

A NEW CONCEPTION OF ROV

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***Abstract.** ROVs (Remotely operated underwater vehicles) are today a very important tool for underwater research, especially because they can carry out many tasks, for instance, ability to make pipe's repairs, verify structures, manipulate hardware in hostile environment and recognition of disasters areas. ROVs are usually remotely human operated for that reason they should have an important level of maneuverability, low power consumption (autonomy of work) and the ability of carry out many task in challenger conditions. This paper is a review of the differents kinds of ROVs used in multiple projects and the development of the design of one ROV with only one helix that can reproduce all the tradicional movments, using only ONE mechanism for selection the work-plane and hydraulic system in order to modify the direction of movement. The Rov was designed based in 3 goals, low power consumption, maneuverability and future industrial implementation (ability to carry cameras, tools, sensors).*

***Keywords:** Industry application, Maneuverability, ROV, Underwater operation, Mechatronics Project)*

1. INTRODUCTION

This work was development as a challenge, is not the first time that a ROV (Remotely Operated underwater Vehicle) is designed or redesigned, but the interest of the authors was to design an new conception for this kind of robots, reducing the power consumption, increasing maneuverability and projecting the device for future industrial implementation; keeping is ability to carry out many different kinds of works, from water's tank inspections to ocean's research, finally the work compile some constraints and makes outlines for the ideal Rov structure

2. A BRIEF HISTORY

Before any instruments had been made for working on water, underwater task has to be carried out by divers, this was a enormous problem because the natural conditions could be an restriction for any work for example in winter is restricted the use of diver for high deep inspection, for these reason, was necessary to built some kind of instruments that can do the work (inspection generally, but in some case maintenance and research work); many solutions were found, but they can be divided in three groups, machines that are controlled and manned by humans (like submarines), Remotely operated vehicles (Rov's) and Autonomous vehicles (AV), first ones are generally used works of inspection and recognition of great areas or as warlike element, in other hand other Rov's was developed unmanned because in some cases despite of being protected by the submarine, the conditions for the work wasn't safe for humans (space, and duration of operation), for this kind of problem the Rov's was used they are remotely (as his name say) operated far away for the place of the operation, maintaining safe the operator for the risk conditions (A.R Frost 1995), finally AV's are used in task that not requires directly human's supervision this task are limited by the autonomy for the AV and his ability to do complex operations.

At the beginning the Rov's was only implemented for high deeps inspections, because the state of the art was not improved enough to leave a man until there, for this reason, rustic vehicles was implemented, they only carry one camera and the umbilical cable in order to keep the system working (it carries communication and power wire), to manipulate the Rov, the operator has to be careful and try to control this new equipment without any help, not only in the working area, also while the Rov do the travel for the surface to the work area, sometimes it was the most difficult task for the operator.

Nowadays the Rovs carry out many tasks as new kinds of work are invented for the humans, inspection of sea resources or maintenance work, the actual Rovs are adapted to work in high pressure environments and the operators has many helpful tools to guide his robot, extending the scenario or work, for this reasons new kind of these device will be proposed to be able to work in all kind of conditions. (Widder E.A 2004).

2.1. Concepts for the Rovs.

Typically the Rovs has 4 basics characteristics, the weigh-dimensions, control strategy, tools and performance, those characteristics has to figure out how to solve all problems associated for the Rovs, like communications, reliability,

operating complexity, technology and economics restrictions, it can be seen on Figure 1, all this information has to be in a mind when it's talking about Rovers.

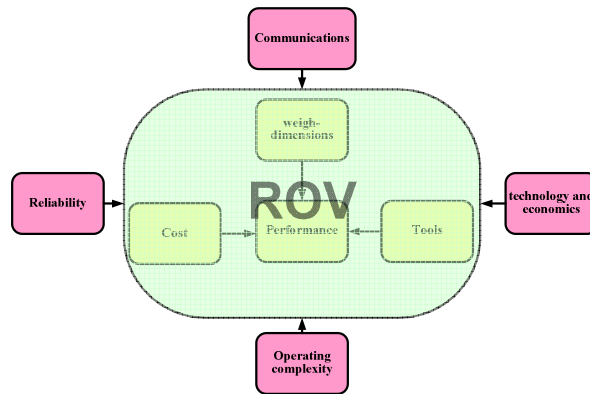


Figure 1 ROV's characteristics

All of these conditions and restrictions has to work as a team, the problem always consist find the right combination, for example, you can not decrease the operating complexity or cost without losing reliability this is a typical problem on the ROV's industry.

