Development of Maglev Switch for the Urban Transit Maglev in Korea

No. 30

Jongmin Lee, Hungje Cho, Kyusok Rho and Dongsung Kim

Korea Institute of Machinery and Materials , Maglev Project Team, Yoosungku Jangdong 171, Daejeon, Korea, lee_jm@kimm.re.kr, cho_hj@kimm.re.kr

ABSTRACT: Switch is one of the key components for the transit systems. Unlike the switch for the wheel-on-rail systems, the maglev switch is massive , complicated , and expensive. Different types of switch like 2 way, 3 way, and X type are needed. Development of a segmented 3 way maglev switch for the urban transit maglev in Korea (UTM -01) is reported. Design requirements and major switch components are described.

1 INTRODUCTION

Korea has been consistent in developing low to medium speed urban maglev for the past 18 years. Figure 1 shows the urban maglev vehicle UTM-01 under test. It was developed in 1998. The Korean government decided to take a lead in commercializing UTM-01 system. According to the maglev commercialization project schedule, the project lasts 6 years until December, 2012. Yet some of the technologies should be optimized before present UTM-01 system is deployed on the 7 km long maglev track. More reliability of the levitation and guidance system is one thing. Development of fast and efficient switch is another. Here we report the development of fast moving segmented maglev switch.

Figure 1. UTM-01 on the test track

2 DEVELOPMENT OF SEGMENTED MAGLEV SWITCH

2.1 Design requirements

Present maglev switch at KIMM's maglev test track is of the parallel moving type. It is simple in design, but so heavy that switching takes long time. We need to develop a fast working segmented maglev switch similar to that of the HSST system. Segmented switches are the most commonly used type of monorail switch in Japan.

In designing a segmented maglev switch, the following design guidelines are considered.

(1) Vertical and lateral steps at rail joints should be less than 1 mm
(2) Horizontal gap clearance at rail joints less than 40 mm
(3) Switching time less than 20 seconds
(4) Shouldn't produce any levitation problems on the switch. No rail vibration under static levitation or with vehicle running
(5) Locking should be maintained in case of power failure
(6) Fail safe function of the major switching components such as control or actuators
(7) Whether resistant
(8) Ease of maintenance

2.2 Segmented maglev switch

The switch consists of three straight girders of unequal lengths that are swung into place by electric motor. The segmented track allows the beam to go from a straight position to a curved one. Total length of the switch, number and the length of each straight moving girders, angle of articulation between neighboring girders are decided from the consideration of the minimum lateral distance between the centerline of the main track and that of the turn out track and the curvature of the switch.

No of moving girders	3
Angle of articulation between neighboring girders	2.3°
Total length of the switch	25.534 m
Articulation angle halving link at girder joints	yes
Radius of curvature of the switch	About 100m

10 kW electric motor was used to move three girders simultaneously. The driving power is transmitted via a long shaft with arms of different length for each reducers. It is shown in Figure 2.

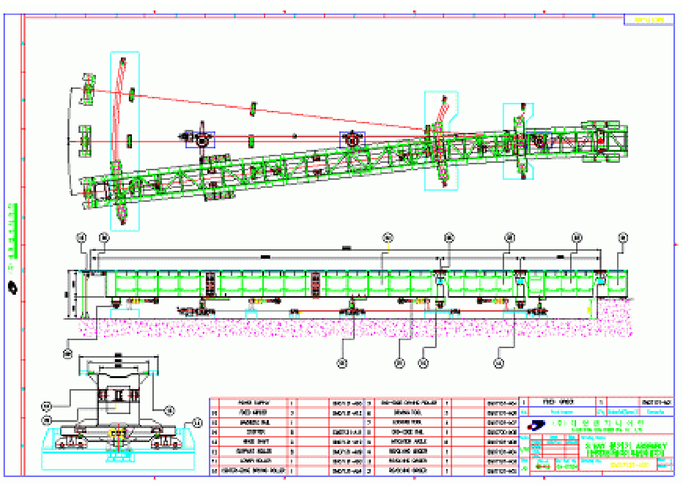

Figure 2. 3 way segmented maglev switch.

The motor speed is reduced by 1/300 through the gear reducers. The speed of the moving girder in the lateral direction as the arm rotates with constant speed goes acceleration and deceleration. The girder accelerates for the first quarter of rotation, while decelerates the second quarter of rotation. There are three moving girders. Therefore the length of the rotation arm at each transmission box is different for each transverse arc length of the moving girders.

2.3 Permissible gap clearance at rail joints

In UTM-01 levitation and guidance control is done independently at each corner of the bogie with gap and acceleration sensors. To avoid undesirable gap sensor signals at rail joints, dual gap sensors are used for control. KERI maglev levitation control team experimentally investigated the effects of the rail joint clearance on control as a function of vehicle speed. It turns out that up to 80 mm rail joint clearance levitation control works. From this the design maximum clearance at switch rail joints was set to be 40 mm.

