Helical Escalators and Moving Walkways

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*Helixator*

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**ABSTRACT**

Helical escalators and moving walkways have been on the minds of engineers for many years. This paper examines the history of these magnificent machines, the different attempts to build them and the numerous advantages their future brings. The paper reaches several conclusions; one of which is the description of a comprehensive solution for the realization of helical escalators and moving walkways of complex geometries. It describes the process of developing the Helixator technology using state of the art tools and software, and investigates the various possibilities emerging with its invention. The paper shows how this technology answers the current need of contemporary cities for better mobility, and suggests a new approach capable of significant shifts within the vertical transportation trends and industry.

1. **HISTORY**

1.1 ** Significant Helical Escalators**

The first helical escalator to be fully realized was build in 1906. Jesse Reno lead his “Reno Electric Stairways and Conveyors” company to build the machine for the opening of the Holloway Road station, London. The machine was built with two helices to carry passengers in both directions. It was an early "cleat-type" escalator where Passenger's feet tilted slightly upward. Erected in a disused elevator shaft, It was the first escalator ever built for public use in an underground station.

Several thousand people rode the machine on the celebrated opening day. Unfortunately it was also the only day it operated. For safety reasons the machine was never certified for the public use. It was partly dismantled in 1911 and remained forgotten until it's rediscovery in 1988.
In the early 1970's, inventor Gilbert Luna researched and campaigned to promote his solution for helical escalators. The suggested machine had an helical path for the ascending passengers and a return path that crossed its cylindrical core. In his design a third set of rails was to be deployed in the middle of the steps, enabling the usage of a single multiaxial step chain.

During his venture, he constructed at least one scaled model and obtained patents in three countries. His research produced various ideas and solutions, many with notions regarding movement in three dimensional paths, and their functional and esthetics advantages.

The only existing non-linear machine available on today's market is Mitsubishi's "spiral
escalator” product. The machine is a curved escalator of a fixed diameter available in various heights and angles respectively. It has spherical bearing step chains from both sides with a conical sprocket arrangement, to compensate for the different inner and outer chain speeds. The machine is relatively expensive and has demanding maintenance costs, yet it is dominating the sector since its presentation to the market in 1985.

1.2 Moving Walkways

Like helical escalators, moving walkways have been on engineers imagination and drawing boards for many years.

One significant machine was built by engineer Max Schmidt at the “Exposition Universal” Paris 1900. Following early versions at the Chicago world fair and in Berlin, he constructed a 3km long winding walkway for the benefit of fair visitors. The machine included three series of articulated platforms moving at different speeds. The first platform was stationary, allowing commuters to board the second moving platform at a speed of 4km/h, and then to the third platform with top speed of 8km/h. The machine carried approximately 7million passengers during it's period of operation and was considered a great success of the Parisian fair.

Since the early 1960's, an awakening interest of city developers and industry parties in accelerating moving walkways, brought new solutions to be investigated and tested. Major companies have tried to produced, install, and regulate these machines. Believing a successful machine and it's installation would create new forms of mobility and open new markets. Proposals for large urban projects where made for a number of key cities, and included plans for Paris, London and Hong Kong.
In recent years several companies installed accelerating machines in busy transportation terminals to test them under loads of heavy human traffic. These experimental machines extend from polymeric conveyor belts with accelerating segments at both ends, to machines with sophisticated interlacing expanding steps. The experience and knowledge accumulated from these tests could lay the foundation for accelerating standards to be developed, and open the era of accelerating machines for everyday use.

2. CURRENT

Due to the variety of machines available on today's market, planers and architects need to overcome major design limitations. The need for flexible moving walkways has produced interesting solutions to be planned and built. One example is the Mid Level escalator, Hong Kong.
2.1 Case Study - Mid Level Escalator, Hong Kong

The Mid level escalator is a demonstration of rare urban improvisation and solution finding. The project is a series of ramps and platform consisting of 18 escalators and 3 Travelators. It rises a total of 135m and winds over 850m through Hong Kong's dense urban environment. It is the longest and most complex escalator arrangement existing today. With 55,000 passengers per day, the Mid level escalator has become a crucial transport route for this lively district, and an important tourist attraction of the city.

