Ministry of Higher Education and Scientific Research

Kasdi Merbah University – Ouargla

College of Applied Sciences

Department of Mechanical Engineering

End-of-study dissertation with a view to obtaining a professional Master's degree

Specialty: Mechanical Industry and Production Techniques

Presented by:-Kouidri Abdessatar

- Mahcene Mohammed tahar

-THEME

Study and monitoring of the surface topography of the wheel-rail contact case of the ouargla tramway

Publicly supported on :14 /06 /2022

In front of the jury :

Mr. BOUHEMAME Nacer	**MCB**	**UKM OUARGLA**	**President**
Mr.MEZOUDJ Mourad	**MAB**	**UKM OUARGLA**	**Examiner**
Mr.ABD ELKARIM MOURAD	**MCA**	**UKM OUARGLA**	**Frame**
Mr.Chiba Elhocine	**MAB**	**UKM OUARGLA**	**Frame**

Promotion

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UNIVERSITE KASDI MERBAH OUARGLA

Faculté des sciences appliquées

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Etude et suivi la topographie de surface du contact roue-rail cas de tramway Ouargla

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Mr. BOUHEMAME Nacer	**MAA**	**UKM OUARGLA**	**Président**
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dedication

Not all letters can find the right words...

Not all words can express gratitude, love, respect and appreciation...

That's simply I dedicate this humble work...

To my dear parents for love, sacrifice, patience and material

and moral support since my childhood

To the professors and supervisors who guided me on this path of knowledge

To my friends and colleagues who supported me and helped me in my time of need

To the official of engineers and those in charge of CITAL and SETRAM To all those who

helped me with prayers and motivation

To those who have supported me throughout this project.

To all those who waited for the completion of this message and who prayed to "ALLAH" for

more success.

Thanks

"First of all, we thank God, the Most Gracious, the Most Merciful for success. He has given us the strength and patience to do this humble work.

♥ We would like to express our sincere thanks to Dr. Mourad Abdel Krim and the jury president Dr.Bouhmame Nacer and the examiner Dr.Mezoudj Mourad for his supervision, guidance and support for us.

♥We also extend our sincere thanks to the kind parents for their continuous support and contribution to completing the school trip

♥Thank you also to everyone who made this work a success

♥ And do not forget the work and maintenance staff of CITAL company

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GENERAL INTRODUCTION

The human need in the beginnings of human gatherings and human settlements for transportation and its subject was linked to the permanent movement of him as he moved from one place to another in search of the necessities of life, and formed the first regular human movements between his home and the place from which he brought food and drink. Transportation is one of the most important elements required by human activities in their various developments, whether in search of sources of livelihood or to move from one place to another for various reasons. This has increased in the contemporary stage, as transportation has become like a sensitive nerve in the economic entity of the unity of the place.

The transport network contributes to the distribution and concentration of various activities and functions, and the city cannot grow and develop beyond the development of the transport network, as urban land uses cannot perform its functions without the movement of people and goods. The old street network, increasing its length and raising its functional density, which caused a fundamental change in the distribution of uses in the city. Therefore, the planner must clarify and analyze the status of the road networks that he used in the planning of the city. The population increase in some cities in Algeria and the rise in the standard of living led to the overlap in jobs. The multiplicity of movement and the diversity of its causes create a set of problems at the level of the transportation system for these cities. The state decided to start improving the sector by introducing other means of transportation of various types, whether sea, air, or land, which Depend on the roads and railways, which is the subject of our research.

The tramway is subjected to several factors that may disrupt its movement (the heat caused by braking, the stresses caused by the imbalance due to the unevenly distributed load, defects and distortions in the rail, the low coefficient of surface roughness, the latter, which is the subject of our study. To do this research well, we adopted the following methodology

- ✓ The first chapter represents the various means of transport, in which the focus is on rail transport (train, tramway), its mechanical and chemical properties, identification and study of its various malfunctions.

- ✓ The second chapter represents the experimental study carried out by the CITAL SETRAM maintenance institution in order to study and follow up the roughness of the contact surface between the wheel and the railway on the tramway transport line in the state of OUARGLA.
- ✓ The last chapter represents the experimental study carried out by the CITAL SETRAM maintenance institution in order to study and follow up the roughness of the contact surface between the wheel and the railway on the tramway transport line in the state of OUARGLA and that to confirm that the contact surface condition has an important role in safety.

Finally, this study aims to improve the maintenance process and help maintain the safety of equipment for as long as possible and the security of transportation and passengers.

Chapter I

Introduction of rail transport

I) Introduction

The means of transportation are of great importance in facilitating the process of moving individuals and transporting goods of various kinds, by choosing to transport by rail, as it is a fast means of transport, which, like other means, is exposed to factors that may lead to disruption of its work, which has a direct impact on the national economy.

I.1) Mode of transport

Mode of transport is a term used to distinguish between different modes of transport or the transportation of people or goods. The different modes of transport are air, water and land transport, which includes rail or rail, road and off-road. In general, transportation is used to transport people, animals, and other goods from one place to another. On the other hand, transportation refers to the transportation facilities used to transport people or goods according to the chosen situation (animal, vehicle, car, plane, ship, truck, train etc.). Each mode of transport has a fundamentally different technical solution, and some require a separate environment. Each mode has its own infrastructure, vehicles, transport operators and operations.**[1]**

I.1) Air transport

Air transport is the fastest mode of transportation, with commercial aircraft reaching speeds of 955 kilometers per hour (593 mph) It is the economic field that includes all forms of transportation of people and goods for civilian or military purposes.**[1]**

I.2) Maritime transport

Maritime transport is one of the oldest means of transportation used by man, especially by countries neighboring water bodies (oceans, seas, lakes). Sailing ships were used, then commercial ships with the beginnings of the industrial revolution using shipping containers.**[1]**

I.3) Rail transport

Rail transport is a means of transporting passengers and goods by means of wheeled vehicles traveling on a rail track, the rails are installed perpendicular to the railroad train and consist of one or more connected vehicles running on the rails. Propulsion is usually provided by a locomotive, which pulls a series of non-motorized cars, which can carry passengers or freight. The locomotive can be powered by steam; diesel or electricity provided by the track systems Rail transport:

Rail transport is carried out on railway tracks, which includes: the train, the metro and the tram. It has certain advantages, over other modes of transport:

-Transport by rail is often faster than by road (guidance system and absence of obstacles).

