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An appraisal of the role for steel forgings and castings in major structural applications

E. F. Walker and R. C. Richardson

Mr K. H. Best, *Bullen and Partners*

As a young engineer I remember being persuaded that weldments had many economic and structural advantages, but experience has confirmed the Authors' views that poor fatigue characteristics of welded joints are a great drawback for the design of major structures, especially those subject to dynamic loading.

49. Figure 4 of the Paper illustrated some of the advantages of the British Steel Corporation (BSC) casting. The axes of the chord and braces intersect at one point, and it is possible to reduce the size of the local enlargement of the chord. This is a straightforward substitution of the original welded design by a casting. Eccentricities were eliminated and fatigue properties and stress concentration factors considerably improved.

50. The Hoesch design in Fig. 5, however, is no longer a substitution but quite a radical change, and as the Authors say, it is a completely new product. The degree of necking at the node point approaches the concept of a pin joint or ball joint, and the advantages in respect of local secondary stresses and concentrations at the nodes are obvious. But does the arrangement give any 'global' advantage, i.e. are there significant economies in the total weight of the structural frame, and, if so, is it possible to give an estimate, perhaps as a percentage?

51. I believe it has taken quite a long time for the offshore industry and designers to accept the concept of castings instead of weldments for these connections. Was the cost of casting these complex pieces in the early days a consideration, or was it a matter of persuading the industry that your quality could be achieved?

52. Regarding the tension elements shown in Fig. 20, could Mr Walker elaborate on the method of connecting them together? Were the sleeves at the end upset forged before machining, and is the complete element in one single forging?

Mr G. J. Marston, *Sheffield Forgemasters*

With regard to the Hoesch design of node in relation to that of Sheffield Forgemasters (Figs. 4 and 5 of the Paper)—the basis for the Hoesch design is vested in a full finite element analysis and a concept of going back to a single working point. There are weight advantages in shrinking the node to the smallest possible size. This has also been done in the Sheffield Forgemasters' design, but it was not taken down to the fully necked concept. With the Hoesch design, therefore, a further small weight saving is made, but in terms of the stress concentration factor (SCF)

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data which both organizations have generated there is little difference between the two. There is virtually no difference in the manufacturing costs either, because they are essentially concerned with creating a size of mould, and then producing a casting, inspecting it, and upgrading it to meet the necessary offshore standards. So the only real advantage is in terms of weight and, although relatively small, if weight is an absolutely crucial factor on a structure, there is an advantage in going down that route.

54. However, the concept of cast steel nodes, particularly for the larger structures (and the deep water towers—1300–1500 ft high—envisaged in the next two or three years really need to use castings) gives the belief that our design of castings by either design philosophy could save 30 or 40% of weight compared with fabrication if it can be effectively designed to overcome fatigue problems due to height and the fact that the frequency of oscillation of those deep water towers is generated by the size of the small waves that occur most of the time, and not the very large waves in the smaller towers.

55. The second question related to the reasons why it has taken so long for these apparently good ideas to take off. They stem from the conservatism of the industry. In the case of a new steel product in a new application, on many occasions we have had to produce 120% of data to satisfy people before they will even go to a prototype. We have now gone beyond that, and in the past year six major oil companies have made large commitments to offshore castings, and have purchased offshore castings either for cast steel nodes or, indeed, offshore lifting items. Our foundry in Sheffield is substantially committed now to the offshore industry with several million pounds' worth of castings being produced. In fact Oscal, ourselves and our German partners are the only organization in the world manufacturing castings for the offshore industry.

56. With regard to Mr Best's question in respect of the tethers, they were produced on the new forge that we have recently installed in Sheffield in the old Firth Brown plant. It is a GFM automatic forge. The force for conventional forging occurs in one direction only whereas with the GFM process, force is applied simultaneously in 2 directions at 90°. With this computer controlled process, bar forgings can be tapered to produce shapes. Therefore the ends can be made to the larger size and forged out in the centre. This particular machine can give a high yield and high quality of forging to a close finish tolerance enabling a relatively small amount of yield loss on machining to occur.

Mr Walker

The GFM machine is capable of producing a tapered forging with the ends of a larger diameter. The tether of course ultimately has a 3 in dia. bore straight up its length so there are no metallurgical advantages in upsetting the original ingot. This results in a straightforward ingot longitudinally forged in the GFM, centrally bored and finally machined.

