Symposium on the Lift and Escalator Technologies

Vibrations in a Lift System

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INTRODUCTION

In this paper various models of the dynamic behaviour of a lift car are discussed. The dynamic responses due forces and motion excitations have been analysed. As an example, the results of a computer simulation to demonstrate the effects of the excitations have been presented.

VIBRATION SOURCES IN LIFT SYSTEM

Guide rail excitation:

There are several cases under which the guide rail installation will cause excitation in lift system:

1- Missalignment of the joints: this case is the most common case of excitations in lift system. The excitation is of shock type. The magnitude of this shock depends on the physical placement of two guide rail edges at joints. The quality of guide rail surface treatment and fishplates are the affecting parameters. The applied shock will be transmitted to the car through the guide devices. Generally the guide devices are equipped with spring damper mechanism. The spring mechanism with lower the applied shock magnitude, the damping mechanism will dissipate the energy in the system during a period of time.

2- DBG variations: DBG (Distance Between Guide Rails) variation will cause change in reaction forces of the guide device (guide shoe or guide roller). The frequency of this variation is very low.

Traction machine excitations

1- Torque ripple: naturally the torque of all electrical machines is not quite smooth. This depends on the internal structure of the machines. In case of asynchronous machines which are coupled with reduction units the torque ripples are reduced to a very low level; however in this case the reduction unit itself could be a source of ripples in the machine output. In case of permanent magnet synchronous machines torque ripples are of much more importance, since there is no reduction unit. During recent years machine manufacturers has improved so many solutions to overcome this issue, some of them improved special feedback systems to overcome the ripples (with the use of digital signal processors) and some has improved the rotor slip angle and magnet placements in order to reach the maximum smoothness in output torque.

   Torque ripple will transmitted to the car - through the suspension ropes which are elastic mediums - in form of longitudinal vibrations. As reported by Schindler [1] in model 3300 and 5300 the recorded values are of less than 25mg inside the car.

2- Traction sheaves and rope impact: one of the major sources of excitation created in traction system is the noise and vibration created because of rope and sheave profile impact. They are of random order in magnitude and direction.

Air turbulence effect

Motion of the car and counterweight in lift well will create turbulence when they pass each other. As reported by SHI Li-qun et al. [2] during experiment when the distance of the car and counterweight is changed by $0.1\,, 0.2, 0.3\,m$ in the lift well the positive lateral forces to the car changed $3, 2, 1.5$ times and negative lateral forces changed $7, 5, 3$ times from the time counterweight was far away from the car.

Unbalanced Rotational movements

Exhausting fan and the door operator machine are the major sources of the noise and vibration excitation in lift system. This kind of vibrations has harmonic nature. Both sources require special isolation mechanism in order to minimize the effect. Basically these kind vibrations create noise rather than movement.

Building structure:

The building structure is always subject to excitation and vibration during operation of the lift. Sometimes effects such as the building sway which may is caused by wind and turbulence may indice vibration to the lift system. On the other hand the vibrational sources of the lift may excite the building structure and create noise or in cases like safety gear engagement may cause larger magnitude vibrations.

Vibration and energy transfer

Vibration is normally defined as a periodic or repeating motion of the body/ object under consideration. Vibrational motions are directly related to the kinetic energy of the object. In a system of particles or solid bodies linked together by constraints this energy can be transmitted between objects through contact / collision or excitation.

Lift car dynamic model

As a part of this study a computer based modeling of a lift car has been developed in Matlab / Simulink software to study the effect of a guide rail joint misalignment. The lateral force is from guide roller reaction caused by a $1\,mm$ step at guide rail joints (see Figure 1). The displacement is applied to upper and lower guide roller within $1\,sec$. The general schematic diagram of the model is illustrated in Figure 2. The roller guide is modeled as illustrated in Figure 3. The physical properties of the lift car are calculated with the use of a real scale computer based modeling in Inventor Software by Autodesk. Unfortunately real time modeling process of the suspension ropes in Matlab requires substantial programming efforts, which is not practical while using personal computers. Thus, for this modeling the suspension ropes are considered as a solid rod of small mass.

The car ($W1800\ x\ D1400\ x\ H2300\ mm$) is considered fully balanced in XY plane and weight vector ($732Kg$) of the car is considered at the center of gravity, the placement of the CG in vertical alignment is considered at $1220\,mm$ from the guide roller ends. All guide devices are equipped with 4 ${}^{kN}/_{m}$ springs with natural length $20cm$ and active length of $10cm$.

Analysis results show a $2\,mm$ displacement in $Y\,axis - lateral\,moevemnt$ and $1\,mm$ Movement in $Z\,axis - vertical\,movement$ Figure 4.