In the other hand is important the kind of tools that a ROV can carry, all ROV's are equipped by cameras, lights and thrusters in order to make the robot turn and move on, besides of that, small robotics arms is often add, the finality is to help the operator to solve easy problems at the moment of the inspection saving time (is a common operation to "call" the ROV to go to the surface and change the arm for a correct tool) (Kreuzer Edwin.1996).

Other important characteristics is the buoyancy of the ROV, because is important that the ROV always prone to go to the marine-bed, this is a security feature, an is implanted for the reason that if the ROV failed, would be dangerous to has an uncontrolled object travel to surface, an equipment and humans will be in a dangerous situation.

Finally in order to close this section, are many kinds of ROV's on the market, and many ways to design their, but is possible to say that all this kind of robots has the same features explained before, but in this work will be presented a new conception for the design of the ROV, specially is design a mechanism able to generate theirs movements without loosing as characteristics explained before.

2.2 Restrictions.

The Rovers, as it can see in the last section, has many advantages in comparison for others kinds of device in order to solve specifically problems, but unfortunately is not the panacea for the problems, it has many restrictions and this work present one solution for a combinational and conflictive problems, but that will be talked later, so far, its important to keep clear the diverse restrictions for the Rovers, the first one is autonomy, it depends in a high degree for the umbilical's cable length, because it is the source of energy and the way where communications are working, at the same time the human operator experience will be a restriction for the ROV, for these reason many projects was oriented to help to the control of the ROV (Silva M 2001). Other important restriction are the communications, because all the data capture for the ROV (image and sensor) will be posted in real time for the operator, this feature let him to take the correct decision and to make the correct movements to avoid a possible accident.

3. THE CHALLENGE.

Was posted the restrictions for design a ROV that could work with the minimum of elements and only one thruster, this characteristics, can not reduce the flexibility of the movements, that are surge, heave and sway, is important to mention that this kind of motion is specially useful when the operator is working in maintenance task, because the ROV would be follow some artificial path (a pipe line for example) or manipulated some tools that requires precision movements. Posted this frame, the author's work in specific areas, the first one was looking forward to reduce the numbers of thrusters.

As was mentioned before ROV's has frequently an important number of thrusters in order to control its movements, traditionally the number implemented is 4 providing all the liberty for movement but increasing the numbers of close loop controls, maintenance and calibration work. for these reason the idea to use only one thruster is attractive, the only inconvenient is the flexibility that the ROV will be have, because in many case the numbers of thruster associated with the numbers of degrees of freedom for the robot.

4 NEW CONCEPTION.

In order to follow the last section the first topic talk here was the implications of use one thruster, as mention before, this idea will be the solution for the high complexity for the control (reducing the motors to be controlled) but make that this thruster turn and drive all the Rov is a little more complex that have the little 4 motors and theirs respective controls, for this reason a principal static thruster was proposed and a auxiliary mechanism was designed for give the flexibility to the new Rov.

The external mechanism is very important because it will make the Rov moves in the desire direction, the idea for achieve this objective can be see in the Figure 2, the Rov, consist in only one fixed thruster with one nozzle (in order to capture all the water and drive it for the arms of the Rov, those arms are the new hardware for this kind of Rovers and has a little conjunct of fins that will help the Rov to has a complete set of movements)

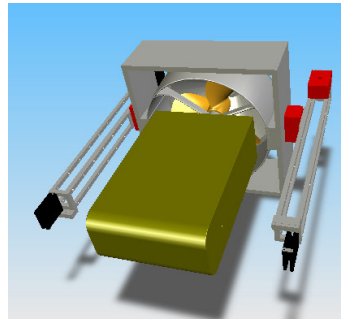


Figure 2 New Conception

The new arms on the Rov has the ability to turn on its axis, it will be helpful went the Rov needs to makes some immersion move. This arms carry inside of them two hoses, that conduces the water capture for the thruster and pull them out in specially direction (front or behind the arm), this selection is taken by the set of valves and for the control of those valves, this is one specific characteristics for this new conception, the use of valves and hose to move the Rov.

The hose used combined in perfect coordination with the arms will make the Rov turn in perfect sequent, besides of that the operator don't have to worry about active the correct valves theses is the labor of the central control that have the next task.

1. Control of the fixed Thruster.
2. Control of the arms
3. Control of the Valves
4. Control of the fins.

All these 4 controls will make the Rov work and navigate in perfect direction, the movements of the Rov is explained in the next section.

4.1 Possible movements.

The new kind of movements for the Rov are very simple, as can see at Figure 3 and Figure 4 this figures shows the arm's movement of the Rov, this kind of moves let the Rov turn and move side by side, it is helpful because in some case is necessary to move in parallel for the work area (because if the Rov turn the camera wouldn't capture the work area and the operators "lost" the objective for work).

