of the tool joint, which may be prohibitive in the case of use of the most desirable alloys. U.S. patent 3 067 593 has sought to overcome this, and to overcome any subsequent problems which would be encountered in welding a tool joint to the standard alloy steel of the drill pipe by welding two dissimilar sections of the tool joint together to achieve preferable properties in each section prior to attachment of the tool joint to the drill pipe. This solution can suffer from similar problems encountered in attaching the dissimilar alloy directly to the drill pipe itself. Moreover such a technique could present problems by causing a heat affected zone having different grain size and properties to the bulk of the joint.

Conventional tool joints and other threaded tubular connectors are normally made from a low alloy high strength steel known as 4137-H steel which is heat treated to more than 827 N/mm² yield strength in the threaded connection. Many wells presently drilled are in sour environments, that is contain hydrogen sulphide, often also in the presence of carbon dioxide and chloride-containing water. These corrosive constituents can give rise to early failure in the threaded end of the male tool joint, due, inter alia to sulphide stress cracking even though they are operating at a stress level only in the 344.7 to 551.6 N/mm². Replacement of the conventional steel with a highly alloyed steel, nickel based alloy or other alloy having desired properties of strength and/or corrosion

resistance could increase the materials component of the costs by a factor of about 20 to 50 times at present prices.

5 The present invention alleviates the problems and difficulties characteristic of the prior art devices by providing threaded tubular connectors for attachment to a variety of oilfield tubular products formed from a composite metallic forging so that the connector has the desired strength and/or
10 corrosion resistance in the threaded portion of the connector but the majority of the connector is composed of a lower alloy material having a substantially lower material cost.

 According to the present invention a process
15 for the production of a composite metallic forging for use in the production of threaded tubular connectors for attachment to tubular oilfield products comprises preparing an appropriate length of billet of an alloy having the desired properties of strength and/or
20 corrosion resistance for the conditions of ultimate use, and an appropriate length billet of a low alloy steel, joining the two billets to form a composite billet, piercing the composite billet as necessary, and forging the composite billet to form a rough tubular
25 forging to use in forming a threaded tubular connector. The forging process is normally carried out in an extrusion press, and the composite forging is subsequently heat treated to achieve an optimum combination of properties of the two alloys, and is
30 then machined into a finished threaded tubular connector.

 Composite forgings of the present invention comprise a tubular body made of a low alloy high strength steel metallurgically bonded to a tubular body of an alloy
35 having desired properties of strength and/or corrosion resistance, the interface of the alloys having been

worked and extending in a substantially axial direction along at least a portion of the composite forging.

Composite forgings of the present invention are normally made from billets of solid bar, and the composite billet is pierced prior to the forging process. Alternatively the billets may be hollow cylinders.

Preferably the two billets are joined by a metallurgical bond in such a way that contamination of the interface between the two surfaces during forging is avoided. One way of achieving this is by friction welding which involves spinning one or both of the members to be welded at a relatively high speed against one another until the friction of the rubbing contact along the interface raises the temperature of the members high enough to allow the formation of a weld between the two members when pressed rapidly and forcefully together. Alternative welding techniques include electron beam welding, diffusion bonding, flash welding, inertia welding, laser welding or plasma arc welding. Some of these techniques are already well known in the oilfield tubular products art and may also be successfully employed to join the two billets of the alloy.

We have found that it may not be essential to have a 100% metallurgical bond between the two billets of metal prior to forging but that, due to the nature of the processing, a 100% metallurgical bond may still be achieved in the final product.

The present invention is particularly advantageously applied to tool joints. Composite tool joints of the present invention contain only the minimum amount possible of the expensive corrosion resistant alloy and are thus not significantly more expensive than conventional tool joints. They offer advantages over composite joints produced by welding

together two separately forged constituent parts since the deformation of the weld caused by forging improves its integrity. Moreover the interface on tool joints of the present invention will have more
5 uniform properties since any welded heat affected zone formed on joining the two billets will be heavily worked during forging and its grain size will not be significantly different from the bulk of the material. During forging the interface is extended in a generally
10 axial direction down a portion of the body of the joint and thus has a greater cross sectional area than the initial transverse joint in the billet. This increased area of weld interface would result in a lower unit stress level under the normal load application.