2.4 Calculation of stress and the thermal expansion of the switch girders

Calculation about the stress distribution, deflection, natural frequency, and thermal expansion was carried out. The vertical load for calculation was set 4.0 tons/m. Temperature difference for thermal expansion calculation was set 60 degrees in Celsius. The results are shown in Figure 3 and in Table 1.

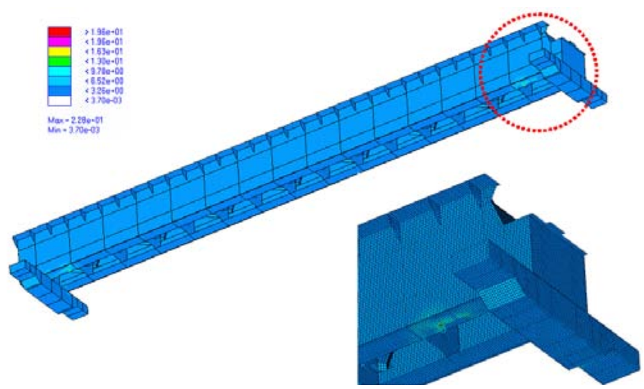

Figure 3. Stress Distribution of the No. 3 switch girder

Table 1. FEM calculation for maximum and thermal expansion of the switch girders

	maximum stress	maximum deflection	natural frequency
1st girder	2.35 kgf/mm2	0.16mm	92.2 Hz
2nd girder	2.48 kgf/mm2	0.18 mm	76.8 Hz
3rd girder	17.7 kgf/mm2	7.41 mm	51.8 Hz

Maximum thermal expansion of the switch due to 60 degree's temperature difference was 19.2 mm. Table 1 shows that the switch girders was designed very stiff resulting in the natural frequency for the third girder to be 51.8 Hz, which is higher than the natural frequency of the guideway, much higher than the natural frequencies of control or switch girders.

2.5 Train speed on the switch

Train speed in the switch through direction is not limited. However, curve negotiation is restricted by mechanical vehicle-to-guideway rail interference, this also applies to the switch. We tried to calculate maximum train speed on the segmented switch. The result is shown in Figure 4.

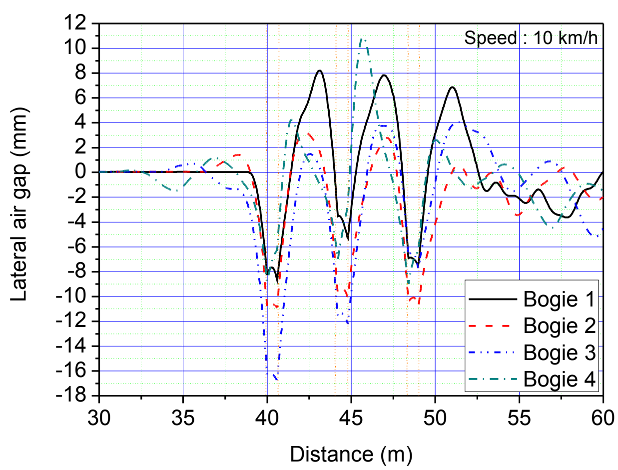

Figure 4. Lateral air gap deviation as the train proceeds in the switch turn out direction. Train speed V = 10 km/h

Figure 4 shows that the switch can be negotiated only at low speeds. Train cannot negotiate the switch in the turn out direction with more than 20 km/h.

2.6 3 way segmented maglev switch

The configuration and some details of the 3 way maglev switch are shown in the following figures. The switch requires less than 15 seconds to move through its cycle. Once through its cycle, the switch girder is held in place by a locking device, which is powered by 0.75 kW motors. 3 locking devices are used to keep the switch girders in place. Two for the longest girder, one for the second girder.

Figure 5. 3 way segmented maglev switch

Figure 6. 3 way segmented switch aligned at turn out

Figure 7. Switch locking device

Figure 8. Main switch driving motor, gear reducer, and the rotating arm

Figure 9. Articulation angle halving link

2.7 Switch operation sequence

Under normal operating conditions, the switch is controlled remotely and automatically by a command through the signaling system. The sequence of operation is outlined below.

1) Switching Command : The operation precedure can be started by a switching command from the operation control panal or on site manually.
2) Unlock Switching Beams : All the locking devices are simultaneously unlocked by the switching command.
3) Move the Beams : The switch beams are moved to the desired position by the rotation crank arm attached to the gear reducer.
4) Lock the Switching Beams : Lock the beams tight to hold the switch.
5) Complete the Switching Operations : A completion signal is forwarded to the operation control center.

3 CONCLUSION

We have successfully completed the construction, and integration of the 3 way segmented maglev switch, and demonstrated its basic operation. The switch has been operating since last May to find any kinematical problems. 70,000 round trip operations are successfully finished up to now. There were minor problems about the limit switch sensors and the locking device attached to the middle of the longest girder. Actual running test will be possible in the spring of 2010 on the maglev test track at KIMM(Korea Institute of Machinery and Materials).