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Hyperloop steel tube

Seven years ago, on a hot August day, American entrepreneur Elon Musk first unveiled the concept of a Hyperloop vacuum train.

According to the project, the train had to cross the 560 km distance between the outskirts of Los Angeles and San Francisco in 35 minutes at a speed of 1,200 km/h. The construction budget was estimated at US$6 billion.

Later, Hyperloop critics didn't have enough fingers on both hands to list all the bottlenecks contained in this bold idea and sought to prove why its implementation is impossible. By August 2020, however, the U.S. Department of Transportation had given Musk's innovation a very practical significance by establishing regulations for Hyperloop technology. Furthermore, the Federal Railroad Administration put Hyperloop in a separate category of vehicles, which created a legal basis for it and made the project eligible for federal funding. Elon Musk calls Hyperloop a "fifth mode of transportation", a cross between a Concorde aircraft, a railgun and an air hockey table.

The concept

The high-speed railway developments preceding Musk's "hyperloop" would get stuck again and again because of friction and air resistance, factors that become critical at high speeds.

The inventors of Hyperloop, however, decided to cheat the laws of physics. First, let's take the system itself. It is a

large-diameter tube

laid in the ground between the start and the end point of the route. It operates a capsule with passengers, dubbed a 'pod'. The tube has conditions similar to a vacuum, which almost eliminates air resistance. During movement, the pod levitates, which, in turn, reduces the force of friction. As a result, the capsule is able to move faster than a plane, at a speed of more than 1,000 km/h.

In fact, the acceleration of the pod to a specified speed and the creation of a vacuum make up the main technical task the project engineers have been toiling over. It is important to understand that the smallest error by the developers can lead to terrible consequences at breakneck speeds. It's worth noting here that, according to Mr. Musk's base requirement, Hyperloop should run solely on renewable energy, which is another "headache" for the experimenters.

So, shortly after Space X and

Tesla Motors

developed the first Hyperloop concept in 2013, the owner of these companies, Elon Musk addressed the public, calling for efforts to improve the "hyperloop". Since then, research and experiments on Hyperloop technologies have been carried out in an open source mode, where all developers freely share their findings with partners on the project. At that time, two companies were created to continue the developments: Hyperloop One and Hyperloop Transportation Technologies (HTT). The latter now brings together about 800 engineers from the United States, who are currently working on the project for free, hoping to receive dividends after its implementation. HTT has already evolved into a social movement, whose goal is to create a single world, where the distance has no special importance as the result of a Hyperloop network spreading across the continents.

Hyperloop One, on the other side, employs experts from Elon Musk's inner circle, who were "schooled" by SpaceX, Tesla and PayPal. In 2017, the legendary British entrepreneur Richard Branson , who invested $85 million in the project, became one of Hyperloop One's executives. According to a recent marketing report on the Hyperloop technology market, the industry already had 10 large players by 2020. The market itself is expected to grow by a third in monetary terms over the next seven years.

However, it is too early to speak about the commercial aspect of Hyperloop. The "hyperloop" solution is still at the creation stage. Yet it is now clear that steel will be the cornerstone of the future global Hyperloop network.

Materials

Based on the description of the future infrastructure project, it is obvious that the main, i.e. the longest, most critical and costly, element of Hyperloop will be the tube. The material from which it will be manufactured should be able to create a vacuum environment inside the structure, guarantee the safety of the capsule travelling at high speeds, and withstand all weather and environmental challenges. Also, given the long length of the future transport infrastructure (on the European continent alone, Hyperloop will extend for 10,000 km) an important factor is the well-established manufacture of tube material, and the relatively low cost of its production.

Teams working on the hyperloop have explored a great number of possible materials for its construction. At the current stage of the project, the scales tilt in favour of steel. Concrete was rejected because of its relatively low strength and difficulty in achieving airtightness. Aluminium, which, as you remember, is one of the main materials in the aircraft industry, was rejected because of its lesser rigidity, while an acrylic tube would have been unreasonably expensive.

The researchers are now busy studying the various forces that will impact the steel tube of "hyperloop" in the future. So far, they can only simulate the impact of the difference in air pressure inside the tube (it is almost a vacuum in there) and the air environment outside the structure. Thus, the calculations of the experimenters show that, with the steel tube radius at a preliminary 1.75 m, the thickness of the Hyperloop wall should be 25 mm, since a thinner wall will not be able to withstand the buckling due to internal stress caused by the vacuum.

To create a tube that is thousands of kilometres long, it will require a huge amount of steel. Its production, primarily due to volume, will not only be expensive, but, without a doubt, will have a serious impact on the environment. The engineers also understand that a steel tube fixed between the final stations will inevitably respond to changing weather conditions. For example, they are trying to find a solution to the thermal expansion of steel caused by increases in the ambient temperature. The effects of wind impact and the inevitable corrosion of metal are also being investigated.

These challenges force Hyperloop developers, just like their fellow aircraft builders, to look to modern composite materials. First, composites are lighter than steel. Second, due to specific manufacturing features, the composite tube walls will be thicker than the steel walls, which, significantly, will help find solutions to the buckling problem of the "Hyperloop". Third, composites are not as sensitive to temperature fluctuations, therefore, the risk of thermal expansion will be much lower than with a steel tube. Fourth, the use of composites allows for the manufacturing of a long tube, thus reducing the number of joints.

Just over a year ago, researchers from Delft University of Technology (Netherlands) proposed the idea of using ultra-high-quality concrete reinforced with steel fibre rebar. The possibility of using aluminium matrix composites also sounds promising. These are lightweight materials that are generally more resistant to pressure and temperature impacts than steel.

However, all of the arguments of the composite "hyperloop" supporters run aground on the financial side of the issue. The production of steel tubes for the Hyperloop will be significantly cheaper compared to composite tubes. Therefore, steel as a material for the futuristic Hyperloop tube has no competitors so far.