ID8- DEVELOPMENT OF A ROV TITANIUM MANIPULATOR FOR LIGHT WORK CLASS ROV VEHICLES

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ABSTRACT
This paper shows the development of a high technical equipment to be used as tooling of submersible ROV (Remote Operated Vehicles) for offshore operations, particularly the design and fabrication by Additive Manufacturing (AM) of a Titanium Manipulator for ROVs. From the initial concept and design until a new formed company "TITANROB", this
document shortly describes the fabrication of hydraulic titanium manipulators for mid size ROV vehicles, the TitanRob series M501, G500 and the M700.

KEYWORDS
ROV, SUBSEA, MANIPULATORS, TOOLS, OFFSHORE

MAIN TEXT

1. COMPANY PRESENTATION AND TRACK RECORD

ACSM (Advanced Crew and Ship Management) provides global maritime services such as nautical management of vessels as well as complete services of submersible ROV vehicles for offshore projects with clients from all over the world. Established in 2001, ACSM key personnel have more than 20 years of experience in marine and subsea services for offshore operations. ACSM has international clients from UK, USA, Italy, Norway, France, UAE and other countries. We operate worldwide, mainly at EU, Mediterranean, and Middle East; and currently we are increasing our presence in West Africa.

ACSM operates and also provides ROV submersible systems services supplying Work Class hydraulic ROV systems, inspection electric ROVs, and subsea Cable Ploughs, with high qualified technical personnel (Supervisors, Pilots and Technicians) for operation, maintenance and management. For over 15 years ACSM personnel have worked with submersible systems aboard many cable ships and offshore vessels with almost all type of ROV systems including Perry Slingsby, SMD, Schilling, Saab-Seaeye, and Sub-Atlantic among others, as well as with SMD and EB submersible cable ploughs.

2. ROV VEHICLES, EQUIPMENT AND TOOLING

The ROV vehicles are used in almost all type of offshore subsea works and operations, equipped with surveillance equipment as cameras, lighting and obstacle avoidance sonar, other survey equipment for data recording as Bathymetry, Side Scan Sonars, Profilers, Doppler DVL, etc. Also hydraulic tools for underwater intervention as cable cutters, torque tools, gripper, grinder, and the manipulators as the main ones.

New technology used to be slowly introduced in the maritime and offshore industry, many times with a significant delay, mainly due to the fact that any equipment must fulfill the harsh marine environment conditions and high standards and requirements form the
Class Societies, Marine Administrations and other legal and safety requirements.

On 2014 ACSM supported by CIMA and Quantum, and investigation group and a spin off from the University of Vigo, started a project looking for some kind of equipment and technology not supported by any manufacturer or subsea equipment supplier. Our group founded that the hydraulic manipulators for ROV systems are supplied by only four companies, with just two of them servicing the 80/90 % of the market; Schilling for heavy WROV, and Hydrolek for light and small ROV system. There aren't standard electric systems or are no suitable enough.
There isn't any high quality equipment supply for small or mid size ROV vehicles, see above Fig. 1.
The titanRob series manipulators cover the gap of high quality manipulators for small and midsized ROV and WROVs

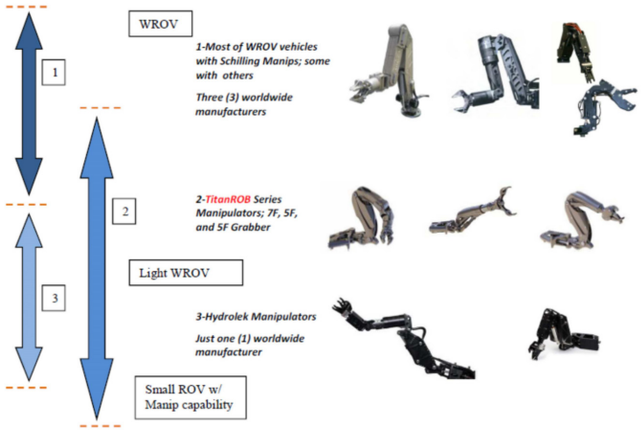


Fig. 1

3. DEVELOPMENT OF A TITANIUM MANIPULATOR

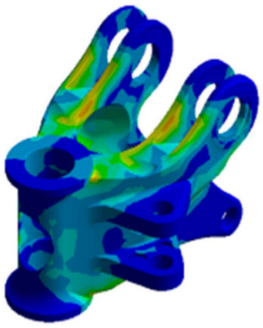
3.1 General and technical objectives

-Research and develop a new concept of anthropomorphic manipulator arm, developing and using
optimized techniques for manufacturing titanium by additive technologies (AM)
-Achievement of an arm with an excellent weight to load capacity ratio, which improves weight specifications, movement (4-7 functions), scope and workload of current manipulators
-Analyze current technical solutions determining advantages and disadvantages
-Versatile designs to develop general subsea works, with variability of functions (4 to 7)
-Adapt the design to AM techniques
-Besides the design and manufacture of equipment, provide ancillary services such as maintenance, repair and commissioning

3.2 Engineering development

The design and preliminary specifications of the TitanRob manipulator arm has been thought to meet the following requirements: Good relationship between own weight and load capacity; full mobility to reach different working positions; low hydrodynamic coefficient shapes; easily exchangeable commercial components.

Then, a five "degrees of freedom" prototype was defined with an operating range of 1 meter. Based on the general parameters, a series of preliminary sketches that helped define the desired aesthetic and functional design of the manipulator were performed
Next engineering works were carried out as follows:
-Adaptation of the design to the mechanical arm mobility: Parameters to consider are specified to allow for expected mechanical mobility in the arm
-Definition of kinematic scheme of the arm (4, 5 and 7 functions)



-Defining tolerances of the various parts, especially those involved in arm mobility
-Definition and selection of elements to provide mobility to the different arms: shafts, joints, hydraulic cylinders, etc.
-Establishment of mobility range for the proposed arms
-Hydraulic system design: Definition of the appropriate hydraulic power needs for the manipulator, pressure and flow (1 kW HPU, 1.5 l/min, 140-200 bar), definition of the hydraulic circuit and its main components, and selection of all the materials as hydraulic hoses and fittings, cylinders, screws, etc.
-Mechanical Design & Optimization: 3D CAD to define the different parts that make up the range of manipulator arms, and edition of first technical drawings
-Structures Optimization: The design of the system undertaken began with a preliminary model, which was subsequently modified to reach the final design or construction, then iterative process with structural FEA calculations in order to study the critical load conditions. Kinematic and dynamic simulations to determine if the parts withstand the operating conditions and to study possible interferences, FEA stress map.
Finally, the fabrication drawings were issued together with GA drawings, and revision of the final specifications.

3.3 Construction, Test, and Sea Trials

The fabrication of the arm itself is done by AM procedures: Selective Laser Sintering (SLS), Selective Laser Melting (SLM) and Electron Beam Melting (EBM) are the options, and finally it was decided to manufacture the set with EBM, as the most suitable option due to the titanium elements design, with no need of any post-heating process.

Finishing where necessary with different procedures such as milling, lathe works, metal fabrication, machining and surface treatments for parts, followed by dimension and alignment checks.
The assembly of the various mechanical sub-assemblies was held, and the manipulator was integrated into one ACSM ROV vehicle for FAT and SAT test, which were performed with excellent results.

A new company called "TITANROB" was created early 2016, with two sets of the M501 manip already sold, the G500 prototype built and tested, and the M700 prototype will be ready for test and trials by end of 2016. An electric manipulator is going to be develop in the near future.