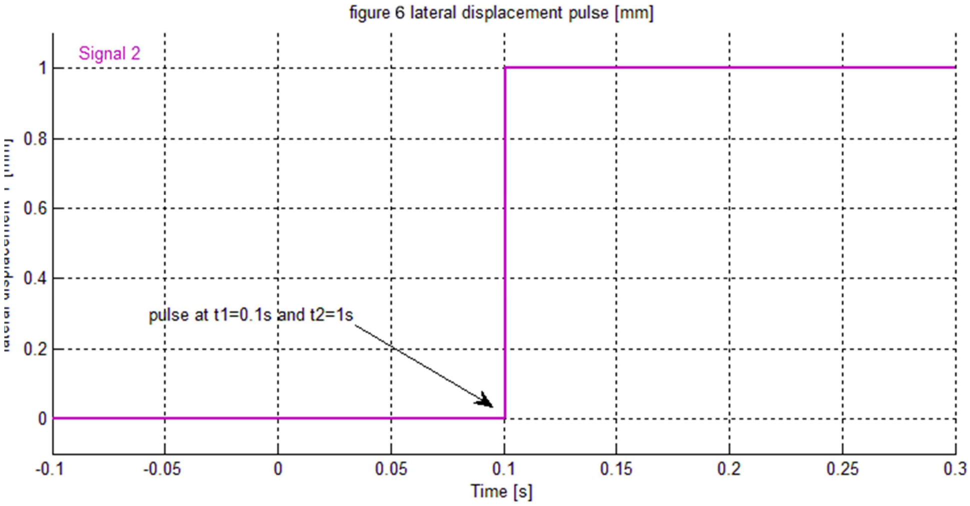

Figure 1

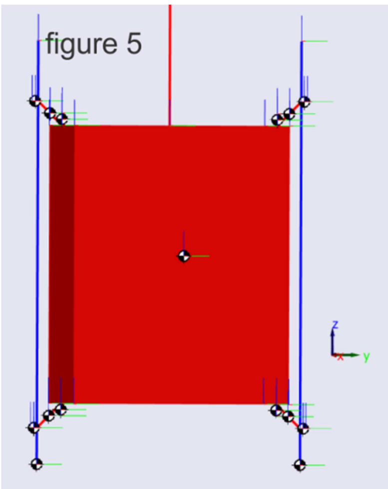

Figure 2

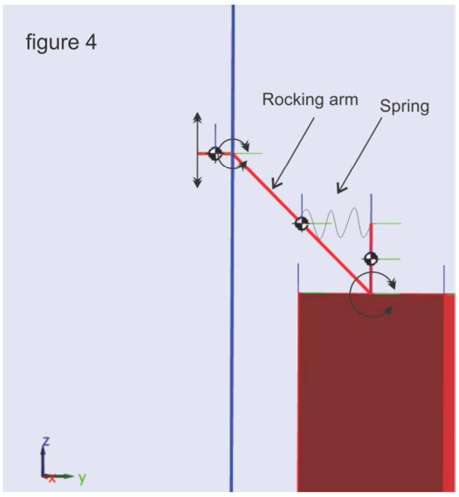

Figure 3

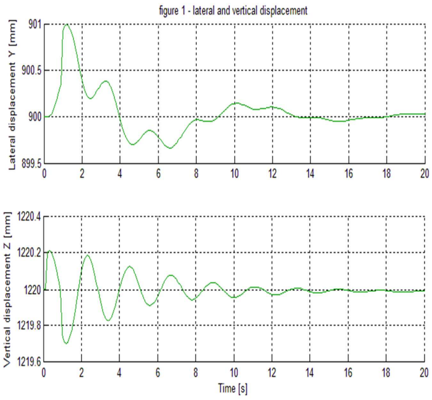

Figure 4

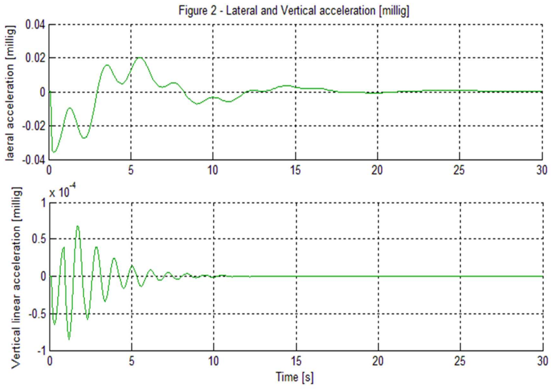

Figure 5

Also the relative acceleration values are shown in Figure 5.

SUMMARY

The ride quality and vibration responses in lift systems depend on many effects. By modeling the lift system it can be seen that the lift car is subjected to rotational vibration while is excited by a lateral forces.

References

1- Schindler 3300-5300 Information on noise and vibration Catalogue.
2- SHI Li-qun, LIU Ying-zheng, JIN Si-yu, CAO Zhao-Min. Numerical Simulation of Unsteady Turbulent Flow Induced by Two-Dimensional Elevator Car and Counter Weight System. *Journal of Hydrodynamics,* **19** (6), 2007, pp 720-725