-It is relatively inexpensive allows the transport of heavy loads.

However, rail transport reached its peak between the two world wars, and then gradually declined in the second half of the 20th century, with quite contrasting situations from one country to another. In many countries, the railway companies have had difficulty in finding their economic balance and the State must intervene in the management of the railways, which require significant investment.

The rail transport of goods or people requires the implementation of transfer infrastructures, to transport and transship people to their train, and the goods or the trailer and the truck, to its platform, and to carry out then the reverse operation. The infrastructures consist of passenger stations, marshalling yards; combined transport sites (gantry cranes, cranes).

Two relatively recent developments mark a shift in this general development. Those are:

For passenger transport, in a few privileged countries, the advent of high speed also for travelers, megalopolises whose suffocation by combustion products (motor vehicles, in particular), could be slowed down by implementing rail public transport (tramways, metros, etc.).

For goods, the development of combined transport using rail-road technology, notably providing “land bridges” between the two coasts of North America and in Eurasia via the Trans-Siberian.

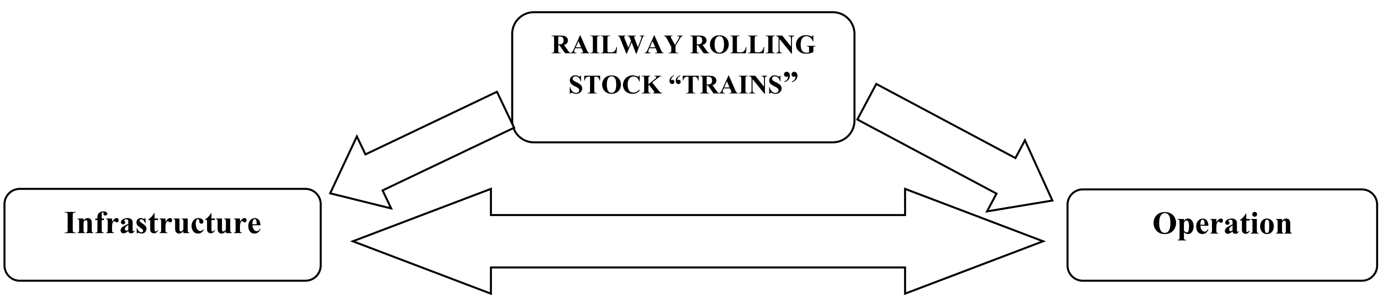
The ability of rail transport to develop great power , from electricity , unlike road transport.

It is indeed the only means of transport (along with certain nuclear-powered ships) which massively uses electricity as a source of energy. The electric train has a long range and greater payload since the energy does not need to be stored in a tank. The production of electricity, if produced by nuclear installations, does not emit CO_2 and is inexpensive [ref. necessary]. It can be non-polluting if the energy is produced by geothermal, wind, tidal-motor or solar systems. It enables states without hydrocarbon reserves to improve their long-term energy independence.

This explains the growing success of passenger rail transport at city and national level (interurban, suburban and urban links) and now, also for goods, at continental level thanks to high-speed TGV trains at bridges and tunnels (Channel Tunnel).**[2]**

I.3.1) Rolling stock

Railway equipment is the key element of the railway system. In common parlance, railway rolling stock is generally designated by the term “train”, which corresponds to one or more “engine(s) towing or not towing one or more vehicles”. This definition refers to an assembly (or not) of vehicles, or railway convoy, designed to move on a specific infrastructure: the railway. This material is therefore guided over its entire route, this guidance being able to be carried out by means of a monorail or two or more rails. Rolling stock is, along with infrastructure and operating procedures, a component of the rail transport system, whether urban (tramway, metro) or interurban (train). Railway rolling stock is made up of all vehicles, engine or towed, designed to move on a railway line.**[2]**



