INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH
TECHNICAL VISIT TO HONG KONG DISNEYLAND ON 1/4/2017

Verse	*主歌*
It's a world of laughter	*人人常歡笑，*
A world of tears	*不要眼淚掉，*
It's a world of hopes	*時時懷希望，*
And a world of fears	*不必心裡跳，*
There's so much that we share	*在那人世間，相助共濟，*
That it's time we're aware	*應知人間小得俏。*
It's a small world after all	
** Refrain**	** 副歌**
There is just one moon	*又有陽光照，*
And one golden sun	*兼有朗月耀，*
And a smile means	*良朋同歡聚，*
Friendship to ev'ryone	*相依相對笑，*
Though the mountains divide	*萬里難隔阻，心裡情長照，*
And the oceans are wide	*應知人間小俏。*
It's a small world after all	
** Refrain**	** 副歌**
Refrain	*副歌*
It's a small world after all × 3	*世界真細小小小，小得真奇妙妙妙，*
It's a small, small world	*實在真係細世界，嬌小而妙俏。*

"It's a small world" is a timeless song of legend of Disney. The Cantonese lyrics for the song were written by legendary Chinese lyricist Dr. James Wong over 30 years ago, which are still lovingly sung across generations throughout China and Hong Kong. This song is the theme of the "It's a small world" attraction in Hong Kong Disneyland Resort (Hong Kong Disneyland), presenting to the visitors how people in different culture, language and geography may share in common in the same song. Besides, Hong Kong Disneyland has certainly more than "It's a small world". Contemplated in November 1999, since its opening on 12th September, 2005, the 68,000 acres theme park located in Penny's Bay on Lantau Island has provided world-

class entertainment experiences to 64 million visitors (including 6.1 million visitors in 2016) and is the pillar of the tourism industry of the territory. The delivery of joyful moments for visitors roots on the safe and reliable operations of the facilities, which members of Institution of Mechanical Engineers Hong Kong Branch (IMechE-HKB) were privileged to appreciate in the visit to Hong Kong Disneyland on 1/4/2017.

Organisation

Hong Kong Disneyland has more than 27 attractions, in which 19 of them are registered amusement rides in accordance with the statutory regulations under Hong Kong Ordinance Chapter 449, regulated by Electrical & Mechanical Services Department of the government (EMSD). Most of attractions were designed by Disney with respect to concepts and requirements, and further designed and constructed by ride suppliers/manufacturers in the U.S., Europe and Asia. While each ride supplier/manufacturer designs its amusement ride products to their national standards, such as ASTM F2291 "Standard Practice for Design of Amusement Rides and Devices" in the U.S. and EN 13814 "Fairground and amusement park machinery and structure – Safety" in the European Union, the requirements are aligned and unified by the Disney in-house standard which is more stringent than the national standards and incorporates the Disney-proprietary operating and maintenance considerations, so that the resulted facilities fulfils both the local regulatory and Disney internal requirements.

In Hong Kong Disneyland, more than 100 professional staffs in Facility Services (FS) manage all facilities and engineering works. Engineering Services which comprises of Attraction Maintenance, Central Shop, Building & Architecture, Electrical & Mechanical and Horticulture services team, oversees all maintenance activities for seven (7) themed areas (i.e. Main Street, Fantasyland, Adventureland, Torrowland, Grizzly Gulch, Mystic Point and Toy Story Land).

Maintenance

Attractions Maintenance is attained by Preventive Maintenance (PM) and Corrective Maintenance (CM). PM are classified either regular maintenance or cycle work for which are safety- or reliability related conducting in calendar- or cycle-based. CM comprises of unplanned and planned. Unplanned CM is classified into three (3) types: Emergency, High Priority and Low Priority which are being responded within six (6) minutes, 30 minutes and two (2) hours respectively.

Maximo is the platform of managing maintenance planning and records as well as inventory management. All frontline technicians are using hand-held devices, which is connected to Maximo and loaded with PM work orders, for carrying out their duties. Step-by-step tasks display on the hand-held screen for completing the PM work orders, and technicians are requested to mark on the hand-held for each completed task. Duty Manager verifies the completeness of PM work orders in Maximo before signing off the readiness of respectively attractions and handing-over to Operation team. Operation team will conduct their own pre-opening checks before opening for guest services in order to conform the safety standard. As of 2016, Maximo has recorded over 120,000 work orders and 190,000 labour hours. Maintenance performance is pledged by balance score-card, stipulating targets on response time, work order back

log, PM completion, and attractions reliability calculated base-on the operating hours, labour utilisation (i.e. labour productivity) and inventory count accuracy.

Stringent Safety Working Procedure is in place to ensure work safety. Ride Access Control and Lock-out-tag-out are implemented to avoid accidental start-up of attractions during maintenance until the completion of works. "Second Set of Eyes" acts as counter-checks for work done with critical components. Automated Maintenance Verification System is also applied in control systems of high energy rides to prohibit the attractions from normal operation for guest services unless PM works have completed.

Iron Man Experience

Iron Man Experience (IMX) in Torrowland is a three-dimension (3D) animation played in a motion simulator. The simulator is a cabin installed on six (6) ball screw-type electro-mechanical actuators, providing six (6) degrees of freedom above 4.2 m from the IMX plant room floor. Each cabin is 12 tons in self-weight and, after utilising its seating capacity of 45 riders, 16 tons. More than 400 sensors scatter across the cabin, monitoring every seat restraint, door access and the operating conditions of each electrical and mechanical operating component. Two (2) 1K projectors and four (4) air knife units installed provide the riders a unique four (4) minute-plus 3D experience.