15 Composite tool joints of the present invention are preferably male tool joints i.e. the pin end of a set having tapered threaded end portion for engagement with the threaded end of a female (or box end) tool joint, the tapered portion being formed of the desired
20 corrosion resistant alloy.

An example will now be described having reference to the accompanying drawings in which:-

Figure 1 is a cross-sectional side view of a bimetallic forging billet. Figure 2 is a side view
25 of a tool joint forging. Figure 3 is a cross-sectional side view of a tool joint forging indicating the non-planar weld line. Figure 4 is a side view of a completed tool joint pin connection. Figure 5 is a side view of a tool joint affixed to a section of a
30 drill pipe.

Referring now to Figure 1, a forging billet
10 is illustrated in side cross-sectional view in which a billet 11 of a standard tool joint alloy steel has been welded to a billet of corrosion resistant
35 alloy 12 by means such as a friction welding process. The weld interface between the corrosion resistant alloy 12 and the standard alloy steel 11 is shown

at 13. It should be noted that whereas the present embodiment is described with respect to the male end or "pin" end of the tool joint pair, the present invention is readily adaptable to either end of the drill pipe. The pin end of the drill pipe normally incurs the greatest stress corrosion cracking when drilling in extreme conditions. Therefore, the present invention will be described in conjunction with the pin end of the tool joint pair, rather than the "box end" or female end of the drill pipe.

After the composite forging billet has been prepared it is upset and pierced to provide a centrally located longitudinal bore 14 and forged on a hydraulic press on which it is worked by forward and backward extrusion to produce the desired configuration which is shown in Figures 2 and 3 and has a tapered pin end 12a, and a formed drill pipe end 11a for securing to the standard drill pipe. During this process the interface is deformed, becoming non-planar due to distortion of the billet material. It will be noted that the interface between the two alloys extends in a substantially axial direction along a portion of the body of the joint. The non-planar nature of this interface greatly strengthens the tool joint since it eliminates the problems arising from a single planar interface within the tool joint. Moreover there are no problems arising from welded heat-affected zones adjacent the interface since the zone is heavily worked during forging so that its grain size is not significantly different from the bulk of the material.

After forging, the bore and the pin taper surface are rough-machined. The tool joint may then be heat-treated and thereafter final machined, which includes cutting the thread on the pin.

In Figure 4, the composite tool joint forging 10a is machined along the pin section 12a to provide the

conventional tapered male-threaded connection for threaded engagement with the female end of an adjoining drill pipe section. Threads may be machined on the pin 12a in any conventional threading manner for
5 example machining or rolling of the threads. Likewise, the weld interface surface 15 at the other end of the tool joint may be machined to provide a relatively smooth, flat weld face.

In Figure 5, the forged and machined tool
10 joint 10a has been welded to a standard upset drill pipe 16 for example by friction welding or flash welding at interface 15. The tool joint/drill pipe weld area may then be heat-treated to harden, toughen and/or relieve stress within the weld area. After the
15 process has been completed, the result is a section of drill pipe having a pin end of a desirable corrosion-resistant alloy joined to a section of drill pipe by conventional welding means, which tool joint pin end provides extended resistance to stress corrosion
20 cracking, a superior non-planar weld interface and a much lower cost factor than a similar tool joint made entirely of a special corrosion-resistant alloy. Through pre-selected heat treatments, after welding the composite tool joint on the drill pipe the overall
25 strength and corrosion resistance may equal or exceed the strength and corrosion resistance of a similar drill pipe welded to a joint made entirely of the special corrosion-resistant alloy. Likewise, the resultant tool joint/drill pipe combination will
30 exhibit superior corrosion resistance in the pin threaded area over that of the conventional tool joint material such as 4130 or 4137 steel. The cost of the present invention over a standard alloy steel tool joint is relatively insignificant when compared to the comparative
35 costs of making the entire tool joint of the corrosion-resistant material.

