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# Hazard Identification and Risk Analysis of Material Handling Semi Automatic Hydraulic Lift In Industry

A.C. Subash[1], J.Gunasekaran[2]
ME Student (Industrial Safety Engineering) [1], Assistant Professor[2]
Department of Mechanical Engineering
Cauvery College of Engineering and Technology, Trichy, India

**Abstract:**
This paper presents a hazard identification, risk assessment and risk control of material handling semi-automatic hydraulic elevator in a industry which constitute phase of safety management. The most critical part of a manufacturing industry, commercial buildings, service oriented buildings from safety point of view are elevators which are used as main source of vertical transportation that moves goods or material between floors of a building, vessel, or other structure. Elevators are generally powered by electric motor that either drive traction cables or counterweight systems like a hoist, or pumps hydraulic fluid to raise a cylindrical piston like a jack there can be no compromise on safety related issues. In this research many aspects and research papers have been considered to understand the importance of an excellent safety program strives to identify problems before they occur. The potential hazards which cause accidents can be identified by conducting proper risk analysis and assessment. And also Properties of hydraulic system decide high efficiency, security as well as stability under different working conditions. Beginning with simulation analysis on hydraulic system of hydraulic lifting appliance under different working conditions, the essay analyzes a certain hydraulic system through which design references can be offered for optimizing hydraulic system properties via hydraulic system force and changes of torque. And then properties of hydraulic system can be improved and a hydraulic system with stable performance can be obtained.

## 1. INTRODUCTION

The advent of high-rise buildings in modern cities requires high-speed elevator systems to provide quick access within the buildings. These buildings require that elevators run at speeds faster than ever before. Elevators have various mechanical structures according to the rating speed and the maximum load capacity. Generally, elevators consist of three principal mechanical parts: traction machine, cage, and counterweight. The traction machine is installed in a machine room located on the top of a building. It is composed of traction motor, main sheave, and breaker. The counterweight is used to balance with the cage and connected to the second sheave of the traction machine through a moving pulley. The compensation rope and the sheave are used to eliminate the weight difference of both side ropes according to the cage position In elevator techniques, proper installation, ongoing maintenance, and inspection are required. Long-time continuous usage increases fault-occurrence probability, which requires troubleshooting quickly. To assess the reliability and efficiency of the elevators, a maintenance program is a significant part of overall elevator system. Safe and reliable operations arc of paramount importance to the owners, the management company, and the tenants. The targets of elevator maintenance are as follows:

- Prolong equipment life
- Improve equipment safety and reliability
- Reduce the cost of major repairs
- Minimize the inconvenience of equipment downtime

The data obtained from the National Statistics Office on elevator accidents shows that there were 90 and 97 accidents in the years 2006 and 2007, respectively. These accidents are increasing annually Therefore, the demand for new technical solutions for lessening the safety accidents and breakdown is necessary. It provides a technical guide to promote the progressive, selective maintenance, and improvement of the safety of existing elevator. So, the aging elevators should be more effective, safer, more reliable and more comfortable through effective maintenance and improvement.

### 1.1 INTRODUCTION FOR SIMULATION ANALYSIS OF HYDRAULIC LIFTING APPLIANCE

With favorable properties over lifting, braking and property control, hydraulic lifting appliance plays an important role in modernization drive. Being a symbol of social advance, hydraulic lifting appliance is indispensible to civilization development. Much attention has been paid by lifting industry to the efficiency, security and stability of hydraulic lifting appliance. With ceaseless development of science and technology, more and more new technologies are applied to lifting appliance design. At the same time, the once exist hydraulic oil leakage phenomenon is overcame gradually by the perfection of hydraulic transmission technology and improvement of domestic hydraulic elements quality. As a result, wide application of hydraulic transmission technology on lifting appliance is becoming an inevitable trend. Beginning with the analysis on hydraulic system of the current hydraulic appliance, the essay conducts analysis on hydraulic system with the purpose of improving properties of hydraulic system and finally establishing a stable hydraulic system

### 1.2 HYDRAULIC ELEVATOR SYSTEMS

The use of hydraulic elevator systems results in the following essential benefits when compared to traction elevators

