Design and Development of Hydraulic Scissor Lift

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Abstract - *In modern manufacturing world automation plays an indispensable role, when it comes for superior product quality for customer satisfaction and market sustenance. With the help of automation it is possible to achieve higher production rate without compromising in product parameters. In automation Fluid power systems play a vital role due to their efficient working and performance as compared to those of the conventional mechanical systems. The fluid power systems can be interfaced with PLC to automate the operation leading to more accurate and consistent product quality. For this paper, case study was taken where manual material handling system is automated by integrating the mechanical system with PLC. In conventional system, human intervention was more, so the time consumption was also more. With the advent of hydraulic power pack, Scissor lifter mechanism and sensor, human intervention can be reduced which in turn will result in increased efficiency and accuracy with optimization of production time.*

Key words- *Hydraulic Lift, Automation, Design, Manufacturing, Material Handling, Fluid Power, sensor.*

1. INTRODUCTION :

In today's modern era, Industries are emphasizing the use of Automation and robotics in each and every task due to which human intervention is reducing significantly. Through increased accuracy and optimized timings, automation has potentially brought drastic changes in the field of Material Handling within these manufacturing firms. This research deals with the case study where manual material shifting from one level to other is eliminated by utilizing an automated hydraulic scissor lift.

A scissor lift is type of platform that can lift semi-finished or finished products in vertical direction. Scissor lift is easy to operate and widely used at industries and other common places due to their convenience. The mechanism incorporated to achieve this function is the use of linked, folding supports in a cross-cross 'X' pattern, known as a pantograph. All safety considerations need to be taken into account while designing equipment or product handling devices. Scissor lifting mechanism is designed to lift person,

materials and loads smoothly to desired height. A scissor lift provides most economic, dependable and versatile methods of lifting loads; it has few moving parts which may only require lubrication. A scissor lift mechanism is used to extend or retract a platform by hydraulic, pneumatic, or mechanical means. The scissor lifts can be classified according to energy used as hydraulic, pneumatic or mechanical. Each of these mechanisms has its pros and cons, which are studied and modified according to its application in various industries. The frame is very sturdy & strong enough with an increase in structural integrity.

In this research, the hydraulic system which operates the lifting platform is automated by using proximity sensors and actuators. The system automatically detects that material is ready to be elevated or brought to shop floor. According to action required hydraulic cylinders are actuated to either raise or lower the platform. Following is the primary problem statement given by manufacturing firm within which this case study is implemented.

2. PROBLEM STATEMENT :

In the automotive firm under consideration, Machine shop floor is at some elevation and Quality inspection section is at lower side. So there is problem of lifting, loading and unloading of material. Considerable manpower is also required to manually lift the load. This can be potentially overcome through stationary Hydraulic Scissor Lifting table of capacity up to 2 tons. Following are the detailed requirements:

1) Lifting capacity: 2000 kg
2) Total lift: 1m
3) Height below ground level: 300 mm (@1ft.)
4) No of cylinders: 2
5) Power pack 3 HP / 3 phase, 40 litre oil tank
6) Top size: 2m x 1 m plate on top
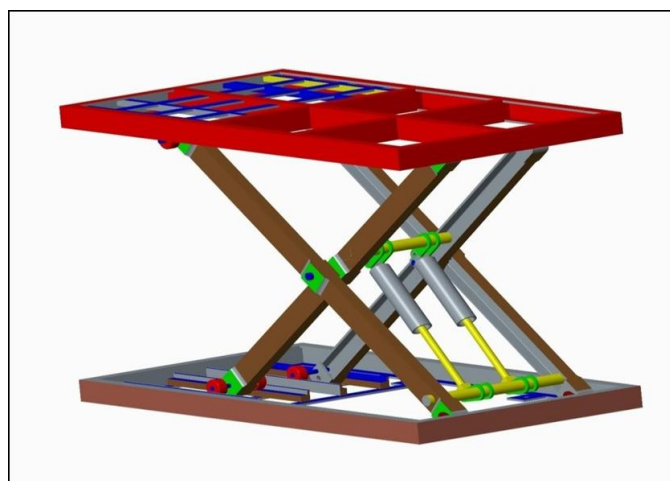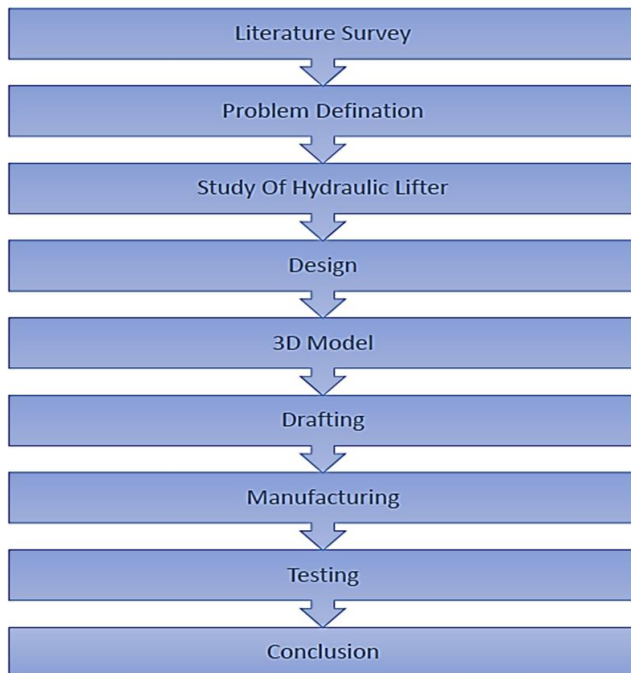7) Bottom size: 2m x 1 m Structure at bottom.

3. METHODOLOGY :

Fig -1: Hydraulic Scissor lifter

Raising a scissor lift table:

Since one end of both the inner and outer legs are connected to the base and platform, the platform rises vertically as the scissors legs open. The free end of the scissors legs are fitted with rollers that run in the base. Any time a lift table is raised, it is being supported by a column of fluid. The lift table remains in a raised position because the fluid is held in the cylinder and pressure relief valve is active. A lift table's up speed is a function of the hydraulic pump and the motor that is turning it. The desired up speed and capacity to be lifted determine the amount of work the motor has to do, thus the horsepower required. If a lift table needs to move faster, it will take more horsepower. If a lift table has to have greater capacity, it will also take more horsepower unavoidable.

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Lowering the Lift Table:

High-capacity scissor lift table is lowered by opening a down valve that allows fluid out of the cylinder at a controlled rate. This down valve is solenoid operated and a normally closed type valve, which means it stays closed until the electric solenoid is actuated. This feature prevents the lift table from lowering if there were a power failure. When the solenoid opens the down valve, the fluid returns to the reservoir. The down speed of a lift table is a function of controlling how fast the fluid is allowed to leave the cylinder. This is done with a flow control (FC) valve. The FC valve is pressure compensated, which means it regulates the flow to a predetermined range whether the lift is loaded or empty. These FC valves are fixed rate or non-adjustable and typically the lift table's down speed is matched to lift table's up speed.

5. INFORMATION OF COMPONENTS USED :

1. Scissors Links: this component is subjected to buckling load and bending load tending to break or cause bending of the components. Hence based on strength, stiffness, plasticity and hardness requirement, stainless steel is the right selection.

2. Hydraulic Cylinder: This component is considered as a strut with both ends pinned. It is subjected to direct compressive force which imposes a bending stress which may cause buckling of the component. It is also subjected to internal compressive pressure which generates circumferential and longitudinal stresses all around the wall thickness. Hence necessary material property must include strength, ductility, toughness and hardness. The recommended material is mild steel.

