DEVELOPMENT OF HYDRAULIC CRANE WITH BASE ON PASCAW LAW: ACADEMIC PROJECT IN THE MECHANICAL ENGINEERING COURSE

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Abstract. With the growing importance of developing skills in students of engineering courses, where the traditional model of education has highlighted the deepening of knowledge in the disciplines contents, leaving aside the formation of skills and attitudes, it shows in the educational institutions, innovations in models to develop their students.

This article highlights the experience of an academic project using the concepts of Pascal's Law in Fluid Mechanics discipline. With freedom of choice, students should develop a hydraulic device. Crafted entirely by actively Project Based Learning method (PBL), the discipline makes up the curriculum of the 4th semester of Mechanical Engineering. Located in Lorena (SP), the course is taught in UNISAL (University Center of São Paulo) brazilian higher education institution that is at the forefront of innovative learning methods.

The purpose of this article is to demonstrate the practical application of Pascal concepts in the development of a fixed crane using recyclable materials in its structure and representing its functionality through the use of different sizes of syringes. The fundamental concept is the application of a specific force in a given area, in order to calculate the pressure at this point. The supports used for balancing the crane while avoiding the overturning of the same, were made from four syringes with the same diameter, representing the footpads. For luffing, two syringes were used with a diameter twice that of the outriggers syringes, to withstand high load. For the telescopic boom three syringes of different diameters were used in order to represent the length of the boom and subsequently the retraction of it.

The project is to create a device with controlled movements by radio frequency and that its main functions are driven by syringes. Moreover, safety sequences were developed to avoid the shifting device with the high weight and rotation of the boom in an accelerated manner. Aimed at economy and efficiency of the devices, setting the crane will be calculated in every way possible based on Pascal's law.

Developed over 6 weeks, the principle is the determination of the payload and the time range. Through an initial draft, it became the design of the rotating system, in which the load simulation was done by checking reactions and tensions. From cylinder specifications (bore and stroke), the pump, the design and working system were adequate in order to scale the rest of the hydraulic system. At the end of the project, it was found that the application of Pascal's law provided the movement of cargo through the minimum effort.

It's Important to emphasize the delegation of duties between members of the group, facilitating the learning process and especially the capacity for decision making, as with the involvement of all during the project development led to the practical application of the theory asserted evenly inside the team.

Keywords: PBL, Active method of teaching, Pascal Law, Hydraulic Crane, Fluid Mechanics, Mechanic Engineering.

1. INTRODUCTION

The crane is a machine used for lifting and moving loads and heavy materials, using the physical principle on which one to move beyond human capacity. They are employed in industries, port and airport terminals, which requires large mobility in cargo handling and transport of a primary source to the vessel, train or primary element transport, a transport vehicle or place deposits. You can download and upload containers, organize heavy material in large deposits, moving heavy loads on construction and known cranes and mobile cranes widely used in industries rolling and heavy-duty engines.

The first cranes were invented by the ancient Greeks and were powered by men or pack animals. These cranes were used to build cars and buildings. Higher cranes were subsequently developed using gears driven by human traction, allowing the lifting of heavier loads.

In construction, the cranes are temporary structures fixed to the ground or mounted on a special vehicle, usually on the side of the building, used for lifting heavy loads to the higher floors.

The cranes can be operated with cabin where there is a controller or operator, by a small control unit that can communicate via radio frequency, infrared or connected cable.

The hydraulic articulated crane is a mechanical assembly hydraulically driven and constitutes a device that is part of the vehicle. Should allow the gathering arm of his spear and telescopic extensions through joints, fully accommodate the supporting device without interfering with the geometry of the vehicle. NBR14768 (2001).

2. PROJECT BASED LEARNING (PBL)

In order to reconcile the presentation of an increasing volume of technical and scientific knowledge to the need for working skills and attitudes such as independent and continuous learning ability, teamwork, respect for diverse and ethical opinions, there are already several interesting alternatives to teaching in the conventional higher education, including the Problem-Based Learning (PBL) (Ribeiro, 2008).

The PBL is a teaching methodology using a collaborative, constructivist and contextual learning process in which problematic situations are used to initiate, direct and motivate the learning of concepts, theories and the development of skills and attitudes in the classroom context (SAVIN-Baden, 2000).