**LIFT COMPONFNIS** - The hydraulic elevator consists of fewer components than the traction-driven one fewer components are used especially for direct elevator systems. Pulleys, over speed governor, safety gear or counter weights do not have to be mounted or serviced. Therefore the purchasing costs are lower and the time needed for maintenance is reduced. The hydraulic elevator system offers an optimum **Specification and description of lifts** price performance ratio for systems with a lift height of up to 15 m. Thanks to more than 50 years of experience. The energy saving frequency-controlled drive offers great benefits for high-frequency elevator systems. Low heat generation, elimination of the oil cooler, reduction in energy consumption and an optimum drive comfort characterize the modern drive concept. The environmentally friendly drive concept is completed with the use of biodegradable oils. As far as energy efficiency, comfort and sustainability is concerned, the hydraulic elevator system is equal to the traction elevator. In emergency situations, neither additional energy sources nor trained experts are needed. By manually pushing the emergency button on the power unit, the cabin is lowered and an emergency situation is quickly and easily resolved. The use of machine room less hydraulic solutions has been adopted by the market for many years. The power unit and the controller are mounted as one unit in a recess of the shag wall. Access to the power unit and controller minimizes maintenance costs while increasing personnel safety at the same time.

**Specification and description of lifts**

Manufacturers produce a huge variety of precision engineered goods lifts and goods cum passenger fills to meet the appropriate requirements of their customers. Hydraulic Goods elevators are the latest state of ART Technology. Apart from being compact and energy efficient, theses elevators posses excellent adaptability and flexibility for installation in multistoried residential apartments, commercial buildings. Some advantage of HEICO Hydraulic Elevators over conventional Traction elevators

- Installation of HEICO Hydraulic elevators is much simpler.
- No need of machine room construction at top.
- No special RCC work for housing the Machine room.
- Load transfer through the base needs minimum foundation.
- NO Counter — Weights and its related ropes and guides.
- No complicated gear train and traction pulley.
- No multiple gear train and traction pulley.
- Less maintenance, less wear and tear, least spare parts needs.
- Precise acceleration and deceleration for optimum comfort.
- Negligible energy requirements in downward motion.

**Table.1. Star-delta options for having the starting current.**

| | |
|---|---|
| Capacity – No's / kgs | 3 Ton (3000 kgs ) |
| Drive | Hydraulic |
| Speed | 0.5 m/s |
| Controller | Microprocessor |
| Operation | Full collective system |
| Travel floors | G + 4 ( Ground Floor Dual Opening ) |
| Landings and operation | 6 stops and openings |
| Car door | SS Telescopic Manual Door |
| Landing door | SS Telescopic Manual Door |

## 2. SPECIFICATION AND DESCRIPTION OF LIFTS

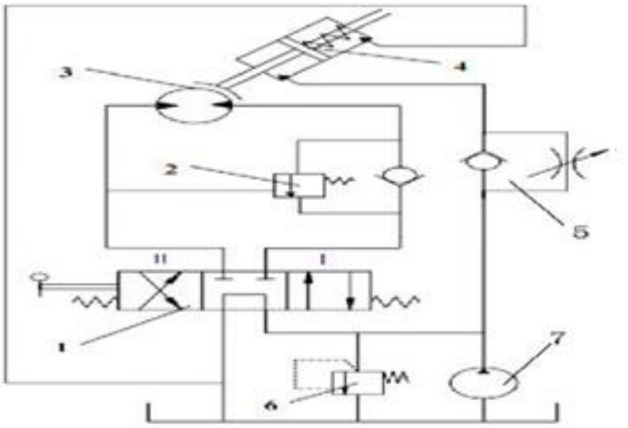
### 2.1 SINGLE LINE DIAGRAM FOR SEMI-AUTOMATIC HYDRAULIC LIFT

The single line diagram is the blueprint for electrical system analysis. It is the first step in preparing a critical response plan, allowing you to become thoroughly familiar with the electrical distribution system layout and design in your facility.

Whether you have a new or existing facility, the single line diagram is the vital roadmap for all future testing, service and maintenance activities. As such, the single line diagram is like a balance sheet for your facility and provides a snapshot of your facility at a moment in time. It needs to change as your facility changes to ensure that your systems are adequately protected.