58. The thread arrangement has a tapered buttress thread. It is something of the order of 15 in long, and at its major diameter probably about 13 in. This is an incredibly precise machined thread for which the River Don as well as the Japanese, who have made some of these forgings, have had to make special investment in special threading machinery to ensure that the tolerances on both the male and female thread are kept within the very fine limits specified.

Mr W. O. W. Roberts, *Shortlands*

There are obviously big advantages for cast steel nodes in the deep water jackets, but in the context of the boom in the southern North Sea have the Authors' any comments on the design philosophy of those nodes used already?

Mr W. Frankland, *Earl and Wright*

I was responsible for the design of the four nodes considered in this discussion. One of the main considerations for adoption was cost. The project was not keen to endorse anything that would be more expensive than the traditional fabricated node.

61. There was little difference in the cost between the two alternative methods, but cast nodes did appear to be cheaper.

62. The target life for that structure was of the order of 250 years. That achieved was in the order of 185 for this node. The highest stress concentration factor was at the crown, which is a little unconventional. Some problem occurred at the connection point to the tubular part and more work is required in this area.

Mr Roberts

On the question of manoeuvrability, can the Authors kill once and for all the criticism which has been raised against cast steel from time to time, namely, the capacity to produce at a rate sufficient to meet the needs of the market?

Mr A. G. Reynolds, *BP*

How are the Authors' discussions going with the certifying authorities?

65. We really do not have reticence. The certifying authorities are in control, and if the S–N curve can be moved upwards, and is acceptable to the certifying authorities, then the fatigue problem may be eliminated.

Mr D. J. Loader

Experience of the design of cast steel nodes indicates that the currently available data in general and S–N curves in particular are not entirely adequate. It is currently necessary to undertake more design effort for a cast node than the fabricated equivalent. While this is expected for the first few installations, it is not desirable for structures which use cast steel extensively. The designs and design procedures being used have been developed directly from experience with fabricated nodes.

67. Cast steel nodes have been designed as direct replacements for fabricated nodes using S–N and fracture mechanics approaches for fatigue. In most cases the fatigue critical sections of the node move from the interior of the nodes to the stub to brace connection. It is likely that significant overdesigning has occurred as pessimistic assumptions have been made where data is not available or not clear.

68. For the future, not only will designers be looking to a far more extensive use of cast steel, but they will also require to use it more efficiently and will begin to design with cast fabrication in mind. To achieve this more data will be required on the basic performance of cast steel so that designers can safely rationalize their approach. It significant numbers of components are to be included in any particular structure, it is essential that there are standards accepted by the Industry and by the Department of Energy and Lloyd's. The data currently available either does not meet this or is presented in such a way as to confuse rather than enlighten the would-be user of cast steel.

Mr R. C. Dyer

I should like to comment on the design aspects in fatigue dominated structures. I feel that, with the steps they have made in the manufacturing technology of large castings, the Authors are now some way ahead of a majority of designers. It is interesting to have pursued a parallel course over the last 5–8 years and watch the progress of the design techniques.

70. The company with which I was associated was interested in the problem of compliant structures, in which they were starting to experience fatigue problems. The route was chosen of trying to change the philosophy of the basic design to integrate casting, rather than picking particular fatigue dominated, fabricated nodes which would be replaced with a cast node.

71. The results of this philosophy can be illustrated with structures of only several thousand tons, but with up to one hundred castings of many different types. Examples are stiffeners, towing lugs and foundation seatings, all primarily to eliminate fillet welding. As a comparison the company completed one project, of a similar geometry and weight to a previous, more conventional, design, on which a 40% reduction of weld metal was achieved.

72. The emphasis must be on the design of structures with casting technology in mind. Only through acceptance of this philosophy at the concept stage will the full benefits be achieved. I accept that it has been necessary simply to replace fabricated nodes by geometrically similar, cast nodes to gain experience. This practice should, however, only be seen as a development stage.

Mr Frankland

Much has been discussed about the medium and large type casting, but not about the smaller type. Problems are encountered on offshore structures with small elements, particularly the conductor guides and attachments for risers. What is the foundry doing towards trying to make the smaller type of casting, which would be of benefit in these areas, more economically viable? When they were last considered, they appeared to be expensive.