Contrary to hydraulic jack of 120 kW, each electrical-mechanical actuator consumes 80 kW of power and requires no hydraulic pump to operate, offering a quieter operation. Continuous monitoring of the motion and health of the actuators is in place to ensure safety. Any fault detected in the system will immediately home the cabin and, in the unlikely event of loss or fluctuation of power supply, the capacitors built in the system will instantaneously release sufficient power to bring the cabin back to the home position. IMX is the first application of electro-mechanical actuators on amusement rides, albeit extensively used on flight simulators.

One of the salient features is the riders embark and disembark the cabin in single direction seamlessly while the significant pitching, rolling and liner movements of the cabin require much space between the accesses and the cabin. The solution for satisfying both functions is retractable access, the 6 m wide Loading Jetways which comprise of static bridge and movable bridge. After the cabin is loaded, the movable bridge slides 73 degree from horizontal down to the plant room ground at 4.2 m below the cabin floor and 1.3 m away from the cabin, creating sufficient clearance for the cabin to motion. Before unloading the cabin, the movable bridge slides up to the cabin floor level so that riders after the movie may disembark the cabin and new batch of riders may embark. The enclosed Loading Jetways are well-designed so that riders do not recognise passing through retractable bridges.

The linear motion of the movable bridge is powered by two (2) VFD a.c. motors installed on the maintenance platform at the top of the static bridge. The movable bridge is fitted with gear rack on each side and the pinion coupled with the motor drives the gear rack and the movable bridge to travel linearly. The synchronisation of the linear motion is very important to the movable bridge and the tolerance is 0.5 mm in level difference out of 6 m width of the bridge. Such stringent acceptance criterion

posted significant challenge to testing and commissioning of the rack-and-pinion-operated installation. “Yellowing Test” was conducted to ensure the rack and pinion gear alignment.

Big Grizzly Mountain Runaway Mine Cars

Roller coaster, an amusement ride utilising continuous change in potential energy and kinetic energy to thrill riders with speed, centrifugal force and g-force, has always been unidirectional. The Vekoma of Holland-supplied Big Grizzly Mountain Runaway Mine Cars in Grizzly Gulch (Grizzly Cars) is an exception. It features reversed travel of the train-set and bidirectional use of section of the 1.1 km long track.

Each of the total six (6) train-sets comprises of four (4) coaches with self-weight and payload of 6.3 tons and 1.9 tons respectively. At peak time, one (1) train-set is dispatched from the station every 46 seconds. The train-set itself has no power and its motion is entirely controlled by gravity and driven by either the Booster and Linear-Induction-Motors (LIM) at level or Chain Lift on the hill. Brake fins housed beneath each train coaches that interact with the air-actuated friction brakes, eddy-current brakes and boosters to provide retarding forces to the train. Brake fins interact with the boosters and launcher LIM motors to provide propulsion and slowing of the trains.

Chain Lift is a long length of chain running up the hill in a trough fixed to the centre of the track. Fastened in a loop, it is wound around a motor-driven gear at the top of the hill. The bottom of the third and fourth coach is equipped with a catching hook, or Chain Dog, for engaging the moving Chain Lift upon approach of the bottom of the hill. Chain Lift transmits the uphill motion to the train-set through Chain Dog and, at the summit Chain Dog and Chain Lift disengage and the train-set travels downhill by gravity. Chain Dog is rightly sized to match with the pitch of Chain Lift and, in spite one (1) Chain Dog is sufficient to push the train-set uphill, two (2) are equipped in providing redundancy for engagement and hence warranting safety.

To avoid roll-back during hill-climbing in case of the failure of Chain Lift, Anti-Roll-Back (ARB) is deployed alongside the ascending track. ARB is a liner ratchet static to the track for the ARB “dog” on the train-set to fall and rest in each groove of ARB, limiting the train-set to travel on the uphill direction only.

Chain Lift and ARB permit the train-set to climb uphill whereas Grizzly Cars features reverse motion during uphill travel. The key is the difference in the catchment of the train-set at the reverse travel hill. Instead of engaging Chain Lift directly, Chain Dog engages a Catcher Car which attaches to Chain Lift. The catch pin on the Catcher Car is not fixed whereas hinged by a pivoted arm so that upon hill-climbing, the catch pin in in its upright position for Chain Dog to engage and, when the train-set reaches the height for roll-back, the pivoted arm swings and lowers the pin, disengaging Chain Dog.

Simultaneously, although ARB prohibits roll-back of the train-set on slope, at the reserve travel hill, ARB is displaceable that when the train-set reverses downhill the ARB is effectively disengaged. , After the train-set passes an ARB segment at reverse travel hill, the passed segment offsets itself powered by an air-actuator beneath. The

ARB displacement is fail-safe so that the train-set reverses only when all ARB segments function and offset themselves.

The train-set travels on some section of the track bi-directionally. This is made possible by two (2) track-switches. After the train-set passes the section, the track switches to receive and divert the reversing train-set to go on a different track.

Each train-set is designed for maintenance once every 90,000 cycles, and riding experience is emphasised. The smoothness of the track-wheel interaction is salient to the riders comfort and train speed. The track material of quality steel were supplied and built by Vekoma the ride manufacturer, coated with paints durable to wear in the outdoor environment.

Remarks

Hong Kong Disneyland excels in providing first-class entertaining experiences to visitors, which top-class safety and reliability of the attraction rides is only possible with the contribution of its devoted FS staffs and structured maintenance systems in place behind the scene. IMX and Grizzly Cars are two (2) salient attractions that thrill visitors and they are perfect examples of how mechanical engineering improves people's lives with joy and excitement. For certain, visitors of Hong Kong Disneyland are in good hands of outstanding hospitality and engineering excellence.

IMechE-HKB thanks Mr. Pik-Hung Chan, Manager, Ride & Show, Scientific Systems and Quality Engineering of Hong Kong Disneyland and his colleagues for their hospitality towards the success of the visit.

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