Through the application of PBL, the development of freeform design was possible by learning according to need and during the project. With the passage of time and the evolution of work, we achieved the ability to solve the problem in a practical and prestigious way.

The success of the project was in line with the beginning of the commitment to finish, from the definition of work to the project, definition of the material, handling of the equipment in a safe way and final assembly of the structure.

3. PROJECT

In a hydraulic system we have to take into account all parties, because they are immensely important for proper operation, including the areas, applied forces, loads, until the fluid between them.

During the research, we came across several projects, such as hydraulic bridges, hydraulic lift, hydraulic crane, hydraulic press, among others. Through group meeting, we decided to apply the knowledge gained by building a crane whose needs were to represent the attachment of the crane on the ground through outriggers (4 syringes 10ml), telescopic luffing (2 syringes 20ml) and the advancement of the telescopic boom (1 syringe 20ml and 10ml syringe 1, both interconnected to ensure the displacement of 14mm boom). Just below lies a simple illustration of the Project.

Fluid is a substance that has the ability to drain. When a fluid is subjected to a tangential force, it deforms continuously, in other words, when placed in a container the fluid acquires its format.

It can be considered as liquid fluids and gases. Particularly when we speak in liquid fluids, we must speak about their viscosity, which is the friction that exists between the molecules during a move. The lower the viscosity, the easier the fluid flow.

During the development work, we use water, which is a liquid easily found in the environment, also considering a runoff. For the coloring of the liquid, we used a product known as "aniline", easily found in candy stores and parties due to the need to add color to the fluid used.

According to Hibbeler (2009), "the engineer responsible for the design of structural elements should restrict the mechanical stress of the material to a safe level. "

Blaise Pascal (1623-1662) was a physicist and philosopher. The physical principle that is used to lift hydraulic gas stations and hydraulic brakes was discovered by Pascal.

From a mathematical point of view, this law is expressed by: A force F acts on the open surface (in which forces act) resting in a fluid contained in a closed space, causing pressure extending across the fluid, which is translated by the Equation 1:

$$P = \frac{F}{A}, (1)$$

The pressure "P" is measured in Newtons per square meter (N / m²) or Pascal (Pa), because the intensity force "F" is measured in Newtons and the area "A" in m² and because 1N / m² corresponds, by definition, 1 Pa (Pascal).

4. THEORETICAL AND PRACTICAL DEVELOPMENT OF THE HYDRAULIC CRANE

Before building the hydraulic crane, we define and research the lifting capacity of a given load to the choice of which of the syringes would be used.

To build the hydraulic crane we formulate some prerequisites:

Table 1 Materials Used

Type of Material	Quantity	Dimensions
Syringe	1	5 ml
Syringe	5	10 ml
Syringe	2	20 ml
Fuel Hose	1	16 meters
Junction / Union	3	-
Timber	1	2 meters
Aluminium bar	1	3 meters
Screws	20	-
Hellerman tape	30	-
PVC pipe	1	1 meter

During the search process for the development of hydraulic crane, we analyze the resilience of the materials used with respect to the load that would be handled. According Hibbeler (2009) "that branch studying the relations between external loads applied to a deformable body and the intensity of the internal forces that act within this body. This issue also covers the calculation of the deformation of the body and the study of its stability when it is subjected to external forces. "

With the material already in hand, and with the design done, we began the construction of the hydraulic crane.

The timber was cut according to measurements for mounting the support structure, and then we did the development of the control box, connecting hoses and "Ts" for joining, and development of the telescopic boom.

After the development of parts, we made the installation and assembly of the entire structure.

Considering all the mechanical and visual part of the project, we also work to electrical parts, making the connection of two (2) VCR engines with a reduction of about 1200RPM for 82RPM, wherein each motor with reduction gear has different function in design. One of the engine was used for the rotation of the boom by 180 ° (90 ° right and 90 left).

The angle of rotation with respect to that line launches and supported by the rest cradle forms an angle of 0º.

In development work, we used a DC motor of approximately 1200RPM and a reduction gear that reduces to approximately 82RPM. It was applied in a second gearbox 6 (six) gears to increase the torque that the nylon cord suffers for lifting the load. This nylon cord is wound into a rotatable coil in reel format so as to make the cable pickup.

Along with this engine a limit switch has been adapted that upon activation, causes the boom to lower the speed by making a 180º spin.