3. Top Frame: this component is subjected to the weight of the workman and his equipment, hence strength is required, the frame of the plat form is mild steel and the base is wood.

4. Frame: this component is subjected to the weight of the top plat form and the scissors arms. It is also responsible for the stability of the whole assembly, therefore strength. Hardness and stiffness are needed mechanical properties. Mild steel is used.

5. Roller: We use eight rollers in scissor lifter. Each roller contains two bearing.

6. Support Plate: It is connected to base frame. In our project we have used 6 support plates which is to be bolted to ground.

7. Clits: We use total eight clits for Cylinder Mounting. It has two holes having 20 mm and 50 mm diameter. Centre distance between two holes is 90 mm.

8.Programmable Logic Controller Unit (PLC) - Programmable logic controllers (PLC) are being widely utilized today for controlling various manufacturing processes and they have significantly reduced human intervention in operations on assembly lines. These industrial digital computers have applications in many robotic devices, activities that require high reliability, ease of programming and process fault diagnosis. PLC come in variety of sizes as per the application requirement, ranging from small ten input/output device with integral processor up to the large rack sized device having thousands of I/O joined with various networks of other PLC and SCADA systems.

Fig -2: Programmable Logic Controller

PLC can be designed to diversify their application range; they can be built to work in increased range of temperatures, electric noise proof, resistant to vibration and impact to suit their working conditions. The programs which control the machine operation are stored in non-volatile memory with battery backup.
PLC consists of:
• A processing unit (CPU) which interprets inputs, executes the control program stored in memory and sends output signals
• Power supply unit which converts AC voltage to DC,
• Memory unit storing data from inputs and program to be executed by the processor,
• Input and output interfaces, where the controller receives and sends data from/to external devices
• Communications interface to receive and transmit data on communication networks from/to remote PLCs

Control System Used:

The PLC used for the project is Allen Bradley Micrologix 1200/1762 Series C with 16 digital inputs and output.
For communication with external devices like sensors, actuators and systems like programming software, SCADA, HMI, PLCs use buit in port such as USB, Ethernet, RS-485, RS-232 and RS-422. For communication we used RS-232-C port which is built-in in Micrologix 1200 controllers. Communication is carried over various industrial network protocols which are vendor specific, like Modbus, or EtherNEt/IP.

PLC programming was so designed that engineers having no programming background can also use it. The ladder logic or ladder diagram are now standardised by manufacturers. This ladder logic is written in programming device which can be desktop console, specially designed softwares by manufacturers with computer etc. Written programs are downloaded in the PLC directly and stored in non-volatile RAM. Few PLC also use programming board which writes the program into removable chip, such as EPROM.

In order to properly understand the operation of a PLC, it is necessary to spend considerable time on programming, testing and debugging PLC programs. PLC systems are inherently expensive, and down-time is often very costly. In addition, if a PLC is programmed incorrectly it can result in lost productivity and dangerous conditions. PLC simulation software can save time in the design of automated control applications and can also increase the level of safety associated with equipment since many "what if" scenarios can be tried and tested before the system is activated. RSLogix software was used for simulation of ladder logic for this project.

5. DESIGN OF LIFTING MECHANISM:

1) Lifting capacity: 2000 kg
2) Total lift: 1m
3) Height below ground level: 300 mm (@1ft.)
4) No of cylinders: 2
5) Power pack 3 hp / 3 phase, 40 liter oil tank
6) Control panel: Motor: on during lift & only coil on during down with limit switch and auto control height of lift panel suitable to lift
7) Top size: 2m x 1 m plate on top
8) Bottom size: 2m x 1 m Structure at bottom.
SO,
1. Design Load= F.S Max. Load
$\qquad$ = 2.2 2000
$\qquad$ = 4400Kg
2. Total Mass = 5200Kg

3. Total Load = 5200 9.81
$\qquad$ = 51012 N

4.   Material Properties & Assumption = Mild Steel

5. Yield Strength = 250MPa
6. Torsional Stiffness = 379125Nmm/Degree

6. DESIGN OF HYDRAULIC CYLINDER:

The surface area of the piston is the area that the air pushes against to outstroke the piston. This area is circular. The force produced when a single-acting cylinder outstroke's is calculated using the formula. Where force is measured in Newton's (N), pressure is measured in N/mm2 and area is measured in mm2.