Initiated by the city of Hong Kong, it was built from 1991 to 1993 and involved a number of local architects and academies. It attracted heavy criticism in its first years for exceeding planned budgets, and not reducing car traffic in the district as expected. Only recently has research shown the wide shifts the project has triggered in the district, and the numerous benefits it has brought.
Apart from being an important daily route for thousand of commuters entering and exiting the district center, the escalator has attracted many businesses to be built around it, and has raised substantially the regions real estate value. It performs as an economic engine for the district and city. Indeed Hong Kong officials have expressed on several occasions their interest in a second project of this kind and magnitude.

3. THE HELIXATOR TECHNOLOGY

Initiated as a study in mechanical engineering, the first objective was to produce a valid solution for realizing helical escalators. The *Introduction to Helixator technology* article (Elevator World, September 2009), presented a geometrical study, explaining the usage and advantages of helical geometries. The study included explanations regarding the variable geometries and acceleration option the technology holds. It also included a comprehensive explanation of it's key mode of operation, the core monorail solution. Once the solution appeared, new possibilities emerged and the research expanded to architecture and urban transportation. In these fields research was carried to find the methods and solutions needed to successfully incorporate the Helixator technology into buildings and cities.

3.1 Structure

Restraining the machine to the supporting structure is achieved by means of structural nodes and steel cables. These methods are widely used in architecture, and are common to structural engineers and the building industry.

![Fig 14. (Structural detail, Bundestag building, Berlin (DE), Norman foster 1999) Left](image1)
![Fig 15. (Structural detail, Palais de justice, Antwerp (BE), Richard Rogers 2005) Right](image2)

3.2 Design

Designing the highly flexible machine is done by adopting methods and tools from contemporary architecture and structural engineering. In recent years these disciplines demonstrated the realization of exceptionally light and supple structures. These structures are usually built from prefabricated segments, transported to site, and then suspended and connected into place. They are unlimited in geometry and have minimal footprints, therefore are highly preferable when applied in buildings and dense urban environments.
3.3 Technology

The technological research included a deep study of various software tools used by architects, structural engineers and machine builders. The rapid growth of computational strength, and the current availability of powerful CAD tools, enables large projects to be incorporated into computerized models. These models improve and facilitate the development process and for relatively low budgets they can be tested, changed and improved until they reach their point of fabrication.

3.4 The Step Chain Case

Due to the step chains importance to the machine's feasibility and safety, a great effort was invested in its design. As described in the *Introduction to Helixator technology – extended* (Design modeling symposium, Universität der Künste, Berlin 2009). The step structure requires an adaptable mechanism to keep the passengers feet safe at all times.

In this design, the steps are driven by one central multiaxial step chain, which is an ingenious feature appearing in many earlier machines. The axis of the step's link to the chain, varies in position as it travels along the rail path, enabling the step riser to stay intact and rigid. By doing so, the machine achieves maximum safety, the number of rails and parts needed is reduced, and a relatively simple and light mechanism can be built.
Enable 3D View
Computerized models enable the usage of various software tools to examine, simulate and test the many aspects of their design. In this case, a program with powerful motion tools was chosen to simulate the systems behavior in motion. Once constructed, the model enabled to mathematically represent the components motion, and to carefully study their dynamic and Kinematics requirements.

3.5 Helixator

Contemporary cities present great challenges for all transportation industries. The rapidly increasing need for new forms of mobility creates opportunities for new environmental, economic and aesthetic solutions to emerge. The unique combination of today's computational strength, and availability of tools and production methods, enables to build extremely sophisticated machines. Combining ingenuity and inventiveness of the past with current methods, it is now possible to design and plan large architectural machines and their components down to the bolt level.
The Helixator development has produced a variety of concepts for all subsystems and major components of the machine. It includes designs for the step chain, step surface, drive system and handrails with excellent dimensional stability. The technology was developed for incorporation into the current industry, and the complete system requires only existing technologies to be applied. All methods and tools needed for the realization of the machine are proven, and some have been used by the industry for many years.

4. CONCLUSIONS

In this paper I have outlined the history of many industrial efforts and unique machines. These machines have occupied my mind for many hours and days. Believing contemporary cities need new solution for mobility and transportation, I found that the best conclusion one can offer, is the solution described in this paper.

4.1 Industry

The vertical transportation industry is one of the biggest transportation industries in figures of passenger capacities and daily users. It produces the world’s safest transportation methods, and demonstrates an impeccable safety record to all other transportation industries since its very beginning. The industry's history work and effort, made elevator and escalator an essential part of our culture, and an important symbol of modernity and advancement.

This research is proudly presented, out of profound acknowledgment to all inventors and engineers, dedicating themselves to this magnificent industry, and its prominent future.

5. ACKNOWLEDGMENTS

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