74. There is a great potential, particularly for conductor guides, so an investigation of an alternative method of manufacture to cut down the cost would be worthwhile.

75. The company are interested in these particular areas and have looked at alternative designs but find it difficult to stimulate interest in the area because of the high price. However, I must take issue with the Authors that the fabrication of these areas is perhaps simpler. There is a great deal of stiffening in these areas requiring a considerable amount of welding. Modification in the way they are produced, perhaps by making a larger moulding box, might reduce the cost to a level where they were not directly competitive but were not far removed from the fabricated unit price.

Dr G. Tither, *Climax Molybdenum*

Could Mr Walker explain why he claims that cast nodes are more readily weldable than fabricated nodes even though both have a similar carbon equivalent value?

77. The authors quoted COD values. Are these for information only, or are they now written into the specifications?

78. The Authors have discussed cast nodes produced from what has been designated CSN 3 grade steel. Do they foresee in the near future production of a higher strength, higher alloyed cast steel node, say a CSN 4 grade, which would be

of lighter weight and might be more applicable for deeper water platforms?

Mr Marston

This development started off because the Conoco Oil Company were very interested in castings. They wanted to prove cast steel nodes for further use in an immediate structure after the tension leg platform (TLP), and therefore they chose the Conoco Victor jacket for the installation of four cast steel nodes. The design criteria basically covered the fatigue data we had developed in Sheffield and Dortmund, and a comparison with the general fabrication design philosophy was made. Section sizes were compared, and the high stress concentration factor on that particular node occurred at the stub-tubular weld rather than having a high stress concentration factor in the casting itself.

80. The weight of the casting was just under 2 t, about equivalent to the fabrication, but the fatigue life was designed for approaching 100 years. It was largely an R & D proving ground, but a node was produced which had a low stress concentration factor, to a tight delivery schedule and a high integrity specification, and the set of castings were delivered to the customer four weeks ahead of the agreed contract schedule.

81. Another very similar order is now currently in manufacture for four more nodes for another company operating in the southern North Sea.

Mr Walker

One problem which my colleagues have to face is of credibility in terms of maintenance of quality and properties. It has been successfully demonstrated that both the River Don and the Hoesch foundaries can do this. Having been associated with this programme for its full $7\frac{1}{2}$ years, I cannot see anybody who has not been concerned with the development work over the last 7 years disregarding everything they have ever done before to design and make a structure to optimize the use of castings from beginning to end unless there are strong motivations from outside that they should do so. The motivation will come from either the development of structures for service in even more hostile environments of the far north, or in situations such as the Troll Field where the design consultants appear to be taking a very broad view of the alternatives that face them on that project. It would still be sensible to consider, for example, any of the alternatives put forward at the moment, whether it be a fixed platform, or a floating platform. However, none of those alternatives can be considered without including the whole breadth of the accompanying alternative technology.

83. Brief calculations can be made on the amount of steel that would be required to produce the tripod structure with the 30 m dia. cans with 6 to 8 in wall thickness. All the weight is added, the steel making capacity worldwide is looked up, and ordering of steel begins in November to make it by 1995. That is, I would have thought, a serious limitation. It is that sort of glaring limitation which will force design organizations, the oil companies and the certifying authorities to have an open mind regarding not only novel designs of structures that are continually being put forward, but also alternative technologies and even alternative materials. Having looked at the latter, steel will then still have to be selected. Alternative manufacturing technologies are then investigated and then the motivation will be there to ask how to adopt completely the concept of castings and forgings and an integrated design approach to optimize the shape and serviceability of the planned structure. My colleagues would not wish to do anything to detract anybody from

looking at the whole concept in total, but I am sure that the view that the concepts of substitution should be accelerated would be supported.