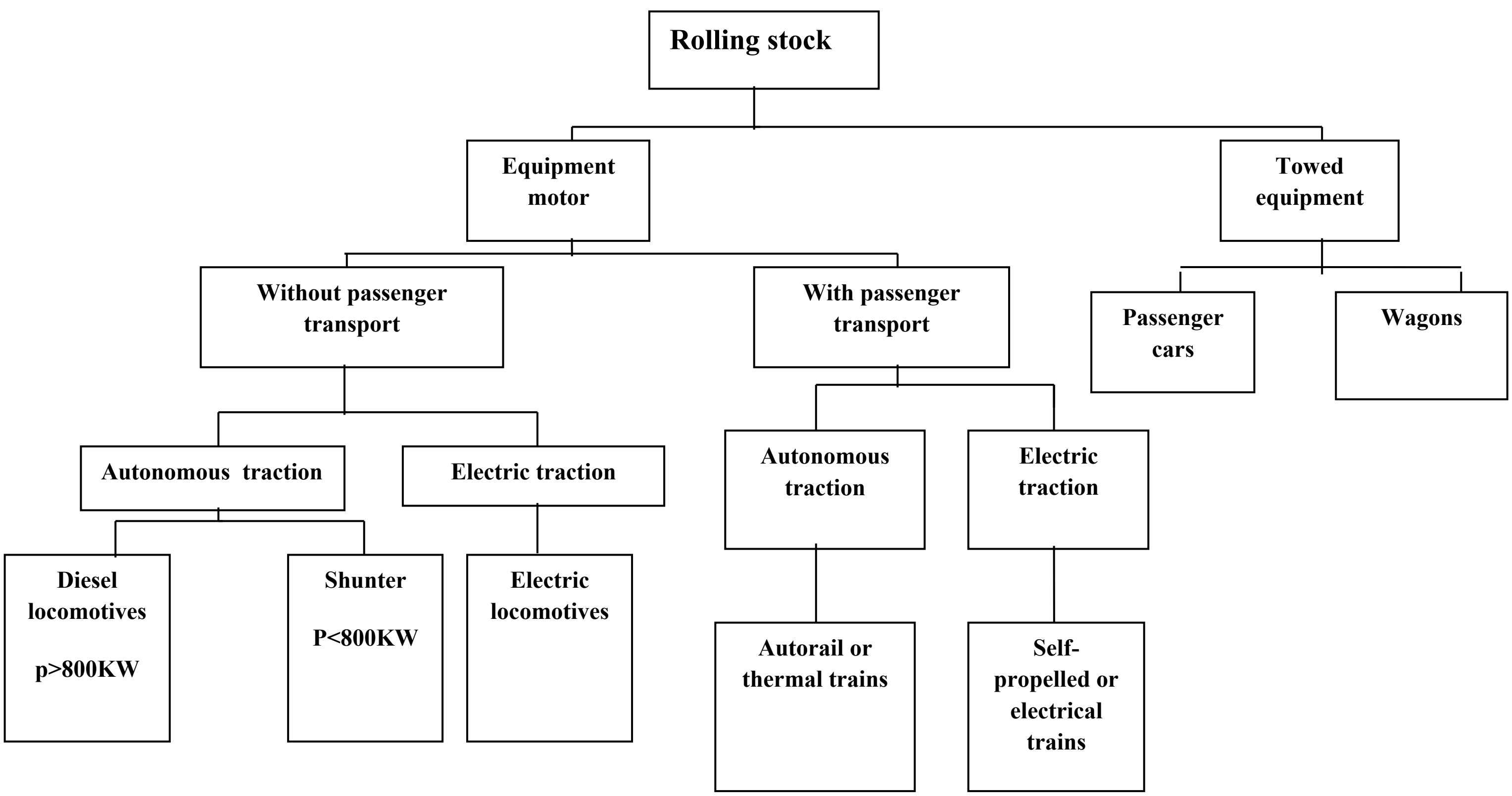
FigureI.1*: Rolling stock*

In the vocabulary used by professionals, the basic unit of railway equipment is the body. A crate can be part of the traction equipment and the towed equipment.

- The purpose of the driving equipment is to tow or push a railway convoy. It can therefore be a locomotive or a motorized body.
- The hauled stock is the part of the rolling stock which does not supply the motive energy of the train. We talk about cars if we are talking about the transport of passengers and wagons for freight.

- When the rolling stock fulfills these two functions at the same time, that is to say that it supplies the motive energy and that it transports the passengers, we speak of self-propelled, self-propelled or even of railcar. To date, there is no regulatory definition of these terms.

The practice of use leads to identify a difference between these words according to the energy of propulsion. Thus, one speaks of railcar when the traction energy is electricity and of railcar or railcar in the event of recourse to thermal energy. And in the context of a dual-current power supply, it is the term dual-current self-propelled trainsets that appears to be used. A distinction should be made between the two groups that make up rolling stock: - motorized rolling stock: locomotives, railcars, railcars and non-deformable sets; - towed rolling stock: passenger cars and freight and service wagons.**[2]**



FigureI.2: *The rolling equipments*

Motorized rolling stock Motorized rolling stock is, unlike freight wagons and passenger cars, equipment that can be moved using on-board motorization, like any road vehicle. The energy required for railway motorization was originally coal, a fuel of the 19th century which preceded oil and electricity in the 20th century. Nowadays, the energy required for motorized rolling stock is either electricity captured by an overhead line, or fossil energy in an on-board tank. Recently, dual-mode rolling stock has arrived on the market, which can run both on electrified tracks and end their journey on non-electrified lines. Rolling stock equipped with batteries is also beginning to appear.

- Electric locomotives receiving their energy from outside in the form of electric current (motors powered either by electricity (catenary).Motorized rolling stock is thus divided into four technical sub-groups:

- Motorcars / Railcars (Thermal Locomotive): Locomotive whose energy source is internal (diesel). (Engines powered by an internal diesel group).

Which constitute traction units without travelers whose traction chain occupies the entire body of the machine, and:

- Railcars (electric)
- Railcars (diesel)

Which constitute the self-propelled elements which embark passengers and whose motorization is located under the body?

High-speed rolling stock as well as tilting trains belongs to the group of multiple units. The current trend in railway operations in the 21st century is to use railcars and railcars in passenger traffic, while the locomotive pulling wagons remains the standard pattern for freight trains.

- Loco tractor: Vehicle used mainly for maneuvering wagons and forming convoys.

- Electric self-propelled unit: Reversible unit (several boxes) receiving its energy from outside in the form of electric current arranged for the transport of passengers.

- Thermal self-propelled element: Reversible unit (several boxes) whose energy source is internal (diesel) fitted out for the transport of passengers.