#### 2.1.1. Working Principle of Jacking Hydraulic System

As commonly used in vertical transportation appliances, hydraulic crane plays a significant part. During the process of lifting, commodities are lifted by drum propelled by rotation of hydraulic motor. Different in lifting hydraulic system of various types, the basic design idea of different factories is the same. Lifting hydraulic system generally consists of electrical machine, oil pump, safety valve, change valve, pressure gage, balanced valve, motor or hydraulic cylinder, pipeline and some other components. Electrical energy can be transferred into hydraulic pressure energy by motor drive hydraulic pump and then into mechanical energy drive load by motor or hydraulic cylinder propelled by control valve. With general adoption of bidirectional meter out regulative system, hydraulic system can control commodity ascension and descension speed effectively. Hydraulic lock or speed limit lock is launched within the oil way so as to guarantee that hydraulic cylinder can stay in any position at any time during operation in avoidance of the danger of commodities' self-descension due to instantaneous power cut or the tripping of air switch. Security settings of overload protection and hydraulic pressure should be launched in hydraulic system. The setting pressure of relief valve should be no greater than 110%of working pressure the system specified and the pressure specified by the system should be no greater than the setting pressure specified by hydraulic pump. Working pressure of relief valve should be adjusted before lifting operation and should be restricted within the maximum allowable working pressure. A Hydraulic lifting system is shown in the following figure.



1-Change Valve 2-Balanced Valve 3-Hydraulic Motor 4-Brake Hydro-Cylinder 5-One-Way Throttle Valve 6-Pressure-Control Valve 7- Hydraulic Pump

**Principle on Hydraulic Lifting System**

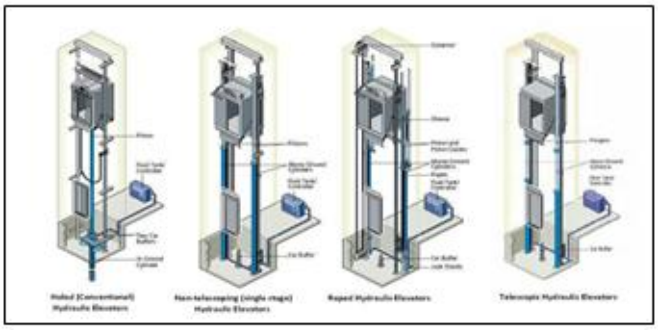
**2.2 ELEVATOR MACHINE ROOM**

An elevator machine room (sometimes known as elevator machinery room or lift motor room) is a room that house elevator drives and controllers. Typically, entrance to elevator machine rooms is located off a public corridor, usually located in a basement of a building or through a mechanical equipment room. if they are located in a room or space containing other machinery (such as the controllers) and equipment essential to the operation of the building, provided that they arc separated from the other machinery or equipment by a substantial metal grille enclosure.

**Elevator room hydraulic equipment**

**2.3 ELEVATOR SHAFT FOR SEMI-AUTOMATIHYDRAULIC LIFT**

A vertical shaft in building to permit the passage of an elevator from floor to floor



**Elevator shaft for semi-automatic hydraulic lift**

**2.4 SCOPE AND OBJECTIVE**

This risk assessment examines the hazards, risks and control measures relating to Maintenance personnel / engineers, or personnel using the material lift for operation, maintenance of elevators and when attending special service incidents involving lifts, escalators and moving walkways.

This generic risk assessment covers lifts, moving walkways that arc permanent features of a building following its construction. These lifts, escalators and moving walkways can he described as:

Depending on the nature and scale of an incident a variety of significant hazards may be present. Risk assessments in this series including:

- Electrical Hazard: Incidents involving electricity
- Confined spaces
- Working at Height

**3. STATISTICAL ANALYSIS**

**3.1 ELEVATOR ACCIDENTS**

Up to late 2007, the total number of elevators installed is 359,098 as shown in Table 1. The rate of elevator accidents per ten thousand elevators accounted for 1.54. In the damage accidents, death accounted for 148 people or 21.8%, the severe injuries accounted for 263 people or 39.8%, and less-severe injuries reached 266 people or 38.4%. In each cause of elevator accidents, users' errors accounted for 15.3%, poor maintenance accounted for 20.2%, while poor management and maintenance reached 11.9%, workers' errors and substandard manufacturing reached 6. 1% and 3.9%, respectively. The rest took up with 6.7%

