Discussion of Railway Noise and its Abatements

Simranjit Singh[1]
Assistant Professor
Department of Mechanical Engineering
Desh Bhagat University, Punjab,India

Ramanjeet Singh[2]
Assistant Professor
Department of Mechanical Engineering
Desh Bhagat University, Punjab,India

Abstract- **Noise would always come across as a source of irritation and distraction regardless of the source of its origin. Railway noise is generated from shunting of boogies and other processes that are associated with it. There can be two ways to stop unwanted sound; firstly to design screens which would stop the sound after has been generated. Second would be to stop the generation of that sound at the source itself, one way of doing the same is to upgrade our own technology to meet the present day requirements. Now a day's models have been developed to understand better the whole process, from the noise emission to the part where the barriers are designed. These models helps get an inside depth view of the subject, once we understand and develop a model in accordance to the ideal models presented to us we would develop a quite environment to live in. Also we need to understand the various aspects of designing abatement if one is needed for the process of noise reduction.**

INTRODUCTION

This article gives a complete view of the railway noises and other points associated with it. Starting from the primary reason of noise generation and the reasons associated with the same, we have to understand that some noises are uncontrollable and their generation is a process that cannot be checked under any circumstances. The only answer to such noise is putting up abatements to hamper its travel and also for the reason that the area follows the noise level norms. For other noises we can develop new ways which would stop their generation, for this we can either modify our old techniques or develop new ones. Either case we will have to push our technology to meet today's needs. Development of a better system to deal with this issue would help us make a better environment to live in. In this research paper we would move through all the aspects of railway noise, right from the sources and reasons for its generation to the models which have been developed to predict the same to the abatements which have been designed and their placements in accordance to the sound. Also it covers the various railway systems as all have their distinct noise problems which need to be dealt with the as their sources are different they need different abatements and methods to stop the same. So towards the end we would develop a correct view of all the whole system.

LITERATURE REVIEW

Railway noise: Sound is exactly what we hear. Noise is unwanted sound which made us uncomfortable. Railway noise is sound produced by vehicles using rail guidance system which includes all types of rail systems like freight, commuter rail, metro and light rail system. Basically, it stems

1. Due to the friction between rough wheels and tracks when a train is moving on the railroad track.

2. Sometimes, whooshing sound is produced due to the air displacement present in rail/train.[2]

Rather than this, some noises are also produced by track alarms and level crossing during the day to day life of the railway. Also, Engineering and maintenance work can also be noisy but these types of noises last after a short period of time. So, Railway noise has seen as a serious problem for rail transport to further development of railway networks high-speed intercity traffic, for freight and for suburban metros and light-rails. [12]

Main sources of railway noise: There are basically two sources of railway noise each having particular sub-features:

1. Rail vehicle: It includes power unit installed in the vehicle which may be diesel or electric and other accessories used in the rail vehicles like ventilators, brake systems. Diesel engine is the main source of noise but now days it is improved to some extent with the use of change of technology.

2. Track condition: It is the most influential source of railway noise. Due to improper joining or welding of railway tracks leads to a number of noises like tracks with tight bend radius leads to wheel squeal.[2]

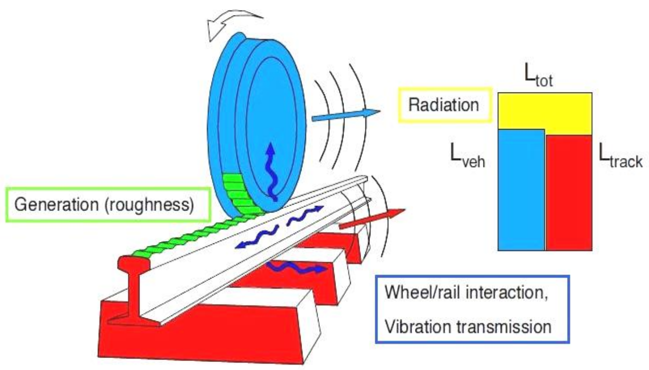


Figure 1.Sources of railway noise[6]

*Prediction of Noise Emission from Railways:*But as we go further it is very much necessary to know what amount of noises comes from where, when and why. For this purpose noise prediction methodology is necessary. According to the European commission it is important to be aware of noise exposure across the community through noise mapping requirements of directive 2002/49/EC (The Environmental Noise Directive or END). As we know the rolling noise is most dominating noise which is mainly produced due to the roughness at the wheel-track interface. Along with European commission TNO was also involved in the development of several models for the prediction of railway noise. Some models for the prediction of railway noise:

• The TWINS model for wheel/rail rolling noise

• A model for curve squeal

• NESSY, a model for noise from steel bridges

• IMAGINE, the newly proposed European rail traffic calculation model

• Vehicle interior noise with EQUIP+. [6]

But these calculation models for rolling noise are totally based on sound exposure level based term for each vehicle making up the railway traffic.