- Bi-mode self-propelled unit: Reversible assembly (several bodies) that can use either external energy in the form of electric current, or an internal energy source (diesel) fitted out for the transport of passengers.

Similarly, the difference between a railcar and a self-propelled railcar with the same traction energy (diesel) is not always easy to perceive and depends on the players considered.

Some companies reserve the term "railcar" for thermal elements with a single body, but for other players, railcars may include several bodies. For example, the “AGC” large-capacity Railcar can have three or four boxes.

In the railway culture, we also evoke the notion of railway train. By train, we mean the coupling formed by railway vehicles. A train can therefore be made up of a locomotive and car(s) or one or more bodies with integrated motorization.

- When several trainsets are coupled together, railway specialists speak of “MU” multiple units.

- We also use the concept of "reversible train" if at each end of the train there are driving cabins to avoid the maneuvers of changing the locomotive.

The majority of the network is made up of mixed lines, which handle both passenger and freight traffic. However, some lines are reserved for passenger traffic (high-speed lines, lines of the regional express network, certain regional lines), others are dedicated to freight (lines serving industrial sites).**[2]**

I.3.1) The rolling equipments

Railway rolling stock includes:

A) - Towed equipment intended for Customers

Passengers or freight

-The motor equipment ensuring the traction of the towed equipment.

-Equipment towed for passengers

The type of passenger transport is decisive in characterizing what is generally called a “CAR”.

In terms of long-distance connections, the imperatives of comfort require numerous and complex equipment:

- Seat spacing

- Layout in cabins or sleeping berths for night trains

- Air conditioning equipment

- Sound system; signage

- Bathroom

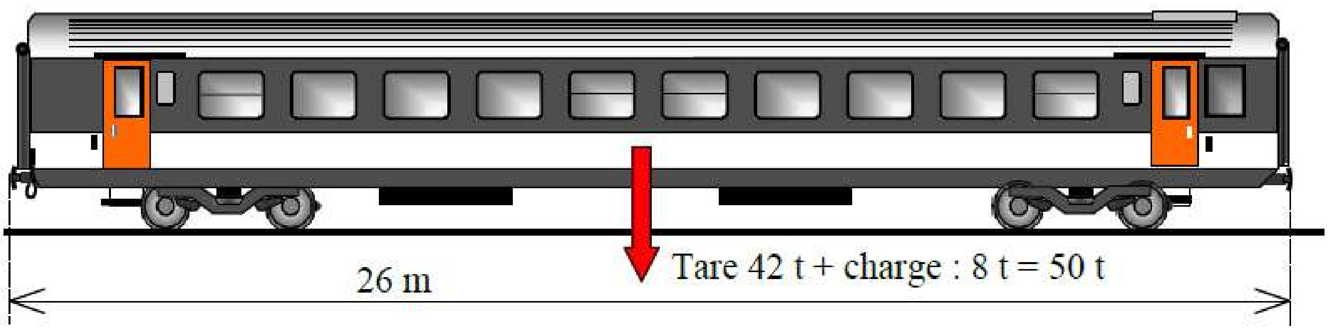


Figure I.3: *Equipment towed for passengers*

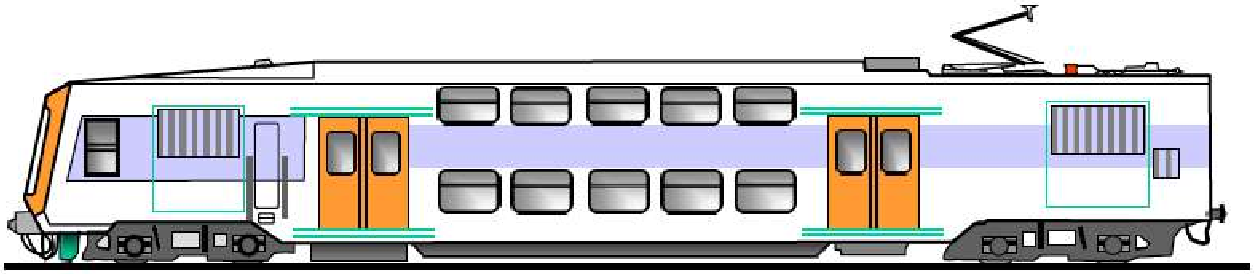
The case of high-speed connections has given rise to an original solution in Europe, thanks to the articulated train system with fixed composition; each of the cars called a “trailer” rests on a common bogie.

The transport of passengers on urban or suburban lines has all other constraints:

- Entrances and exits facilitating ascents and descents in resort

-Ventilation; aeration

-Standing places; 2 levels; etc



FigureI.4: *Equipment towed for passengers*

B) Towed equipment for freight

The "freight wagon" of yesteryear has virtually disappeared from European traffic. the specialization of freight transport leads to the design of a vehicle adapted to each use:

- Transport of bulk products: cereals, solid, liquid or gaseous fuels: hopper wagon, tank wagon