Mr Marston

It is necessary to define what sort of offshore casting is being referred to. The company is currently producing lifting beams and lifting pad-ears for UK contracts. Those are being made to a schedule of something like 18 weeks in total to the first castings delivered. That includes about four weeks for pattern making, two weeks for moulding and casting, one week to allow it to cool, two weeks to strip it, burn the feeder heads off and heat treat it. Another two weeks are required to clean (or fettle) it, three weeks for NDE, (dimensional mark out, magnetic particle inspection for surface cracking and full ultrasonic testing) then weld repair, final heat treatment and inspection. All that comes to about 18 weeks to first casting. Two or three castings of 10 t can be produced together, so that in week 18 there would be, say, two castings. Assuming the same pattern is used, moulding of the second set would then start two weeks later, so two or four castings would be produced per week after 20 weeks. So for those lifting beams about 2 per week can be made from each foundry and as two foundries operate together, that is four castings per week. That would satisfy most people in terms of building rate. Small nodes up to 10 t would fall in the same schedule. For 25 t castings, the delivery time might be 20 weeks. For a large 9 brace launch node, say a 70 t node, it would be 28 weeks. That is the first casting, and then castings would repeat at the rate that the moulding operation can be restarted i.e. one to two weeks, so one node would be turned out every ten days. For deep water jackets at present our proposals for 100 t nodes give a 34 week lead time, and then one node every ten days to two weeks from each manufacturing facility. For deep water jackets with say 60 nodes in the total structure, it would take around 18 months with one foundry operating. If two foundries were operating the rate is halved.

85. In the Sheffield foundry the objective is something like 15 to 100 t per week in full production with full repetition.

Mr Walker

Mr Reynolds' question is complicated because there is no simple answer. The data generated would certainly support the construction of an S–N curve for the cast cruciform joint. The results obtained under ECSC sponsorship certainly give an impressive collection of fatigue data from cruciform joints in the thickness range 25 to 100 mm. All the results completely support the concept that the F_C design line could be adopted as a fatigue design curve in the same way as the F_2 line would be accepted in the current code of practice.

87. Similarly, fatigue tests are done on full scale cast joints and fatigue data has been developed, but more success has been made at breaking the contractors' fatigue machines than at breaking the castings, simply because the stress concentration factor in the cast node is about 1·8. The stress concentration factor in the equivalent welded fabrication may be of the order of 5 or 6, and unfortunately the stress concentration factor associated with the weld made to attach the casting to the fatigue machine has a stress concentration factor of about 3. So breakage of the weld attaching the specimen to the fatigue machine occurs continually.

88. What was thought by the management at the time as an inordinate amount of money was spent and many cracks were produced, none of which were

useful. But when the data was put together, the limited amount of success achieved in producing fatigue cracks in full size cast nodes again supported the view that a much more generous fatigue line could be adopted for castings. But is it really needed? The philosophy adopted has been to avoid changing those things the engineer has confidence in unless it were really necessary. The T curve, the Q curve or any of the other recommended curves which appear in the guidance notes and revisions to the BS 6235 and any other specifications can be accepted, and benefit can be taken from the fact that, with a casting which is properly designed, there is a much reduced stress concentration factor, say, 50% and a 50% reduction in fatigue stress gives us more than an order of magnitude improvement in fatigue performance. So unless there is a hyper-critical fatigue problem, within the constraints of what is written down and what the certifying authorities will accept, a casting can be offered that is fatigue resistant. Therefore, there have been no discussions with anybody that identified the real benefit of proposing another fatigue design curve. If a casting is produced with a fourfold improvement in fatigue performance and all results show that the design curve could be moved an order of magnitude over to higher life anyway, what would be the point of suggesting that this should be done, and that much money be spent in getting a statistically viable collection of fatigue data just to prove that the casting then had a fatigue life of 800 years or more?

Mr Marston

In reply to *Mr Reynolds*, if fatigue is pushed as far as it can go, this would mean getting down to very thin section sizes. The castings shown for Conoco were to a fully optimized design. Those castings could not have been made with thinner walls if sound castings were to be ensured. By virtue of the geometry fatigue life was very good. Fatigue life may not have changed much if it had been possible to make the node lighter.

90. There are other constraints regarding manufacture to ensure sound feeding, directional certification and so on that mean there are certain critical section sizes that have to be in the castings to ensure soundness. Other than removing that excess metal by machining or whatever process, that would add greatly to costs.

91. There is an optimum balance between the weight that can be produced, manufacturing method, fatigue life and the geometry of a particular situation. The certification societies have given full approval as far as fatigue is concerned for the castings, as well as the SCF improvement over existing fabricated designs.

Mr Walker

The Dutch Welding Institute identified in their coming research programme the scarcity of data concerning the fatigue behaviour of the circumferential weld. They are to start a major programme looking at the fatigue performance of circumferential welded tubes or connections, looking at the severity of defects likely at present in these welds due to site welding operations.