In some situations, we would know the size of the force needed to do a job properly. In this case, we would want to calculate the pressure needed or the size of the piston. To do this we need to rearrange our formula

1. As our design model consist of 2 actuators.
2. Load acting on cylinder = 51000/2 = 25500N
3. Actual load on cylinder 25500 cos15 = 24631.10
4. Considering for factor of safety and dead weight Load = 25000 N
5. For cylinder design, we use pressure is 30bar i.e. 3 N/mm2
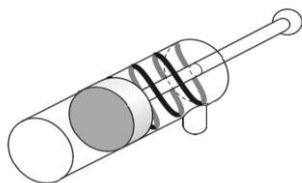6. Hence, we selected 40 mm diameter each.

Fig -3: Hydraulic Cylinder

DRAFING OF 3D MODEL-

ITEM NO.	PART NAME	MATERIAL	QTY.
1	BOTTOM-FRAME	M.S.	1
2	SUPPORTING-BRACKET	M.S.	8
3	LINKS	M.S.	4
4	TOPER	M.S.	1
5	PIN25	EN31	2
6	ROLLERS	EN31	8
7	PIN-20	EN31	4
8	PIPE-890	M.S.	1
9	PIPE410	M.S.	1
10	CUTS	M.S.	8
11	CYLINDER	STD	2

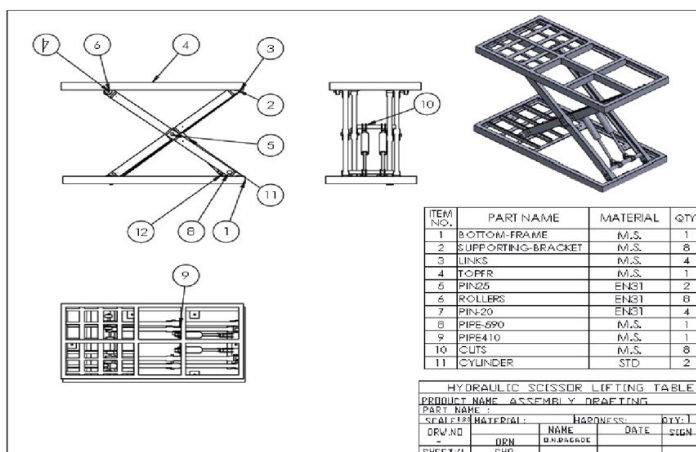| HYDRAULIC SCISSOR LIFTING TABLE			
PRODUCT NAME ASSEMBLY DRAFTING			
PART NAME :			
SCALE1:3 MATERIAL :	HARDNESS:		QTY:1
DRW.NO	NAME	DATE	SIGN
	DRN D.N.PAGADE		
SHEET/L	CHD		

Fig -4: Technical drawing of 3D Model

7. POWER PACK USED:

Hydraulic power pack is a self-contained unit that consists of motor of 3HP/3 phase and hydraulic pump. It uses fuel to transmit power from one location to cylinder. Capacity of oil tank is 40Ltr.