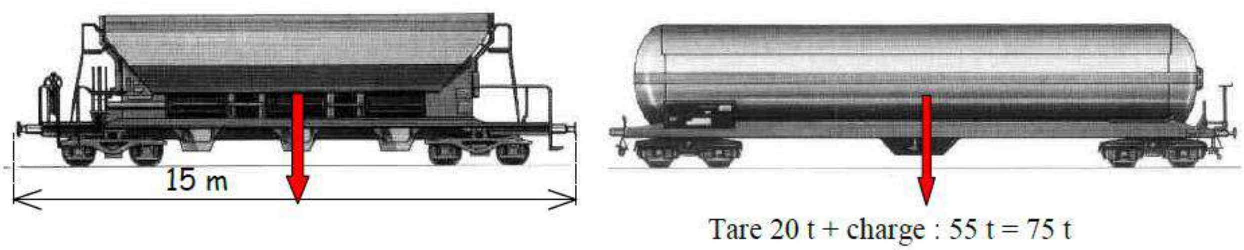
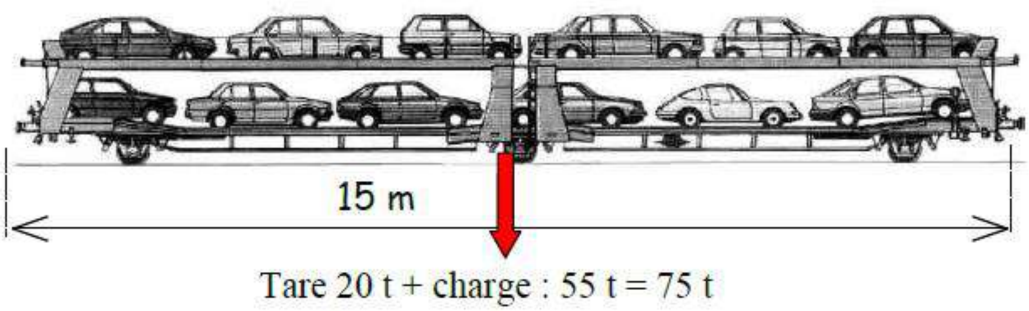


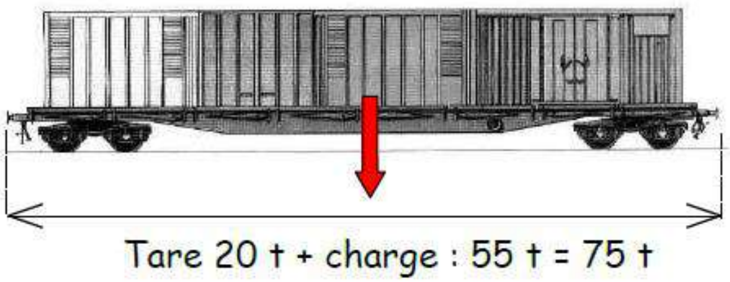
Figure I.5: *Towed equipment for freight*

C) Vehicle transport: car carriers; truck carriers



FigureI.6: *Vehicle transport: car carriers; truck carriers*

D) Combined transport

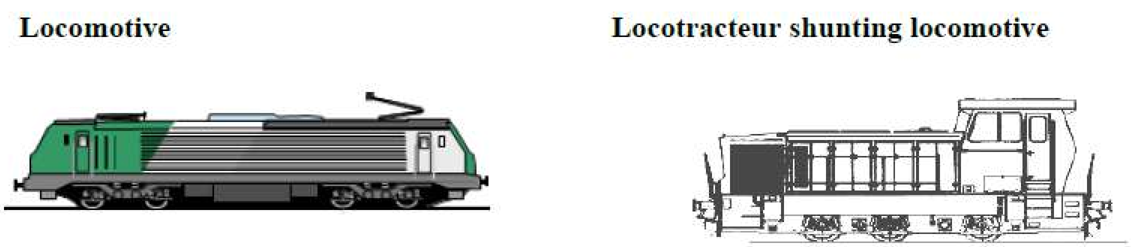


FigureI.7: *Combined transport*

E) The engine material

The classification is made according to whether or not the motor vehicle carries passengers. If it is dedicated to traction it is a locomotive – or shunter at low power. If it is designed for transport passengers are self-propelled - emu - and self-propelled - dmu - depending on the mode of traction.

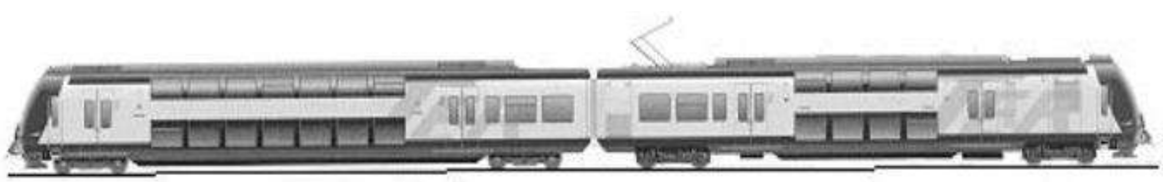
-Motor vehicles without passenger transport



FigureI.8: *Motor vehicles without passenger transport*

F) Self-propelled Electric Multiple unit – EMU

Motor vehicle with electric traction comprising passenger compartments:



FigureI.9: *Self-propelled Electric Multiple unit – EMU*

G) Self-propelled Diesel Multiple unit – DMU

Self-driving motor vehicle with passenger compartments (single body or multi-cash).**[2]**

FigureI.10: *Self-propelled Diesel Multiple unit – DMU*

I.4) Rail

The railway infrastructure is a track with all the appropriate facilities plants and other devices, which are in function at the railway traffic. Rails as an important part of the railway infrastructure have exactly level of quality. In Europe, the quality of rails is prescribed by international standards, the European Union of Railways UIC 860 and EN13674. In other vital parts of railway infrastructure in order to: increase the speed of trains, increasing the axles loads of trains and locomotives traction and increasing the density of traffic and increase resistance to harmful influences of the environment (environmental aspects), required and improve the quality of rails.