93. In reply to *Mr Loader*, would his organization be content with fatigue data demonstrating the suitability of the casting and the fatigue design curve based on cruciform type data? If not, our company would have to provide data on items which we have said are fatigue resistant, and therefore cannot be broken, and he has been asking us to try and break them to prove the point.

94. Mr Loader made a very important point. The policy decision that our

group took would lead to generation of fatigue data which demonstrated the advantage of the casting, but did not quantify in significant numerical terms the exact benefit. The reason is that with a weld some computation has to be made to characterize an alternating stress level that that welded joint sees. The actual stress level cannot be measured. The stress levels plotted on S–N curves are the result of the extrapolation of strain measurement made some distance from the weld. So there is then a hypothetical S–N curve while the stresses that are plotted are more of a figment of the engineer's imagination than usual.

95. The parallel to that is when a casting is produced relatively smooth surface. An alternative approach to the fatigue problem would then be: can a design procedure be produced that tells what the membrane stresses are across the node? If the design procedure gave that, a plot of a fatigue design curve would be required, in terms of membrane stress and numbers of cycles to failure from a cast surface. That information is not available, although it would not be too difficult to get it. The information already obtained could be used and replotted to produce that actual S–N curve, because the data measured on cast cruciforms is the actual strain because the stress concentration is very much smaller.

96. If a fatigue design curve is needed, there is no difficulty in plotting all the fatigue data obtained in terms of membrane stressing and number of times of failure, and that will show the order of magnitude of improvement.

Dr R. C. Richardson

In answer to *Mr Frankland*, the group has produced prototype conductor guides in the foundry. However, although they are a relatively lightweight casting for River Don, the manufacturing methods are basically the same as for a large casting, using sand processes and labour intensive means of production. The complexity of production for the fabrication may not be too great and consequently on a production cost basis the group is probably not too competitive. There is a big advantage in terms of fatigue performance, and that should be taken into the overall cost equation. In terms of the cost of fabrication against the cost of casting, the group cannot compete, and no major foundry technical modification can be seen at present that would bring the cost down.

98. There are certainly areas for improving manufacturing costs on these smaller castings using the same basic technology. If there are several numbers of the same design then both patternmaking and moulding costs can be reduced as well as steelmaking.

99. Costs can be reduced by an imaginative approach to design which accommodates the foundry technology requirements thereby enabling a good quality cast product to be produced with minimal costly rectification and welding. As far as a conductor guide is concerned, we would prefer to make the guide ring solid rather than mimic the tubular fabrication. This reduces fettling, NDT and many other problems, albeit at a slight weight disadvantage. I think the whole topic is open for discussion.

Mr Marston

There are certain cost levels below which one cannot go. The proposals my company has been putting to various people mean that there are other savings the fabricator can make in terms of simplifying the conductor ladder quite dramatically. Instead of having a complex tubular structure, the whole ladder can be set up with just two main tubulars, hanging castings off all the way up, therefore limiting the welding cost quite dramatically. There will be a significant reduction in cost, and competitivity with fabrication, and the big problem of fatigue of the tubular connections will be overcome. The decision is between the oil company, the fabricator and the designer, and we as a foundry cannot influence it too much.

Mr Walker

The whole question of weldability, raised by *Dr Tither*, is a problem which is taxing the imagination of people who, five years ago, were brave enough to say that if heat input could be controlled, weldability could be disregarded in respect of heat affected zone toughness in 50 D type structural steel. So at first a casting was offered against a backcloth of the fabrication industry saying that such great confidence was held in the weldability of 50 D, 50 E type structural plate, that measurement of the heat affected zone toughness was unnecessary. The group was asked about the toughness of the heat affected zones in castings. Immediately a problem existed in that there was nothing to compare it with because little data was available on HAZ toughness for 50 D type structural steels. The programme was energetically directed towards generating data that would convince the offshore industry that the heat affected zone of a casting was tough and that the hardness was acceptable.

102. But the question was why is it proposed that castings are more readily weldable than the parent plate. The answer is in several different parts. The answer to part one is that when a casting is produced a surface chill effect occurs such that the surface areas and the edges to solidify first accord with the uni-directional solidification concept and are very good areas in terms of the metallurgy. Very little segregation occurs. The casting is very well closed up. There is no evidence of micro–micro shrinkage or similar problems. Compare that with the situation prevailing in a piece of plate. It solidifies as a concast slab from the outside, it is then rolled down and a zone of segregation develops in the through thickness direction. At first the plate users specified through thickness tensile strength to avoid laminar tearing problems. It is not known what is acceptable with respect to the level of centre line segregation in concast plate. A cut plate has no edge chilled effect to weld upon. A weld would be attempted across a structure that may have segregation of the order of 150 to 170% of the alloys that are not very good for weldability—carbon, manganese, molybdenum, niobium and all other segregating material.