So, in the end for the prediction of daily noise emission it is necessary to consider relevant factors responsible for the generation of railway noise like the roughness factor and the management of the traffic flow i.e. train types, composition, timetables and speeds. So, for this purpose time histories for 24 hours for a particular train type (single by-pass) with selected wagons are considered.

Noise situation	Pass-by noise: Constant speed and acceleration/ deceleration	Stationary noise	Shunting and other
Noise sources	Rolling Traction/auxiliary Aerodynamic (Locally: Squeal, Impact, bridges)	Traction/auxiliary	Squeal/Impact Traction/ auxiliary Rolling

Table 1. Major noise sources[7]

When considering the noise emission characteristics of individual train number of major noise sources are also taken into consideration, which are relevant for particular situations.

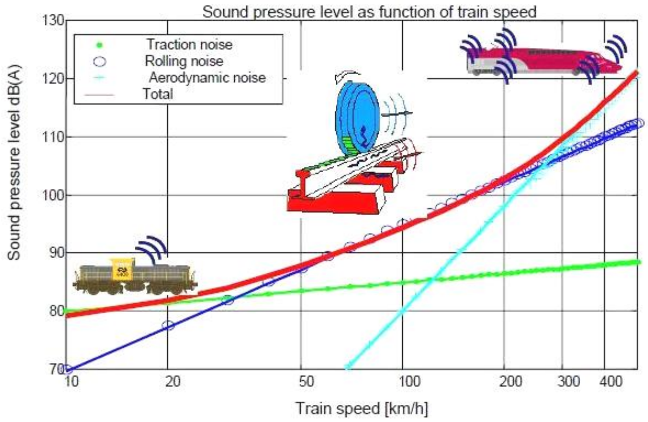
	Rolling noise	Noise from traction and auxiliary systems	Aerodynamic noise
Freight trains	++	+	
High speed trains	++	+	++
Intercity trains	++	+	
Urban trains	++	+	

+: Relevant

++: Highly relevant

Table 2. Different train speeds [7]

From the above calculated data it is cleared that train speed is the crucial issue for railway noise to validate this following graph shows the proportionality of noise with an increase in the speed of the train.



Graph 1.Train Speed v/s Sound Pressure [9]

Types of Railway Noise:

Depending upon available data the following are the number of noises that were predicted a contributing to railway noise:

1. Traction Noise – Traction Noise is emitted from the traction motor and extra cooling fans. It is one of the noise source produced by powered railway vehicles such as locomotives, electric and diesel-powered trains and high-speed trains. Especially at low speeds and idling, also at acceleration conditions for a wide range of speeds, traction noise can be dominant. This is relevant for noise in residential areas near stations and shunting yards, but in some cases also along the line.[1]

2. Rail/Wheel Noise – Rail and wheels are set into vibration. This produces external and internal noises due to poorly associated strip joints and also due to the roughness of the wheels and the tracks. This type of noise is also known as rolling noise.

3. Aerodynamic Noise – It is produced when the train is passed through the air with high speed. Its contribution to the total noise is directly proportional with the increased train speed.

4. Auxiliary Equipment Noise – Some noises are also produced by track alarms, level crossings, and auxiliary and necessary equipments of the train like compressors, ventilation and brake systems.[3]

But out of these noises, rolling noise is most predominant noise source in medium speed traffic and even for high speed up to 300 km/hr. There is little concern for noise radiation in the design and shaping of present train wheels. A number of technological improvements are made in the design of the trains to reduce the railway noise instead upon spending on the construction of the noise barriers. [2].

Some basic suggested techniques for noise abatements: For reducing noise emission from railways some preventive measures are to be taken: on the tracks, on the vehicles and in the sound propagation path. As we know that most predominated noise is the rolling noise, which can be reduced to some extent with making the noise barriers, later it was realised that noise barriers with the height of more than 4m is most hazardous for track workers, railway passengers and line side residents because it blocks their visual intrusion that's why it is not recommended.[7] So, several studies were conducted at the end it is concluded that measures at the source is more beneficial (STAIRRS project) than other afterward abatements. The following are some noise reduction techniques suggested to lower the railway noise.