The European Union standards for railways (UIC) have agreed national standards of different countries.**[3]**

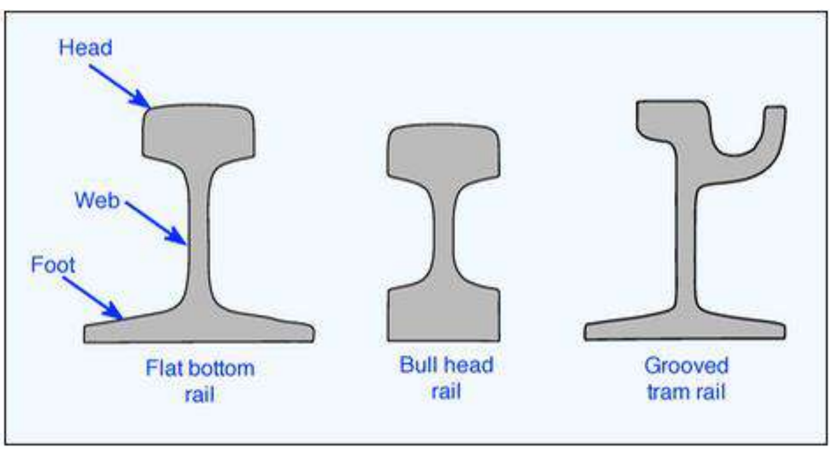


Figure11: *Rail types [4]*

I.5) Rail manufacture

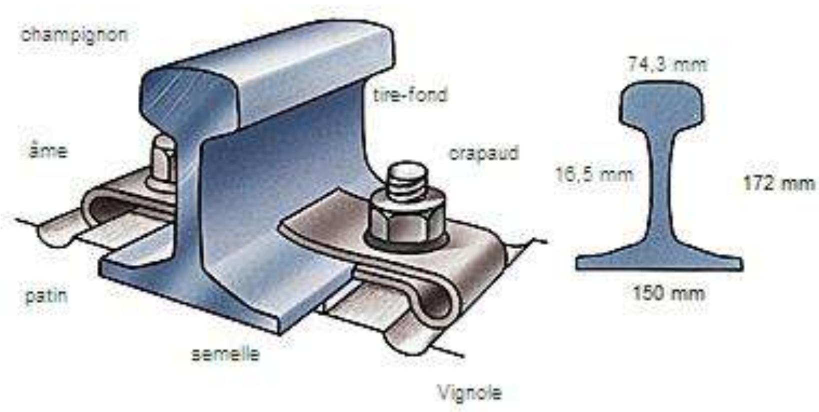
In Serbia, the quality of tracks, measures and tolerances are prescribed standards SRPS.C.K1.020 and SRPS.C.K1.021.

These standards clarify in detail the most important components of quality, tracks production of steel for rails, and to control the final delivery of new rails. Depending on load rails in service are set levels of quality tracks, with the aspect tensile strength and ductile properties. Depending on the degree exploitation load rails, rails are divided into two main groups, namely:

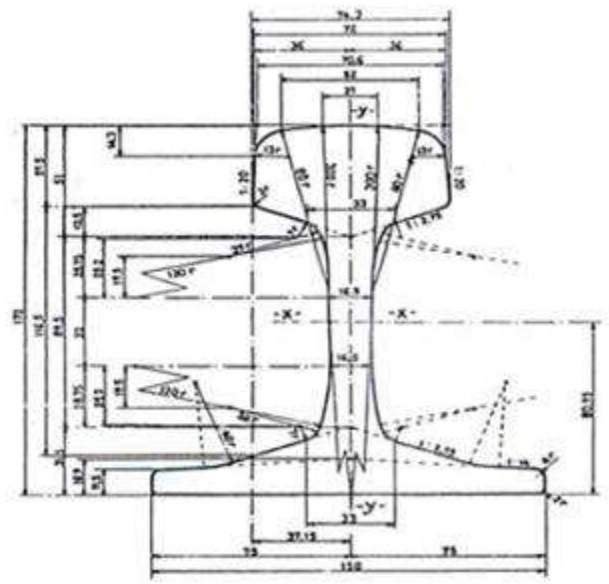
- Rail and normal quality
- Wear resistant rails (rails with high resistance to abrasion). Demands for quality rails, metal-in during production steel rails, emphasis given to the following adjustment in the production of rails:
- Increased the mass of the rail due to the meter 45 to 77 kg / m. Now the most used rails with a mass 60 (Fig. 11) the prescribed weight of 60,34 kg / m, represented by former rail profile 49 kg / m prescribed weight 49,43 kg / m (Fig. 12).
- Increase the value of tensile strength from 700 to 1300 MPa.
- Increasing the purity of steel especially sulfur and phosphorus from the previous maximum of 0,050 to 0,030%.**[4]**

I.6) Train rail

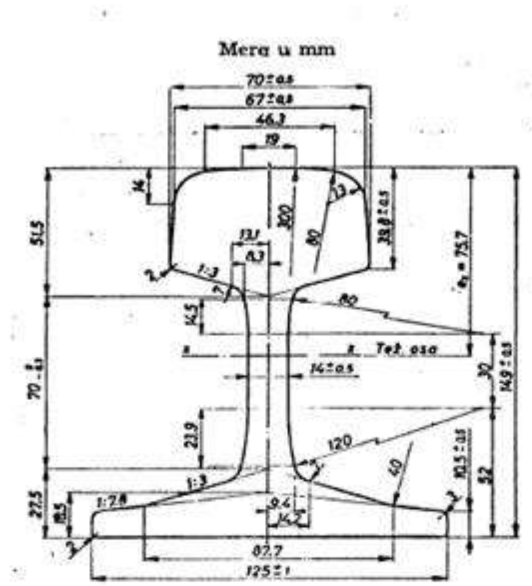
The figures represent a cross-section of the railroad tracks (Figure I.12) and two other similar sections rails 49 Kg/m (Figure I.13) , Rails 60 Kg/m(Figure I.14).