**3.2 ACCIDENT TYPES AND CAUSES**

Elevator accidents arc increasing every year. Even though the same kinds o accidents have steadily occurred, the causes have not been eliminated vet Accidents in relation to escalators or moving walkers among total safety accidents account for the highest rate of 20.3% as shown in Table 2. The rapid increase of the installed escalator triggers accidents to surge among most children and the aged. Even though most citizens require high safety of elevators, accidents still rise owing to the absence of the double-function units of safety devices or the age of the elevators. Accordingly, efforts are made to improve the safety laws which are necessary for reinforcing public safety, across the world. Also, the same sorts of accidents frequently occur. At this point, when the lift laws are only applied for elevators to be newly-built, it is necessary to improve the safety level of aging elevators. The probability of failure and consequence of failure. Three types of RBI assessment are generally recognized as follows: qualitative approach which is based on descriptive data using engineering judgment, experience quantitative approach which is based on probabilistic or statistical models, and semi- quantitative approach, being an approach that has elements of both qualitative and quantitative methods. In this study, we adopt the semi-quantitative RBI approach to analyze elevators. A risk analysis is a series of logical steps that enable a systematic identification and study the hazards and their corresponding causes and effects. The identification of hazards, followed by an assessment of their severity and probability of occurrence shown in Table 3, yields a measure of risk associated with the individual hazards. Through the use of an interactive process, each hazard and effect are evaluated and either eliminated or, if necessary, controlled by means of appropriate safety measures that reduce the corresponding risk to an acceptable level of safety as shown in Fig. 1. For this purpose, the best approach is to form a risk analysis team by selecting the members and choosing a team leader/moderator. The cause and effect of each hazard in terms of probability of occurrence and the severity of its effects are assessed. The combination of severity and frequency of occurrence quantifies the risk associated with the hazard. The assessment results are evaluated in terms of residual risk and the acceptable level of safety. If the level of safety is unacceptable, further risk reduction measures are required and the following procedure should be used:

**Table.2. Shows the Appearance of accidents types**

| Breakdown causes | Rate (%) |
|---|---|
| Changed adjustment parts, looseness, transformation | 46.2 |
| Destruction, damage | 0.2 |
| Abnormal sound, vibration | 4.6 |
| Life excess, component aging_ abrasion | 4.0 |
| Contact badness | 2.8 |
| Contamination | 1.8 |
| User carelessness | 1.4 |
| Malfunction | 1.1 |
| Jamming | 0.9 |
| Trip | 0.8 |
| Snapping of a wire | 0.8 |
| Others | 15.5 |
| Sum | 100 |

## 4. RESEARCH METHODOLOGY

### 4.1 HAZARD IDENTIFICATION

#### 4.1.1 Evaluating the Hazards

The hazards are identified and evaluated by using the suitable tools (hazard identification techniques). The methodologies for various tools are given below.

#### 4.1.2 JSA Methodology

- Select the job
- Divide the job into various steps
- Identify the hazards in each steps
- Evaluate the consequences and problems
- Recommend the actions
- Document the result

#### 4.1.3 What If Analysis Methodology

- Divide the system up into smaller, logical subsystems
- Identify a list of questions for a subsystem
- Select a question
- Identify hazards, consequences, severity, likelihood, and recommendations
- Repeat Step 2 through 4 until complete.

#### 4.1.4 Recommendations to Control And Prevent The Hazards

In identifying new risk control measures, the most effective form of control measures is to eliminate the risk. If that is not reasonably practicable we need to identify effective measures to reduce the risk by establishing the following.

- Substituting the plant or substance with another one that is less hazardous
- Using engineering controls (eg. modifying the design of the workplace or plant)
- Isolating people from the source of exposure.

#### 4.1.5 Analyzing and Discussing the Various Hazards

Once the hazards have been identified, they should he listed for a risk assessment to be carried out in consultation with the relevant health and safety representatives and employees. The purpose of risk assessment is to determine whether there is any likelihood of injury, illness or disease associated with each of the potentially hazardous situations identified in the hazard identification process.

