Subsea Connectors In The Marine Renewable Energy Sector

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Presently, the Marine Renewable Energy (MRE) sector (both Wave and Tidal) is moving toward the deployment of the first arrays or "farms" of generators, having proven the basic design concepts with prototypes. Many of the problems of deployment will have been encountered during these initial installation processes, but the solutions will probably not be cost-effective for use on arrays. For instance, in a lot of cases the export cable at the test site will have been "hard-wired" to the generator using a field-installable splice or a low-cost connector.

This method is quite acceptable for deployments that are only intended to last for around 12 months and no retrievals are planned for routine maintenance. However, with longer-term deployments and multi-generator installations, retrieval of the cable and splice to the surface for disconnection is, in most cases, not an option for a number of reasons:

• Vessel time is very expensive and a specialist vessel may be required for this operation;

• The export cable would be disturbed with every retrieval and would have to be protected when returned to the seabed;

• Extra cable length would be required to facilitate its removal to the surface. This is normally estimated as being 2 X water depth (i.e., 100 m length in a depth of 50 m). This extra cable length is also a significant additional cost;

• With the extended time required for this operation comes the additional problem of weather windows, which, when taken in addition to the already restrictive slack-water periods, can greatly extend time on site.

In short, the costs of installation and maintenance are presently far too high to begin bringing the MRE industry towards a cost of energy that will match that of other sectors. If MRE is to be financially viable, a cost-effective solution to installation and maintenance by the introduction of new and innovative methods and products is essential.

Some Misconceptions Regarding Available Connector Products

In the very early days of this industry, it was often thought that there were already proven connector products available from the Oil & Gas industry. This was correct in that there were a number of companies producing products that had long and successful track-records of deployment in Oil & Gas and also in Military and Oceanographic applications. The truth of the matter is, however, very different. Most recent Oil & Gas applications are in deepwater, typically 500 to 3,000 m. In these environments, the only real problem is the presence of high ambient pressures, and these can be controlled by pressure compensation. The environment at these depths is somewhat lacking in oxygen and no really significant currents exist to refresh the supply, so the impact of marine growth and corrosion is not too severe. Also, the temperature is very stable at around 4°C, which also serves to reduce these problems.

The methods of physical connection and hook-up available in the Oil & Gas sector include both ROV intervention and the use of automatic connection via "stab-plates." For the MRE sector, it is virtually impossible to use ROVs other than for observation due to the severe currents and short slack-water periods that exist in the areas of deployment. This means that if we are to discount retrieval of the cable to the surface for disconnection, we are left with only one option — the incorporation of an automatic connection system. Furthermore, the existing connector products were unsuited to the environment in shallow, warmer waters by virtue of their construction, materials in particular, and expensive cost. Thus, we have a situation where the ideal product for use in the MRE sector has to have superior long-term performance as well as being far cheaper — quite a tall order!

The Ideal Product

The features that the ideal product should exhibit include the following:

• Simplicity of design;

• Simplicity of operation;

• Long life without maintenance or deterioration of structure or reduction in electrical/optical properties;

• Protection of exposed components, particularly when un-mated;

• Field-installable at remote sites;

• Economically priced, bearing in mind the above requirements; and

• Good availability and after-sales support.

Experiences with prototype generators have proven that the ideal product does not yet exist. Existing products will meet a number of the above requirements, but by no means all. It is, therefore, the task of the subsea connector industry to come up with innovative designs that will come as near as possible to meeting these without compromising one of the most important, price!

Present Methods of Connection

As indicated above, there are two main methods of connection — on the surface or underwater. These require two very different types of connector, dry- or wet-mateable, both of which have their own particular advantages and disadvantages.

A dry mate connector is by far the less complex of the two types and, thus, the cheapest by a factor of at least three when compared to a wet-mate. It would seem, then, sensible to use this product where possible. However, as described above, the need to raise the connector to the surface for mating or de-mating has many disadvantages in the time required and cable disturbance. Overall, the reduced cost is far outweighed by these disadvantages, and an evaluation of these will normally indicate that this is not the cheapest option overall. The main advantage of the use of dry-mates is that they are mated in a benign environment and seals can be tested before deployment. Wet-mates are, therefore, far more expensive to purchase, but will return significant cost-savings down-line. Wet-mates require connection to be undertaken subsea, and the procedures for this have to be devised. Systems using stab plates are the most viable, and a number of designs have been trialled already by the industry. The stab-plate is provided with features that allow certain misalignments to be accommodated during the mating phase.

The existing connector designs provide protection to the contacts when mated, and some even provide this automatically when un-mated. However, they are still lacking in some respects in terms of meeting the requirements of the extreme conditions.

Normal Connector Requirements for MRE

There are normally up to three separate connections to be made when hooking-up a generator: Medium Voltage/High Power (6.6kV and up to 150 amps), Low Voltage (24V, 5 to 10 amps), and Fiber Optic (anything from 2 to 12 optics). At present, there are connector options available for all of these requirements from other market sectors. The simultaneous mating of multiple connectors is provided by the incorporation of these into a stab-plate assembly, but any reduction in the number of connectors will vary significantly, reducing the complexity of the design and overall cost of the assembly. It is, therefore, worth considering the production of hybrid connectors that will contain more than one element in the one housing.

Design Features of the SEA CON® Hybrid

Any new design should incorporate as many proven features as possible while ensuring that the resulting product is innovative. To this end, it is the intention to utilize electrical contacts from a long established range of connectors as well as an optical element that operates on proven principles but is reduced in size. To meet as many of the requirements in terms of electrical and optical capacity, the operating voltage is set at 6.6kV(u), current at 250 amps (4 pins), and with 4 optical circuits. This will allow the product to be used on generators of up to 1 MW with ease or 2.5 MW maximum.

Great emphasis is placed on making the resulting connector as suitable as possible for long-term operation in shallow water (up to 100 m), and the design will utilize the most appropriate materials for the application. Not only will this product reduce the size and complexity of any connection system, it will also come at a significantly reduced cost.

Test Standards and Design Requirements

Many test standards exist both in the general electrical sector (IEC standards) and for subsea connectors for Oil & Gas applications (STATOIL specifications, for instance). While these are useful in establishing some test parameters, they do not cover the sector-specific requirements of MRE. It would be very useful to set up a joint industry project to set out the basic requirements for testing, even to the extent of producing an industry-accepted specification.

The connector design could also be considered for a degree of standardization, not in terms of how it actually works as this would limit innovation, but by specifying certain parameters such as depth rating, service life, maintenance periods, power capacity (typical voltages and currents), mating forces, misalignment tolerances, and more. The establishment of these factors as well as test requirements would go a long way to helping the connector industry produce products that are fit for purpose at the best possible cost.

Conclusions

A decision has to be made by any developer as to the merits of increased capital expenditure weighed against reduced operating costs — this is common to most emerging industries. However, increased capital cost would not be wisely spent on un-proven products. The device developers and the connector industry should be seriously considering working closely together to ensure that any product offered is “fit for purpose.”