FigureI.12: *Train rail[5]*



FigureI.13: The form and extent of cross-section cross-section rails 49 Kg/m



FigureI.14: The shape and extent of Rails 60 Kg/m

I.6.1) Train railway

production of long rails up to 120 m in length (decreasing the number of welded joints and dilatation spaces). **[4]**

Macrostructure of the consistency of the material is checked by Baumann test. For Baumann test can be seen the level of expressed macro segregation, which is in direct correlation with low soluble micro constituents layout (Fig I,15).

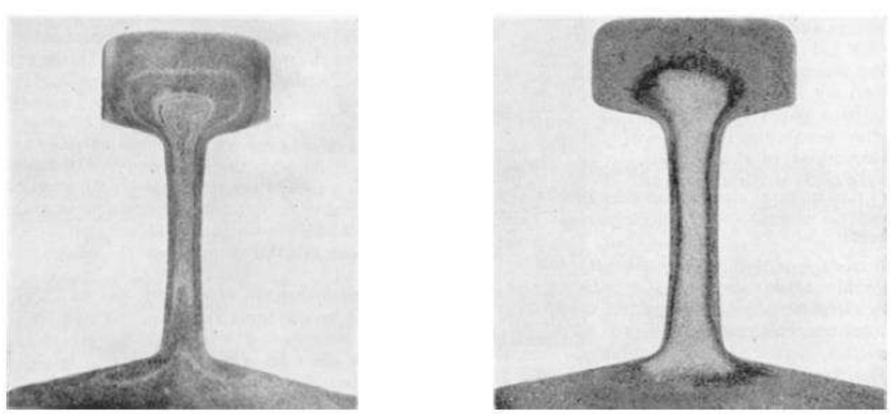


***Figure I.15:** Strong segregation block at the intersection of rails*

I.6.2) Prescribed properties for steel of rails

Requirements of UIC 860 *V* For a selection of different types of rails, the corresponding chemical composition and mechanical property requirements are presented in (TableI.1) according to standard UlC 860 - 1. From the Table it is obvious that, in the case of wear - resistant rails, increased carbon (C) and manganese (Mn) content is responsible for the improved mechanical properties. The increase in wear resistance is based on a theory of the mutual influence of certain elements. Carbon influences the mechanical properties through the volume fraction of cementite and the content of pearlite. Manganese influences the temperature decrease of the eutectoidal reaction and the fineness of pearlite lamellae, that is, the reduction in the interlamellar distance. As an illustration of the influence of alloying elements, such as carbon, manganese and silicon, on wear speed for a pearlite structure, the following equation is given:

$$W = 0.1427\left(C + \frac{Mn}{4.72} + \frac{Si}{10}\right) \qquad (I.1)$$

where:

W - Represents the speed of wear expressed as volume loss per unit of path over which sliding occurs, C, Mn, Si - represent the percentage contents of carbon, manganese and silicon respectively.

For all rail types, the appropriate values of mechanical properties are also laid down and controlled by the Standard (Table 1).

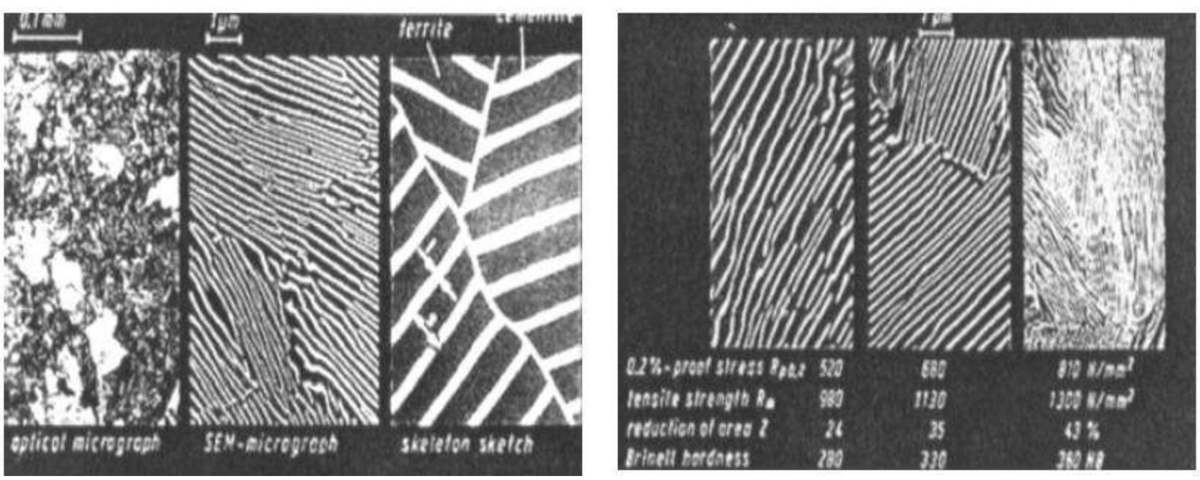
In pearlitic steels, the structure of which is depicted in (Fig. 4). The mechanical properties are largely governed by the distance between the cementite (Fe_3C) lamellae, their thickness and by the grain size. The influence of the interlamellar spacing on yield point, tensile strength and reduction of area is demonstrated by the structures shown in (Fig. 5). These examples display microstructures of the same steel subjected to different cooling rates. The same effect can be achieved by controlling the diffusion rate via the alloying contents. **[3]**