#### 4.1.6 Documenting the Results

Maintenance of appropriate records will assist to know what has been done and what more needs to be done and to reviewing the processes after the application of control measures. Documents provide information on summary of identified hazards, the risk assessment method used and new measures have been recommended to control any risk.

### 4.2 PURPOSE

To assess the risk of the activities to be executed, rate the risk levels as per the risk assessment matrix, and identify the control measures so as to bring the risk level to ALARP (as low as reasonably practicable level).

#### 4.2.1 Procedure

The team in co-ordination with concerned Engineer should carry out the Risk Assessment for Material handling Semi automatic hydraulic lift through analyzing expected hazards and extent of risk involved in each activity. Against each hazard identified, the existing control measures were analyzed as per the effect / impact rating and probability rating give risk level for each activity is been identified from the matrix based on the ratings given. Accordingly, future control measures were evolved to bring the risk level to ALARP (As low as reasonably practicable level). Based on the rating and devised control measures, an appropriate action is been recommend and given below in the table

### 4.3 RISK CONTROL

Risk control is the method by which firms evaluate potential losses and take action to reduce or eliminate such threats. Risk control is a technique that utilizes findings from risk assessments and implementing changes to reduce risk in these areas

.

#### 4.3.1 Breaking Down 'Risk Control'

Risk control takes that information gained during risk assessments and develops and applies changes to control the risks. Risk control can involve the implementation of new polices and standards, physical changes and procedural changes that can reduce or Eliminate certain risks within the business. Risk control is an important action taken by firms that is intended to proactively identify, manage and reduce or eliminate risks.

**4.3.2 Risk Control Methods**

Avoidance - There's a great deal of risk. You don't want to assume the risk and it can't be transferred, so you avoid the risk altogether. This method eliminates any possibility of loss. It is achieved either by abandoning or never undertaking an activity or asset.

**Loss Prevention** — Reduces the frequency or likelihood of a -particular" loss. Examples include:

- Improve safety measures to reduce the possibility the risk
- Improve maintenance of facilities to reduce the possibility of a tripping hazard.

**Loss Reduction** — Reduces the severity or cost of a "particular" loss. Examples include:

- Require the use of seatbelts to reduce the chance of bodily injury in a vehicle collision.
- Require the use of hearing protection to reduce the chance of a hearing loss.
- Reduce the cost of workers' compensation claims through the use of return to work programs.

**Segregate Losses** — Arrange activities and assets to prevent one event from causing loss to the whole. There are two methods — duplication and separation.

**Separation** — your activities or assets are distributed among multiple steps.

**Duplication** — relies on spare or duplicates that are only used if assets or activities suffer a loss. Examples of Risk Control Measures

- Personal Protective Equipment
- Housekeeping;
- Inspections
- Tools and Equipment
- Policies, Procedures, Processes
- Supervision & Training.

## 5. SYSTEMATIC MODELING OF HYDRAULIC JACKING APPLIANCE

### 5.1 SIMULATION MODELING METHOD OF HYDRAULIC SYSTEM

The prerequisite for conducting systematic simulation is to establish accurate systematic and dynamic math model and obtain accurate parameter data of the system and components. Continuous steady lumped parameter model is commonly used for studying hydraulic system or machinery and hydraulic system. And the relevant frequently-used math models are differential equation form, transfer function form, block diagram, signal flow graph, state variable math model and so on. The frequently-used methods for modeling are analysis, state space, power bond graph and "grey-box" modeling.

### 5.2 THE ESTABLISHMENT OF SIMULATION MODEL ON THE BASIS OF AMESIM

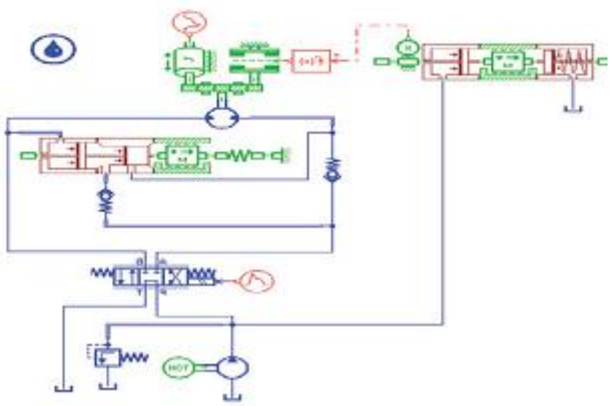
Jacking system model of hydraulic crane mainly consists of establishing model, selecting model types and setting up model parameters. Hydraulic pressure principles of hydraulic crane's lifting mechanism are shown in figure. When establishing model, partial hydraulic components are missed in AMESim software, therefore it is necessary to conduct equivalent treatment and the relevant treatments are as follows:

**(1)Three Figured Four-Way Valve**

Three figured four-way valve doesn't exist in AMESim software, therefore three-figured four-way solenoid valve is used in simulation software and direct signal loading method is substituted for manual operation.

**(2)Brake**

In the figure, made up of brake cylinder and returning spring, the brake accomplishes hydraulic motor braking and normal operating through spring contraction when conducting oil-taking. Due to the fact that no brake exists in AMESim software, motor connection pin for the stall of the variable friction.Torque model is adopted. In order to realize the start, normal operation and brake of the lifting mechanism, friction torque model parameters should be adjusted.



**Lifting System of the Simulation Model**

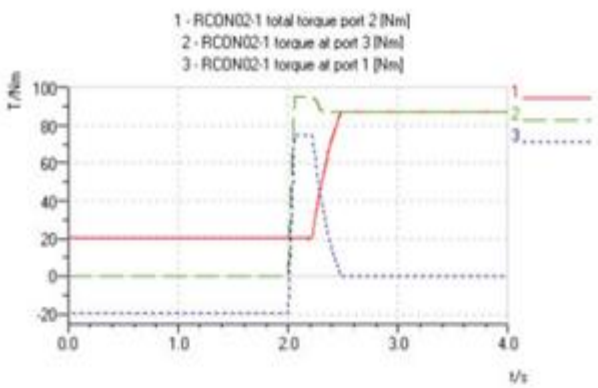
## 6. ANALYSES ON SIMULATION RESULTS OF LIFTING HYDRAULIC SYSTEM

Suppose that torque of systematic load is 20Nm. The movement of the lifting structure is analyzed under six working conditions. The six conditions are sudden ascension after systematic stop, dissension after stop, sudden stop after ascension, sudden stop after descension, sudden descension after ascension and sudden ascension during descension.

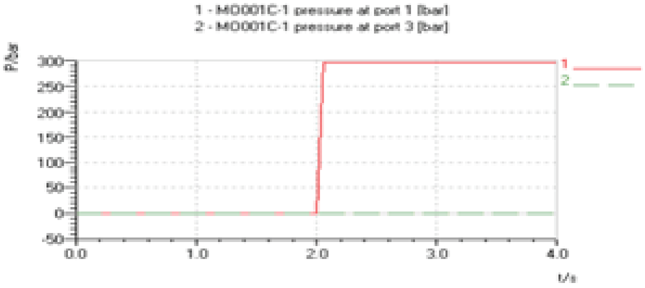
### 6.1ANALYSES CONDUCTED UNDER EACH CONDITION ARE AS FOLLOWS:

**6.1.1 Sudden Ascension after Systematic Stop**

When change valve is on the left side, it is the lifting loop that offers motive power. The relevant simulation figure is shown as follows.



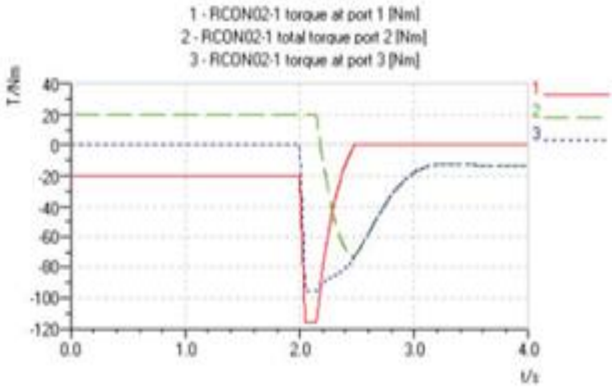
**Changes on Lifting Brake, Load and Motor Torque under the Condition that System Ascends after Stopping**




Simulation results demonstrate that between 0~2 seconds, change valve locates in the meso-position. In this case, the motor is in off-working state, load torque equals with brake torque and differential pressure on the two sides are zero. Between 2~4 seconds, change valve turns left and the system offers lifting power. In this case, load torque equals to motor output torque. After loosened for a while, the brake stops working so that the system can conduct normal operation. Pressures on the two ports of the original lifting motor are the same. Pressure values vary according to different working situation. Pressure on port1 is larger than that of port3. System offers lifting power when the motor is contra rotating.