103. It is found that the expected heat affected zone toughness is not obtained. Hence groups of people meet round the country under the auspices of the Department of Energy to try and establish what is an acceptable level of heat affected zone toughness.

104. Current practical experience has shown that grades of high quality structural steel plate have been developed, and it is not important whether it originates from Germany, British Steel, Japan or anywhere else, it is apparently less readily weldable than it was before carbon was reduced and the micro alloying elements put in to make sure adequate strength was achieved in thick section plate. Five years ago the weldability of the casting had to be demonstrated, and the heat affected zone properties have not changed. Hence little has been done other than stand still, but castings will meet stringent weldability requirements.

105. When it comes to welding procedures, Charpy impact properties and COD properties are now being specified by almost every oil company communicated with. Unless the Charpy impact properties are outstandingly good, as a

matter of course now, particularly for plates supplied to the offshore industry, weld procedure tests must be done including COD tests on any section above 40 mm. Specific procedural tests associated with some commercial orders have sometimes been done. On other occasions clients have accepted the data they already have. COD transition data has sometimes been requested. It can be done, but it costs money and it is not particularly useful when it is demonstrated that the COD transition temperature is −55°C. The tendency is to specify COD more and more. Once the information has been produced it is to be hoped that the consultants who write the massive volumes of unreadable specifications will begin to look back a little and accept that some of the things done in 1983 were still good in 1984 and would be afterwards.

Dr Richardson

On the question of COD against Charpy impacts for release test purposes on castings, our company readily accepts release requirement which specifies a COD. Charpy impacts in themselves are not necessarily the best means of assessing the toughness properties of a cast product. A Charpy is a very small specimen, and in relation to what is being demonstrated in the bulk properties of the casting it can give adverse results. For instance, very small micro defects may occur in a casting and if they are located near the notch tip of the Charpy specimen which is subjected to very high strain rate impacts, it will cause immediate cleavage and failure at temperatures near the brittle/ductile transition. This is not considered a sensible method of assessing the toughness properties of a thick section casting that will by nature give variability in micro- and macrostructure. The bigger the test piece the more realistic it is for a casting. A COD test can accommodate this requirement on top of which the release test value does have an engineering derivation rather than being an arbitrary figure.

Mr Walker

The Charpy test is specified at a test temperature that is in the transition region, normally 35 J or similar magnitude. To get 35 J in a steel with a strength of 320 MPa no matter whether it is a casting, a continuously cast slab, a forging, or a thick direct rolled ingot, all that is needed is about 0·25 mm of ductility underneath that Charpy notch. That will give 40 J impact energy at initiation irrespective of propagation and the specimen passes the test. That is a nonsense, because if there is a micro-pore which effectively sharpens up that Charpy notch tip, then cleavage fracture occurs straight away and the micro band of ductile fracture is not obtained, and 45 J is obtained instead of 25 J, and hence a purchase specification has not been achieved, which causes great problems.

108. Guidance would be appreciated on higher strength cast steel nodes from the designers, because the designers and some oil companies are moving towards the possibility of using slightly higher strength steels for parts of thick structures, and semi-submersibles or tethered structures. If high strength steels are used of course no benefit can be gained from welded fabrications. The fatigue life of the welded fabrication in the higher strength steel will be exactly the same as it was in 50 D. So if higher strength steels are to be used and fatigue is a major concern, our concept is that first of all the conventional CSN 3 casting can be used in a fabrication where the braces and chords and simple tubulars are made out of higher strength steels. This is because the fatigue strength and the static strength in our existing design and product exist to accommodate this. However, if it is

desirable to take properties to the ultimate advantage, and to improve the overall weight performance of offshore structures made from higher strength steels, a higher strength casting may then be required. The designers and engineers who are thinking about these things should talk to we the manufacturers, because we are currently working on these two development concepts, one for colder waters and one for deeper waters where higher strength steel may be needed.