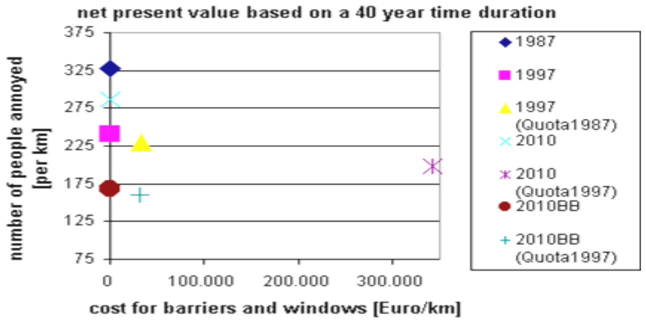
1. Replacement of cast iron block brakes having rough wheel surface with disc or drum brakes or composite block brakes in new coaches having speed more than 140 km/h but not recommended for freight wagons because rolling stock does not change.
2. Rails can be made smoother by "polishing" and vibrations can also be reduced by using rail dampers.
3. Replacement of jointed tracks with continuous grinding racks and wheels.
4. Construction of noise barriers to reduce aerodynamic noise from the upper part of the high speed trains but these noise barriers is too low to stop this type of noise.
5. Improved design of locomotives and rolling stock.
6. Elimination of obstacles in ducts, intakes and outlets and installation of quieter fan design for the reduction of traction noise.
7. Low movable noise barriers were also suggested in Austria but still yet not implemented.
8. Bogie shrouds were suggested over 30 years but they were never tested till 1994. In the end bogie shrouds with its bottom edge so close to the head of the rail with gauging restrictions is built to overlap with the top of the barrier tested by SNCF research development. [2]
9. Track insulation from the ground (with rubber pads and ballast).
10. Insulation of buildings near railways.
11. Insulation of affected buildings. [5]

DIFFERENT STRATEGIES FOR CONTROLLING RAILWAY NOISE

From 1955 different large case noise control studies were carried out in The Netherlands, Switzerland and the Europe. These studies concluded that noise control by barriers lead only to tremendous cost which was exceeding the budgets of national govt. and railway companies. So to limit the large scale noise impact a change in policies of railways was needed.

1. *Case study for noise abatement in the Netherlands*.

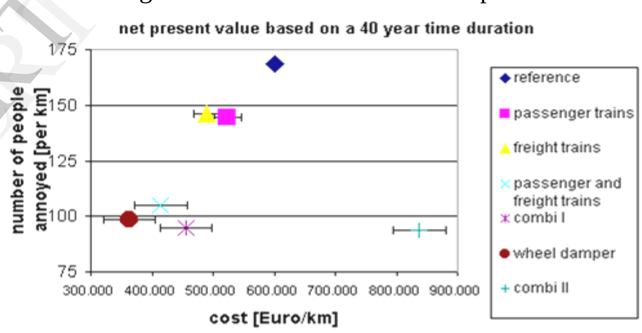
The main motive of the study carried out was to enumerate the effect of noise creation on entire Dutch railway network with line length of 2,800 km and to prevent an actual allowed growth of transport by about 20% per year. The results concluded that by 2010 an increase of rail transport with noise creation based on the level of 1997 will cost 350.000 Euro per km needed for 600 km of noise barriers and window insulation of 1780 houses. [8] Sound control measures like a 7 db(A) improvement of tread braked national passenger and freight trains and timely replacement of wooden sleepers by concrete sleepers(-2 dbA) will reduce barrier and window cost to 32.000Euro per km.



Graph 2.Net present values for noise barriers and window insulation

In 1997, 241 people per km were annoyed by railway noise and by 2010 this number will increase to 286 per km approximately(+19%) without using any additional noise measures but the controlled noise measures will reduce this number to 198 which is approximately(-18%) in number.A future scenario with source measures and without any additional barriers will result in 168 annoyed people per km (-30%) and using additional barriers will lead to 160 annoyed people per km (-34%).The following graph shows the effect on the people annoyance due to railway noise in accordance with increasing railway traffic of different trains in terms of cost in EURO/km.This study concludes that:

- A general noise reduction to 65 dB(A) at the facade wall of houses in combination with 0 dB(A) source measures will lead to high barrier cost of 250.000 Euro per km.