### 6.1.2 Sudden Dissension after Systematic Stop

When change valve turns right, load is in a falling state. The simulation figure in this case is shown as follows:

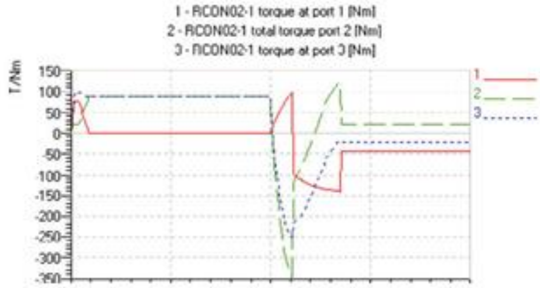



**Changes on Brake, Load and Motor Torque under the Condition that System Descends after Stopping**

Simulation results demonstrate that between 2~4seconds, change valve changes from the meso-position to that of the right and the integrated system is descending. After a while, motor output torque balances with load torque. In this case, the brake stops working after a short time's response. The fact that load torque is far less than 20Nm demonstrates that weights are working when descending and the motor is under the influence of block load. Under normal circumstance, pressure on port3 is larger than that of port3. But in such case, the situation turns to be different due to rightward displacement of spool and the returning of motor output flow back to the tank via balanced valve under the influence of pressure so that over-quick falling speed of load can be prevented.

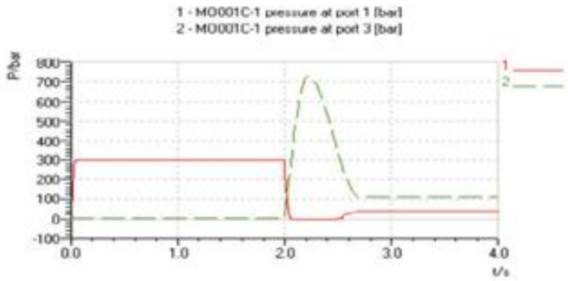
### 6.1.3 Sudden Stop during Systematic Load Ascension

When change valve turns from the left position to meso-position, load stops suddenly during lifting movement. The simulation figure is shown as follows:




**Changes on Suspend Brake, Load and Motor Torque under the Condition that System Stops during Ascension**

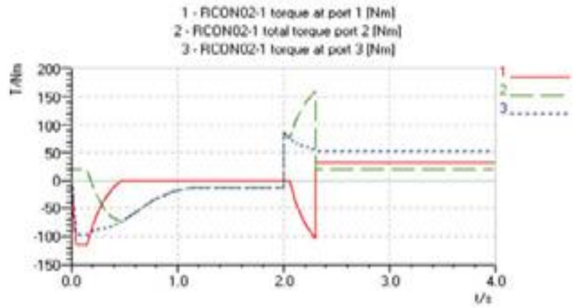
Simulation results in figure5 demonstrate that after change valve changes into meso-position, brake that doesn't work can return to work again. Loss of components can be reduced after forceful suspend of torque fluctuation of load and motor. After a period time's of cushioning, the system stops. At this moment, being supportive to load and motor, the brake offers the power to loading moment and surplus motor torque. Pressures on both ports of the motor vary due to interference from the brake. Pressure on port3 is larger than that of port1 due to sudden brake working and the consequent inertia effect of hydraulic oil. Pressures on the two ports are no longer balanced.