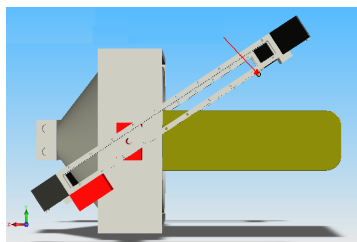


Figure 3 Lateral view

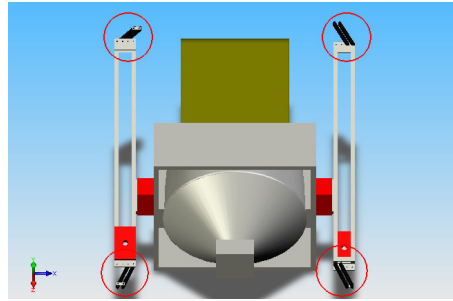


Figure 4 Fins

All those moves generates diverse kind of movements the set of the specific moves can be represented by a correct combination of the elements before mentioned, this set of specific movements can be watched on Figure 5, were the blue arrows represents the flow of fluid, and the red arrow the direction of the movement, as we can see on the figure, the movements on the plane of work could be carry out without changing the hardware drastically, Really, the only things that change are the fins and certainly the valves combination, but the operator can change the movement configuration without wasted energy and time, is visible the importance of a precise calibration of the device (mass center, buoyancy center) to carry out the movements.

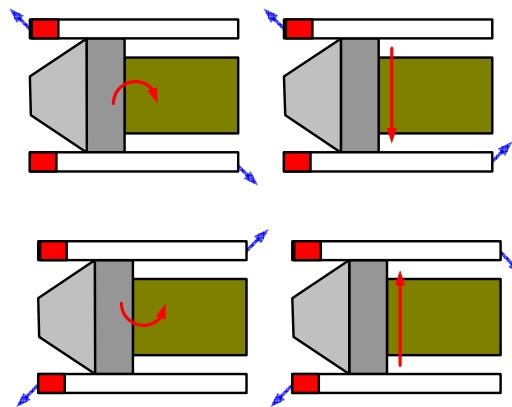


Figure 5 Diverse kind of movements and configurations

Finally the ultimate movements are the heave moves that will leave the Rov from the superficies to the deep ocean, this moves are obtained turn up or down the arms leaving the Rov horizontally or vertically, the operator take the decision, and put the arms in the correct position.

Other interesting possibility is to make the Rov a little independent in the travel trajectory, this his while it is between the surface and the work area, with this kind of Rov, this task will be easier, because now the mechanism will be guaranties that the Rov is parallel to the surface, and would be follow a line until the deep-sea.

5. FUTURE WORK REFERENCES

In order to develop this idea is important to make hydrodynamic studies to figure out how the Rov reacts to diverse conditions, at the same time, will be helpful to make a prototype in order to experiment different natural conditions and Rov response for the operators instructions (it is the more important stage, because a Rov is only a extension for a operator and if him don't make the Rov follow a simple path all the technology involving on the Rov will be wasted). In the other hand is important design the nozzle, because an incorrect selection of this part, will be reduce the performance of the device.

6. REFERENCES

A.R. Frost, A.P. McMaster, K.G. Saunders and S.R. Lee. 1995 The development of a remotely operated vehicle (ROV) for aquaculture. Aquacultural Engineering, Vol 15 No 6

- Caccia M., Veruggio G. 1999. Guidance and control of a reconfigurable unmanned underwater vehicle. Pergamon Control Engineering Practice.
- F.R Driscoll, R. G. Lueck, M. Nahon 2000, The motion of a deep-sea remotely operated vehicle system Part 1: Motion Observations, Ocean Engineering N 27
- F.R Driscoll, R. G. Lueck, M. Nahon 2000, The motion of a deep-sea remotely operated vehicle system Part 2: Analytical model, Ocean Engineering N 27
- F.R Driscoll, R. G. Lueck, M. Nahon 1999, Development and validation of a lumped-mass dynamics model of a deep-sea ROV system. Applied Ocean Research
- Kreuzer Edwin. C. Pinto Fernando 1996. Controlling the position of a remotely operated underwater vehicle
- Ming-Chung Fang, Chang-Shang Hou, Jih-Hong Luo. 2005 On the motions of the underwater remotely operated vehicle with the umbilical cable effect. Elsevier Ocean Engineering 34
- Silva M. Zanoli. Giuseppe Conte. Remotely 2001 Operated vehicle depth control. Control Engineering practice N 11.
- Widder E.A, Robinson B.H., Reinsenbichler K.R., S.H.D. Haddock (2004). Using red light for in situ observations of deep-sea fishes. Elsevier Deep-sea Research.

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