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Train a Grande Vitesse
(High-speed train)

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Abstract— The TGV (French: *Train a Grande Vitesse*) is France's high speed rail service, currently operated by an organization known as SNCF Voyages. To counteract the popular misconception that the TGV would be another premium service for business travelers, SNCF started a major publicity campaign focusing on the speed, frequency, reservation policy, normal price, and broad accessibility of the service. This commitment to a democratized TGV service was further enhanced in the Mitterrand era with the promotional slogan "Progress means nothing unless it is shared by all". The TGV inspired its power from rocket train. The aerodynamic structure was derived from mallard. The stability was a modification of the shinkansen train commonly known as the bullet train. The nuclear power stations of France helped these trains attend such a speed. These all factors helped the TGV train to set the record for the fastest scheduled rail journey with the top speed of 574.8km/h (Testing). The TGV was considerably faster than normal trains, cars, or aeroplanes. The trains became widely popular, the public welcoming fast and practical travel. This paper presents the origin and operational aspects of the pride of France i.e. TGV.

Keywords—(SNCF-Société Nationale des Chemise de France, TGV- Train a Grande Vitesse, LGV -Ligne a grande vitesse, AGV-Automotrice à grande vitesse)

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I. INTRODUCTION

The pride of france, the hard work of engineers have set a perfect example, the TGV. Engineers now are putting forth their theories and upto building the next generation bullet on wheels. Travelling at over 500km/h the TGV is the accostics of france's high speed railway.

Figure-1. TGV

The TGV owes success to four key innovations found in a series of landmark each one carries a major technicle advancement wich allowed engineers to push the speed limit further and further, from the first inter city railway to the fastest rail on the planet.

II. HISTORY

A. *Leap 1: Power*

To understand how the TGV can travel to such a speed we need to go back in time. In the 19^{th} century, Britain, a group of Businessmen wanted to built the world's first intercity rail, so the first engine "The Rocket" was discovered.

Figure-2. Rocket

Instead of a large pipe they divided it into 25 small pipes and thus there was lot of steam to power the engine. Rocket holds the world record of the fastest steam train in the world till date [1].

B. *Leap 2: Aerodynamic structure*

When these trains race along with speed they face an invisible obstacle, the air. Sir Nigel Greslie who was a great

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fan of the Buggati cars implemented this idea on his experimental model.

In order to slip through the air in front of the train Greslie gave his train a wedge shaped nose just like that of Buggati car's. To prevent the wheels with sterling up with wind he covers the top edges with elegantly stream lined panels, to stop turbulence formation in the carriages he covered them up with sheets of rubber. Now the train is not just powerful it is "Aerodynamic".

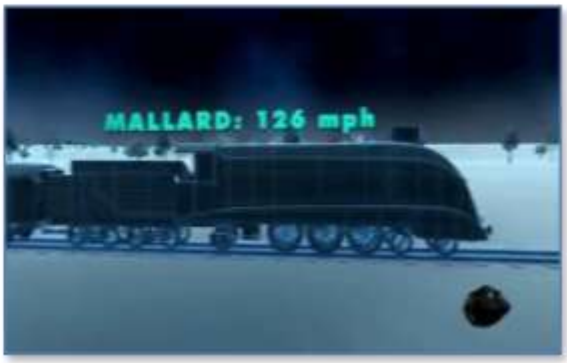

Figure-3. Mallard

In 1945, a mallard named A-4 pacific shattered the records by attaining a speed of 145km/h which is much faster than the cars of today. This train has more engine power than all the cars of formula 1 put together [2].

C. Leap 3:Stability

Figure-4. Bullet Train

As we move a quarter century ahead the world was introduce to the pride of Japan gushing across the mount Fujiyama, the shinkansen also known as the bullet train. But this prototype has a serious problem, at certain speed the carriages starts moving side by side inducing a snake like moment. These vibrations were so violent that it would derail the train. That is why the legacy of shinkansen is still visible on TGV today [3].