Graph 3. Net present values for noise control measures

- Above tested source measures (up to 7 dB (A) for replacement of cast iron tread brakes of all national trains) can reduce these barrier cost up to 50 %.
- 44-53% of the total barrier cost is along railway lines where local communities prefer to have window insulation instead of noise barriers.
- 18% of noise barriers along railway lines (where local communities prefer to have barriers as a noise measure) is not efficient (compared to window insulation). [8]

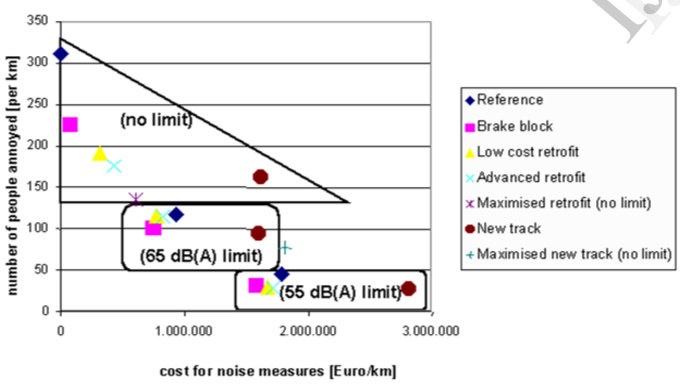
2. *Noise Control Strategy for Switzerland:*

The Swiss devised their own way to combat this problem which was to develop an extensive mapping system which falls under the economic and operational limits. The first tier of maps pointed out the areas which indicated the location of the noise problems, these maps were on a scale of 1:25000. Further, they narrowed down the area under scrutiny to 1:2000 where the costs involved and the combinations of measurements were also considered for the same. Then on with collaboration with the authorities involved a strategy was devised which covered the improve of all Swiss rolling stock along with the installation of noise barriers for cases where a cost effective index was attained.

Lastly insulated windows were installed for the cases which did not achieve the threshold limit with the first two conditions. They achieved a protection percentage of 70% with the first two conditions only using up around 30% of the budget which is assigned for the total threshold limit. Even if the third step of installing insulated windows is applied a 5% usage of the total funds is observed. The priorities are based on a “noise mass” index which is defined as the number of persons above the threshold limit weighted by number of decibels above the threshold limit. This basis turned their attention to the north south fright corridors. The program would be seen in full operation by the year 2015. Currently, noise creating cars have been fitted with brake blocks. The design tool for noise barriers has also been upgraded as to provide an automated report alongside all maps needed for the approval. It also counts the conditions if the changes are needed on site and whether the same would be rendered to as cost effective. This gives them a wider perspective view and thus increased their productivity and efficiency manifold. [3]

3. European economic study on railway noise reduction measures (Europe):

The International Union of Railways (UIC) started an EC/ERRI sponsored project studied the cost and benefits of low noise solutions on one major freight transit lines was analyzed. For which various factors are considered like annual cost which consist of long term interest rate, maintenance along with life cycle over the measures. According to the survey it is cleared that to reduce noise levels beneath 60 dB approximately yearly costs of €20,000-100000/km would be necessary. [11]



Graph 4.Values for reducing people annoyance due to railway noise [8]

So we can say that to achieve maximum effectiveness at least €60000km/year is needed but if we consider the noise barriers with high height as measures it would not be a cost effective solution. [7]

For the cost effectiveness solution different scenarios were considered like reducing freight wagons by 10db, retrofitting freight wagons with K-block, grinding tracks/wheels, using absorbers and use of barriers. Now for the investigation and validation of these low noise solutions STAIRRS project by UIC was introduced. When obtained results were compared with reference then a tremendous decrease in the noise levels is recorded with these suggested solutions. But as already told noise barriers with height more than 4 m are not so much cost effective as compared to rolling stock. The combination of rolling stock with other track solutions are seems to be most effective solutions. The following table shows the noise reduction in dB (A) for various track/wheel combination with reference. [4]

	WHEEL					
TRACK	Ring damper	Perforated wheel	Perforated wheel + ring	Shape optimised	Shape optimised + absorber	Shape optimised + web shields
Ref. track + stiff pads	3	3	3.5	3	3.5	3.5
Ref. track + tuned absorber	5	6	6	6	6	6
Ref. track + pads + tuned absorber	5.5	6.5	7	6.5	7	7
New track	2	2.5	2.5	2.5	2.5	2.5
New track + tuned absorber	6.5	7.5	7.5	7.5	8	8

Table 3. Noise reduction in dB (A) for various track/wheel combination [4]

4. Case study for Luxembourg:

The Swiss Federal Railways was undertaken by Luxembourg railways CFL for noise mapping using the Eurano-2001 software program to the scale of 1:20000 while considering different networks, strategies and threshold levels in close contact with government ministries. When results were compared with STAIRRS project results, similar results were obtained i.e. rolling stock measure is the best cost effective noise strategy for the CFL. But till 2005 it was not implemented. [3]

CONCLUSION

An approach which integrates mapping and cost-effectiveness considerations allows adherence to the EU requirements while obtaining a network-wide noise control strategy at the same time. The procedure results in a strategy that finds a balance between legislation, railway competitiveness and environmental protection. But these designs are only in the pre-prototype stage, and much work is to be done before it would be implemented railway engineering hardware.

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