Two on / off key models were used for the activation of the two motors, which is triggered after activation of the crane outriggers.

The study of the hydraulic crane will be limited to the observation of the effects caused by application of external forces, without, therefore, observe the effect of internal stresses resulting from the manufacturing processes (rolling, bending, machining, welding, etc.). The main problem to be solved with the area of resistance of the material is the dimensioning of the beams.

According to Fialho (2008), "the analysis of the structural components will be treating their bodies as beams ". In this case, as a beam supported at one end and the other cantilever, or clamped at one end and free at the other. There is a need, especially where no beams have a constant section over the length, using the finite element method, and new technological tools that incorporate them.

Figure 1 - Practical Development Hydraulic Crane

5. CALCULATIONS

- Outriggers: Syringe 10ml (d = 0,014m / Fpl = 5 kg)

$$A = \frac{\pi \times d^2}{4} \gg A = \frac{\pi \times (0,014)^2}{4} \gg A \cong 1,54 \times 10^{-4} \, m^2$$

$$P = \frac{F}{A} \gg P = \frac{5}{1,54 \times 10^{-4}} \gg P \cong 3,25 \times 10^{-4} \, Pa$$

- Guide Launches Telescopic: Syringe 20 ml (d = 0,018m Fp = 1 kg):

$$A = \frac{\pi \times d^2}{4} \gg A = \frac{\pi \times (0,018)^2}{4} \gg A \cong 2,54 \times 10^{-4} \, m^2$$

$$P = \frac{F}{A} \gg P = \frac{1}{2,54 \times 10^{-4}} \gg P \cong 3,93 \times 10^{-5} \, Pa$$

- Telescopic Boom: Syringe 20ml and 10ml (d1 = 0,018m / Fp = 0.250 kg / d2 = 0,014m):

$$A = \frac{\pi \times d^2}{4} \gg A = \frac{\pi \times (0,014)^2}{4} \gg A \cong 1,54 \times 10^{-4} \, m^2$$

$$P = \frac{F}{A} \gg P = \frac{0,250}{1,54 \times 10^{-4}} \gg P \cong 1,62 \times 10^{-5} \, Pa$$

$$A = \frac{\pi \times d^2}{4} \gg A = \frac{\pi \times (0,018)^2}{4} \gg A \cong 2,54 \times 10^{-4} \, m^2$$

$$P = \frac{F}{A} \gg P = \frac{0,250}{2,54 \times 10^{-4}} \gg P \cong 9,84 \times 10^{-6} \, Pa$$

$$Pt = P1 + P2$$

$$Pt = 1,62 x 10^{-5} + 9,84 x 10^{-6}$$

$$Pt \cong 2,604 \times 10^{-5} \, Pa$$

6. CONCLUSION

Through the application of Pascal's concepts, it was possible to develop a lifting loads system, applying the minimum of effort required to do so. Design of a Hydraulic Crane gave up on the idea and purpose of monitoring the design process, schedule Organisation, Definition and necessary material for sale, in addition to manufacturing and system assembly.

The project was developed in the course of six (06) weeks, giving the ability to acquire and apply seen concepts in the classroom and in addition to all system features, such as the application of mechanical concepts Fluid, Electrical Circuits and Physics, aiming that besides the project has been established for only one of the aforementioned disciplines, it took apply other knowledge acquired, such as the lifting of loads, application circuits and electrical controls, account for certain features of the crane.

During the design and project planning, some information relevant to the type of work to be done, and this was a free choice, deadlines to be followed to present the prototype and information as materials and methodology to be followed. From the definition of the elements needed for the project, was initiated the manufacture of specific components such as bushings, fixing joints of hoses, support structure development and installation of electronic components, in addition to the system connection via a remote control .

Each person responsible for the project development has taken responsibility for a necessary factor, such as purchase of materials, solutions development, research, organization of information and system assembly and the definition of a member of the group is responsible for taking the main decisions and guidance of others, with the ultimate goal and the completion of the project.

Throughout the process of development work, several difficulties and shortcomings were found, and from this it was possible to develop the ability to troubleshoot problems and develop technical and logical nature, and may be concluded that with the development of the calculations, assembly crane and final testing, we learned that we can apply the concept of Pascal in lifting loads, ensuring less effort.

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