III. COMPLEX COMBINATION

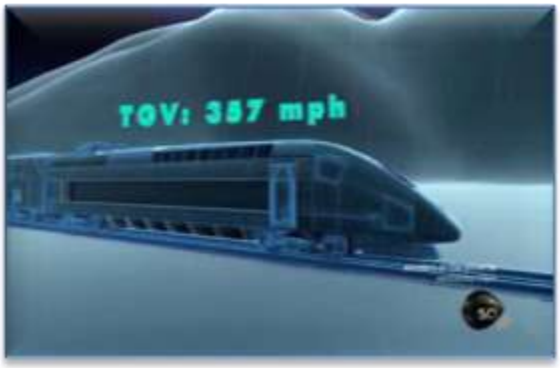

Figure-5. Complex Combination

Hence, TGV is the complex combination where it acquired power factor from "The Rocket", the aerodynamic structure from "Mallard" and the stability factor from "The Bullet Train" [4].

VI. MODIFICATION IN TGV

It was originally planned that the TGV would be propelled by gas turbine electric locomotives. Gas turbines were selected for their small size, good power-to-weight ratio and ability to deliver high power over an extended period, but due to prices of oil and energy crises gas turbines were deemed uneconomic and the project turned to electricity from overhead lines. The electricity was to be generated by France's new nuclear power stations.

TGV was not a wasted prototype its gas-turbine power plant was only one of many technologies for high-speed rail travel. It also tested high speed brakes, needed to dissipate the large amount of kinetic energy of a train at high speed, high-speed aerodynamics, and signaling. It was articulated, i.e. two adjacent carriages shared a bogie, allowing free yet controlled motion with respect to one another. It reached 318 km/h which remains the world speed record for a non-electric train. Changing the TGV to electric traction required a significant design rearrangement.

A. Track Design

Figure-6. Tilt While Turning

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They had larger radii of tracks at the turn (minimum of 7km).Deeper ballast than normal tracks so as to maintain stability and load bearing capacity than the traditional trains. For high-speed train it is possible to have greater super elevation (tilt), since all trains are travelling at the same speed (high) and a train stopping on a curve because of a stop signal is a very rare event.

The Process of raising the outer edge of the track over the inner tracks through a certain angle is known as Banking of Tracks. The angle made by the surface of the track with the horizontal surface of the trace is called Angle of Banking.

Mathematically,

$A=(v^2/R)$
Where R= radius of curvature
$\mu_k = \tan \theta_k$

W can be replaced with,

where,

F_k =Centripetal force
$F_\perp$ and N=Normal force
Mg=Mass of the train
θ_k=Angle of banking

$\mu_k = (F_k / N) = (W \sin \theta_k) / (W \cos \theta_k)$,

or

$\mu_k = \tan \theta_k$

$F_\parallel =(\mu_k . N)$

$(F_\perp = W \cos \theta_k)$ …………..…….(1)

$(F_\parallel = W \sin \theta_k)$ ………………..(2)

$F_k = F_\parallel$ ……………….......(3)

$F_k = W \sin \theta_k$ ………………..(4)

Since, by definition $\mu_k = F_k / N$

$V=(\mu_k R)^{1/2}$

Therefore,

$V=(\tan \theta_k . R)^{1/2}$

$\tan \theta_k =(v^2/R)$

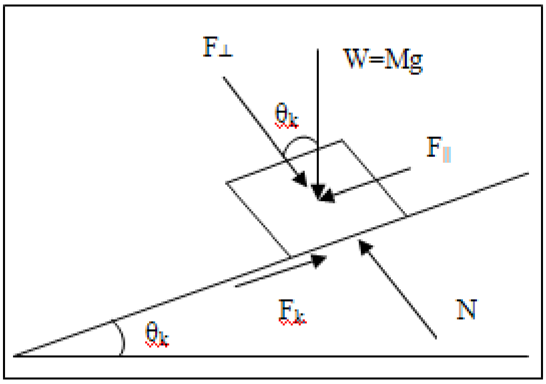

Figure-7. Banking of Tracks

The curved horizontal tracks are banked at an angle θ.

B. Tunnel Design

Figure-8. Traditional Tunnels

To reach countries like Spain the engineers have built tunnels through mountains, but tunnels create serious problems to high speed trains. On a well designed train most of the air rushes on the top ant the sides, within the tunnel the air gets squashed and turns into a shock wave and shoots ahead of the train with the speed of sound like a bullet from a barrel it exits the tunnel with a sonic boom which rattles the neighborhood devastatingly.

Figure-9. Tunnels of TGV

To deaden the boom engineers installed a canopy over the tunnel entrance that has slots cut into its roof. The holes dissipate the energy of the blast, so the train leaves the tunnel only with a wind boom [5,6].