TECHNICAL FEATURES:

1. AC electro-hydraulic unit, easy-to-assemble, compact
2. Modularity offers many combinations of hydraulic circuits to suit various requirements
3. Main applications are in industrial automation such as machine tools, the food or textile industry or power engineering
4. 8 optional central block basic circuits see ZB06 (HA0010) data sheet
5. Possibility of building up an additional circuit in the form of vertical or horizontal stacking assembly
6. Three-phase motors with power ratings of up to 7.5 kW
7. Tank capacities from 10 to 250 l
8. Regulated and constant gear pump options
9. In the standard version, the steel basic block is phosphate, oil tank and cover are painted and steel plates are zinc-coated for 240 h protection acc. to ISO 9227

FUNCTIONAL DESCRIPTION:

1. This technical information serves as a basic summary for configuring and building hydraulic power packs designed from standardized sub-assemblies.
2. Table 1 supports the selection of the required combination like tank capacity, pump type, flow rate, pressure, size of the electric motor, type of pressure control etc.
3. If you cannot find the required solution using the components shown below, please consult with us. We can offer standard and special oil tanks, remote control of components, drives with double pumps, special component connections etc. On request, also the separate components can be delivered.
4. A questionnaire, which is enclosed with this information, also should help you specify your requirements. Please enclose also the respective circuit diagram, the required installation dimensions, as well as the size and orientation of the connecting ports.
5. That we can offer you a power pack, which will comply completely with your requirements, we need exact information about your system.
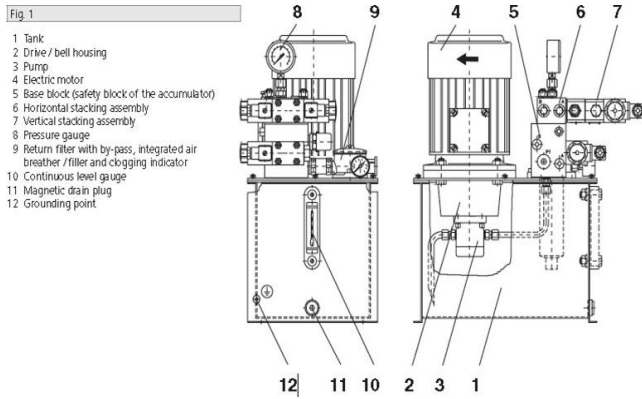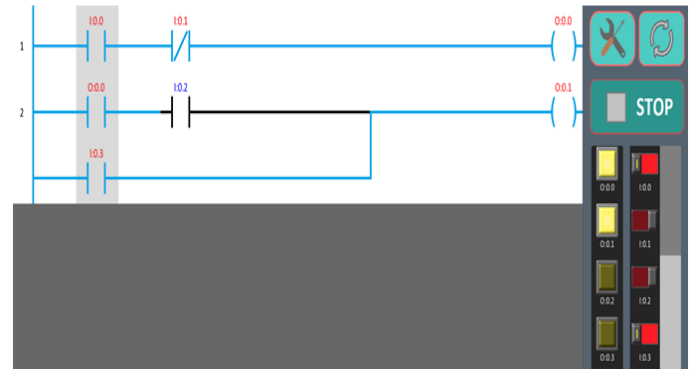6. The following schematic figure shows the hydraulic power pack system.