Suitable high alloy material for use in the

production of composite tool joints of the present invention includes ASTM A-453 Grade 660, ASTM A-638 Grade 660 (A-286), 17-4PH (UNSS-17400), and INCONEL alloy 718 (UNS No. 7718). INCONEL is a trade mark.

Alternative alloys having acceptable strength and corrosion resistance characteristics may of course be substituted. Conventional low alloy steels include AISI 4137H. For sour well applications composite tool joint forged from a composite billet of A286 and 4137H is preferred. The compositions of these preferred alloys are shown in Table I.

TABLE I

Alloy		C	Mn	Si	P	S	Cr	Ni	Mo	Ti	Al	V	B	Fe
A286	Min	-	-	-	-	-	13.5	24	1.0	1.90	-	.1	.003	Bal
	Max	.08	2.0	1.0	.025	.025	16.0	27	1.5	2.35	.035	.5	.010	Bal
AISI-4137H	Min	.34	0.6	.15	-	-	0.75	-	.15	-	-	-	-	Bal
	Max	.41	1.0	.30	.30	.04	1.20	-	.25	-	-	-	-	Bal

Such alloys require heat treatment after forging in order to develop strength and the composite forging may be given an appropriate heat treatment which may be a combination of those conventionally applied to the two component alloys of the composite. In the case of an A286/4137H composite we have found that a suitable heat treatment is 2 hours at 900°C, water quench, plus 16 hours at 720°C, air cool, plus 8 hours at 650°C, air cool.

Although the invention has been described above with primary emphasis on providing increased resistance to sour gas stress corrosion, the method is equally applicable to producing composite forgings which have improved strength characteristics. Likewise the invention is applicable to the forging and finishing of threaded tubular connectors for attachment to any of a variety of oil field tubular products including drill collars and pipes, tubing and casings of all kinds which are interconnected by threaded connectors.



1. A process for the production of a composite metallic forging for use in the production of tubular connectors for attachment to oilfield tubular products comprising preparing an appropriate length billet of an alloy having the desired properties of strength and/or corrosion resistance for the conditions of ultimate use, and an appropriate length billet of a low alloy steel, joining the two billets to form a composite billet, piercing the composite billet as necessary, and forging the composite billet to form a rough tubular forging for use in forming a threaded tubular connector.

2. A process for the production of a composite threaded tubular connector for attachment to oilfield tubular products comprising preparing an appropriate length billet of an alloy having the desired properties of strength and/or corrosion resistance for the conditions of ultimate use and an appropriate length billet of a low alloy steel, joining the two billets to form a composite billet, piercing the composite billet as necessary, forging the composite billet to form a rough tubular forging, heat treating the forging to achieve an optimum combination of the properties of the two alloys and machining the forging into a threaded tubular connector for attachment to oilfield tubular products.

3. A process as claimed in claim 1 or claim 2 in which the billets are solid bar and the composite billet formed therefrom is pierced prior to the forging process.

4. A process as claimed in claim 1 or claim 2 in which the billets are hollow cylinders.

5. A process as claimed in any preceding claim in which the low alloy steel is a low cost high strength steel.

6. A process as claimed in claim 4 in which the low alloy steel is AISI 4137H.



7. A process as claimed in any preceding claim in which the composite threaded tubular connector is a composite tool joint.

8. A process as claimed in claim 7 in which the alloy having desired properties is ASTM A-453 Grade 660, ASTM A-638 Grade 660 (A-286), 17-4PH (UNSS-17400) or alloy 718 (UNSS No. 7718).

9. A rough tubular forging for use in the production of a threaded tubular connector for attachment to oilfield tubular products comprising a tubular body of a forged bimetallic construction having one tubular portion of a low alloy steel metallurgically bonded to a second tubular portion of an alloy having desired properties of strength and/or corrosion resistance, the interface between the alloys having been worked and extending in a substantially axial direction along at least a portion of the tubular body.

10. A threaded tubular connector produced by heat treating the forging of claim 9. machining to its finished dimensions and cutting a male or female thread thereon.