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C. Signaling Systems

Figure-10. Transducer for Signaling System

About 800 passengers on board the signaling system must be 100% reliable even in extreme weather conditions. The French out there are rolling out their latest signaling technology which works without any physical contact; they install transducer at regular intervals along the tracks. These transducers send electric signals through the rails which creates a magnetic field around them. As the train passes an onboard sensor picks up the signal and relays the information to the driver in the cab but if the signal ever disappears an onboard computer automatically slams on the brakes [7].

D. Pantograph

Feeding electricity to such high speed trains is a real challenge. Engineers rely on a metal contact extending up from the train called the Pantograph.

Figure-11. Pantograph

Pantograph has a pivotal load of transmitting electricity from the over head wires down to the motors that drive the train. For this Graphite is the optimum metal use with low friction rubbing and is very good in transmitting electricity. A straight power line will wear a groove on the soft graphite strip but on TGV wire crosses from one end to the other side so that the graphite strip wears uniformly. If the strip is damaged the pantograph snags out and then the wire is ripped out. To stop this happening the pantograph is pushed up with compressed air, if any part of the pantograph gets damaged the air escapes and the contact drops down before the wire can snag.

D. Wheels

Figure-12. Springs

The supple conical shape of the wheel is the key to keep the train on its track. At scale model tests the wheels started swinging at higher speeds and slide off the rails. Engineers realized that the problem lies in the train suspension with nothing to absorb the sideways motion of the wheels. This problem became worse. Their plan was to attach steel springs to the axel which should keep the train on track and it did. This new innovation is an outstanding success and keeps the TGV firmly on track. With this advance the train became fast, safe and on time.

E. Boogie Arrangement

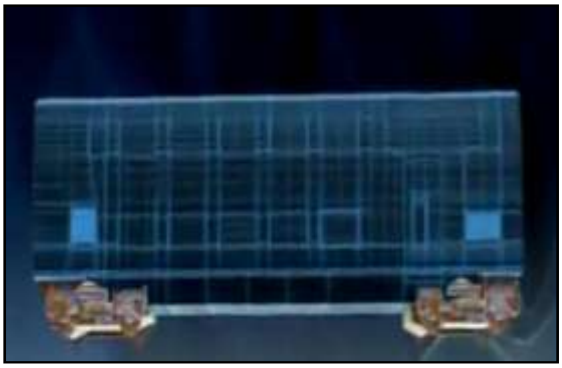

Figure-13. Tradition Carriage Design

Conventionally we have a boogie in the front and back of each carriage and they get linked up together to form a train. This is a disadvantage in a crash the carriage can jackanize against each other and derails the train.

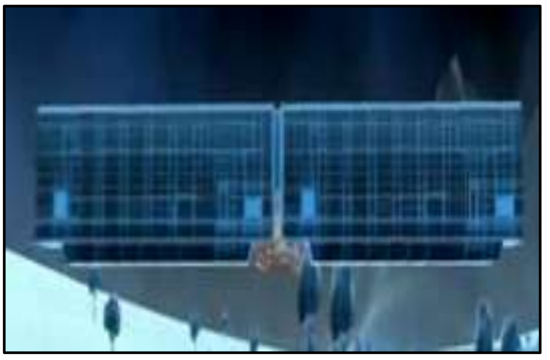

Figure-14. TGV Carriage Design

But on a TGV the boogies sit between two carriages which makes strong connection, the train is more rigid, so in a crash it is more likely to stay straight on tracks keeping the passenger safe inside.

CONCLUSIONS

The concept of "Digital India" put forward by Prime Minister Mr. Narendra Modi on 14th July 2014 motivated many individuals from co-operates and research sector in this "Nation Development Program". The metros, mono rails are the beginning of this new era in railway transportation of India. The fastest train in India is the Bhopal Shatabdi running between New-Delhi and Bhopal. Its speed is of 91.83Km/hr. Rapid metro rail gurgaon, which started operating in November 2013, is India's first privately owned and operated co-operation. It is estimated that with dedicated hard work and advance technologies India will soon see trains like TGV, LGV and AGV speeding along the tracks. In case of TGV President Metterand had said that "Progress is not complete unless shared by all". The railway transport is the most effective, cheap and reliable source of public transport. The railway transport is the best mode for the speedy transport even for common person. TGV was not only for the premium people but also for the common once, moreover with TGV we can travel at the speed of aeroplane but at a lower expense.

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BIOGRAPHY

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