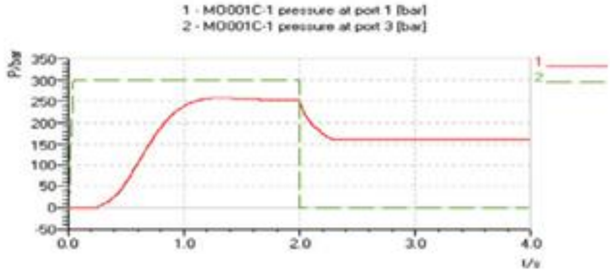

**Pressure Changes of Port 1 and Port 3 in the Motor**

### 6.1.4 Sudden Stop during Systematic Descension

When change valve changes from the right position to meso-position, load stops suddenly during descension. The simulation figure is shown as follows.




**Changes on Brake,Load and Motor Torque under the Consition that System Stops during Descension**

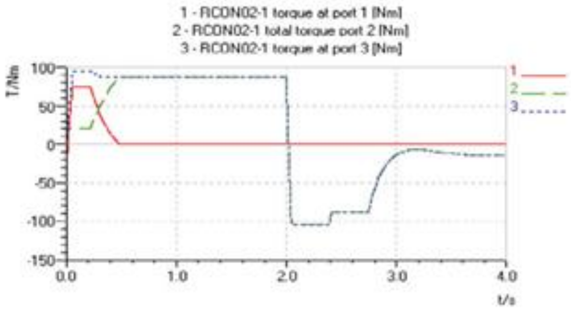



**Pressure Changes of Port1 and Port3 in the Motor**

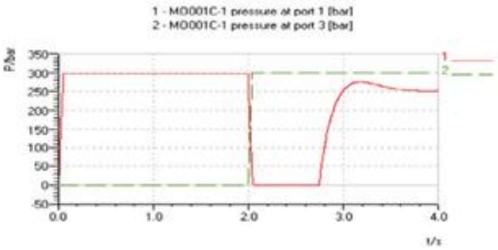
Simulation results demonstrate that when change valve changes from the right position to the meso-position, load descension is stopped forcibly. Brake previously in the loosened state begins working and terminates torque change fluctuation of load and motor. At this moment, motor torque equals to the sum of brake torque and load torque. Pressure on port3 becomes zero suddenly due to brake working.

#### 6.1.5 Sudden Descension during Systematic Ascension

When change valve changes directly from the left position to the right, the system changes working direction. The simulation figure is shown as follows. Simulation results demonstrate that when change valve changes directly from left to the right, the system descends rather than ascends. The system has already changed movement direction and it is too late for brake to work due to instant change. At this moment, the brake stops working and load torque equals to motor torque consistently. This suggests that it is the motor that completely offers load torque. Big fluctuation would emerge during the process. Therefore the system should avoid the occurrence of such working condition as far as possible.



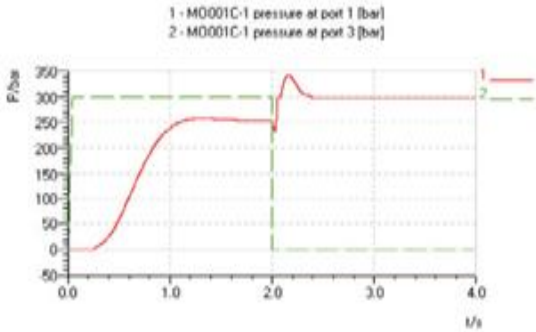

**Changes on Brake, Load and Motor Torque under the Condition that System Descends Suddenly during Ascension**




**Pressure Changes of Port 1 and Port 3 in the Motor**

#### 6.1.6 Sudden Ascension during Systematic Descension

When change valve changes directly from the right to the left, the system would change working direction. The simulation figure is shown as follows.




**Pressure Changes of Port 1 and Port 3 in the Motor**

## 7. CONCLUSION

This paper presents an investigation of risk management, elevator risk analysis, based on studying and surveying of the elevator. It also provides the elevator management and elevator evaluation criteria to apply the condition prognosis and maintenance. The risk management by HIRA method gives the proposed guidance for optimal HIRA this paper studies the risk assessment based on the elevator accident and data by using HIRA techniques. It then offers propositions on how to prevent elevator accidents for premium management and maintenance. And also basis of AMESim software, the braking and change characteristics of hydraulic system under each working condition are worked out by taking advantage of simulation analysis conducted under each working condition of a certain kind of lifting appliance in hydraulic system. The author's own opinions are put forward on correctly use and improve the hydraulic system.

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