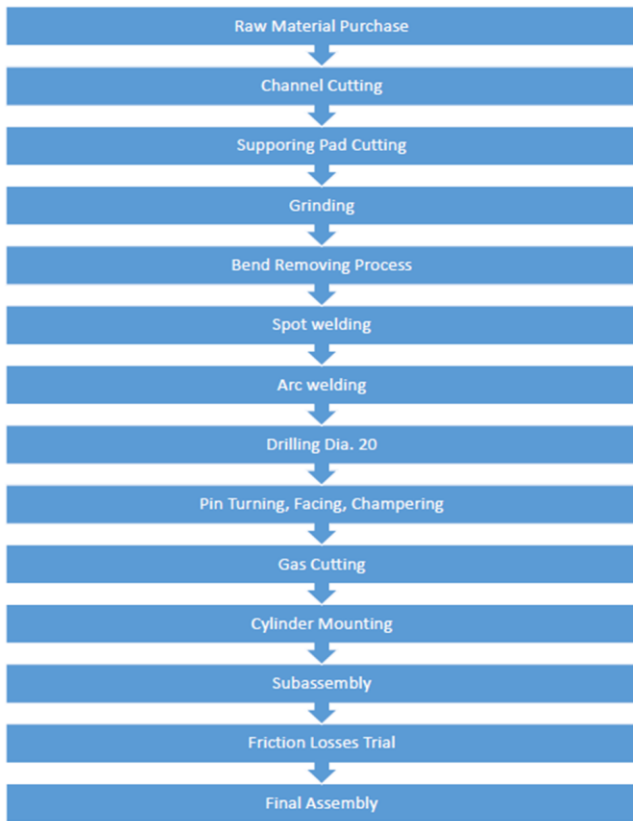**Fig -5**: Hydraulic Power Pack

8. FABRICATION PROCESS:

Fig.-6: Fabrication process flow chart

9. PROXIMITY SENSORS AND PLC PROGRAMMING:

Application of proximity sensor is to detect the presence of any object or person without physical contact. One way to achieve this is by using the electromagnetic field or electromagnetic radiation beam in which the field or return signal changes in the event of the presence of any object in its surrounding. This object sensed by the proximity sensor is termed as target. It is also known as proximity switch. Both, the object to be sensed with sensor, have transformer like relationship. Due to the absence of mechanical parts and

lack of physical contact, proximity sensors have high reliability and long functional life.

Fig. Ladder Diagram
Fig -7: Ladder Diagram

Above ladder diagram shows the simplest form of ladder logic which can be utilized for the task of achieving the total automation in this hydraulic scissor lift. Normally open Input switch I:00 when pressed gives output O:00 which gives supply to all the electronic components, representing system is on. There is an emergency switch I:01, which is normally closed. When it is pressed, it cuts off the supply and there is no output at O:00, making whole system turn off. When I:00 is made on, the output at O:00 is given to normally open switch. NO switch I:02 represents proximity sensor at upper level. NO switch I:03 represents proximity sensor at lower end. While O:01 represents hydraulic pump. When any of the proximity sensor detects the presence of material to be taken from one level to other, normally open switch is closed and it gives output, which makes hydraulic pump on and lift the platform. When the proximity switch gets off, hydraulic pump will stop and return to its normal position.
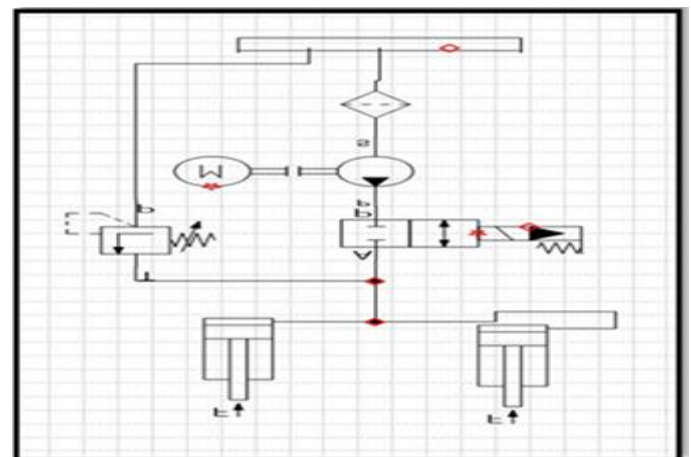

Fig -8: Hydraulic Circuit

Fig -9: Hydraulic Lift

Fig -10: Spray Painted Lifting Structure

Fig -11: Assembled Hydraulic Lift

10. RESULTS:

Through this project manpower utilization was reduced, as 8 men were involved in manual lifting of material. After projects implementation, only 2 men can do the required work. In the same way, time required for manual operation was reduced by 60%.

11. CONCLUSION:

Through automation of lifting mechanism, load handling capabilities are increased. Also significant reduction in manpower and time consumption can be achieved. Through load lifting capabilities of 2 tons by hydraulic scissor lift, efficiency of material handling system can be improved by more than 60 percent.

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