Table I.1: *Rail characteristics according to UIC 860-1*

Steel grade	Chemical composition, %						Rm N/mm²	A_5 min %
	C	Si	Mn	Cr	P_{max}	S_{max}		
700	0,40-0,06	0,05-0,35	0,80-1,25	-	0,05	0,05	680-830	14
900 A	0,60-0,80	0,10-0,50	0,80-1,30	-	0,04	0,04	min. 880	10
900 B	0,55-0,75	0,10-0,50	1,30-1,70	-	0,04	0,04	800-1030	10
1100	0,60-0,82	0,30-0,90	0,90-1,30	0,80-1,30	0,04	0,03	min. 1080	9

1.6.3)Requirements of EN 13674

The new European standard EN 13674, which deals with issues of quality rail, takes into account the increasing demands for safety and economy of railway traffic. European standard EN 13674 includes symmetrical rails with wide rate of mass ≥46 kg/m. This standard was developed by the European Committee for Standardization CEN (European Committee for Standardization) of the National Committee of the 19 countries. This standard has built a modern approach to the issue of quality tracks with the recommendation that manufacturers should be required tracks have introduced quality management system in accordance with the requirements of ISO 9001 standards.**[3]**



FigureI.16: *Requirements of EN 13674*

I.6.4) Chemical composition/mechanical properties :(according to the standards EN 13674-1:2003)[3]

***TableI.2**: Chemical composition/mechanical properties :(according to the standards EN 13674-1:2003*

% By mass

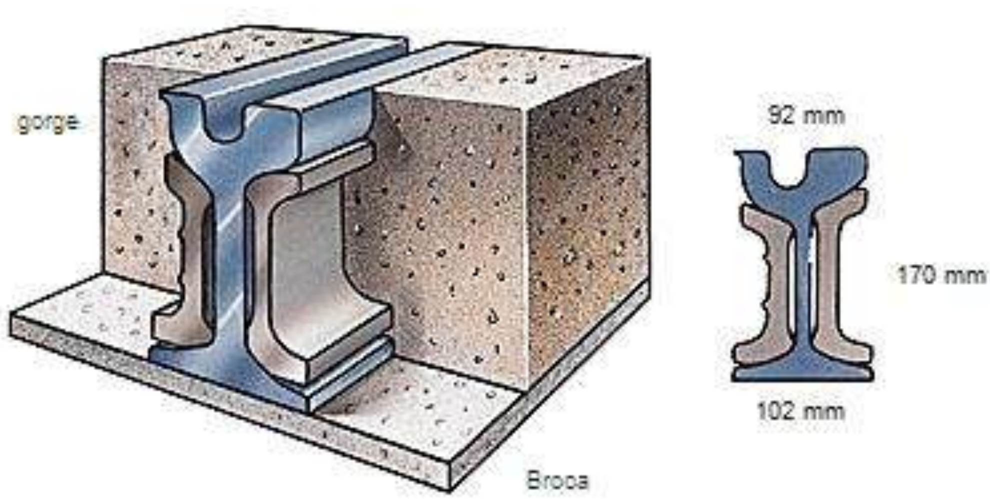
N max.	O (10^{-4} % ppm max. by mass)	H (10^{-4} % ppm max. by mass)	Rm min. MPa	min. elong A %	Centre line	Steel sample grade		C	Si	Mn	P max	running surfice	Cr	Al max.	V max.
0,009	20	3,0	680	14	200/240	R200	Liquid	0,40/0,60	0,15/0,58	0,70/1,20	0,035	0,008/0,035	0,15 max	0,004	0,030
0,010	20	3,0					Solid	0,38/0,62	0,13/0,60	0,65/1,25	0,040	0,008/0,040	0,15 max	0,004	0,030
0,008	20	3,0	770	12	220/260	R220	Liquid	0,50/0,60	0,20/0,60	1,00/1,25	0,025	0,008/0,025	0,15 max	0,004	0,030
0,008	20	3,0					Solid	0,50/0,60	0,20/0,60	1,00/1,25	0,025	0,008/0,025	0,15 max	0,004	0,030
0,009	20	2,5	880	10	260/300	R260	Liquid	0,62/0,80	0,15/0,58	0,70/1,20	0,025	0,008/0,025	0,15 max	0,004	0,030
0,010	20	2,5					Solid	0,60/0,82	0,13/0,60	0,65/1,25	0,030	0,008/0,030	0,15 max	0,004	0,030
0,009	20	2,5	880	10	260/300	R260 Mn	Liquid	0,55/0,75	0,15/0,60	1,30/1,70	0,025	0,008/0,025	0,15 max	0,004	0,030
0,010	20	2,5					Solid	0,53/0,77	0,13/0,62	1,25/1,75	0,030	0,008/0,030	0,15 max	0,004	0,030
0,009	20	2,5	1080	9	320/360	R320 Cr	Liquid	0,60/0,80	0,50/1,10	0,80/1,20	0,020	0,008/0,025	0,80/1,20	0,004	0,030
0,010	20	2,5					Solid	0,58/0,82	0,48/1,12	0,75/1,25	0,025	0,008/0,030	0,75/1,25	0,004	0,030
0,009	20	2,5	1175	9	350/390	R350 HT	Liquid	0,72/0,80	0,15/0,58	0,70/1,20	0,020	0,008/0,025	0,15 max	0,004	0,030
0,010	20	2,5					Solid	0,70/0,82	0,13/0,60	0,65/1,25	0,025	0,008/0,030	0,15 max	0,004	0,030
0,009	20	2,5	1175	9	350/390	R350 LHT	Liquid	0,72/0,80	0,15/0,58	0,70/1,20	0,020	0,008/0,025	0,30 max	0,004	0,030
0,010	20	2,5					Solid	0,70/0,82	0,13/0,60	0,65/1,25	0,025	0,008/0,030	0,30 max	0,004	0,030

able 3 Maxumum residual elements

Nb	Cu, 10Sn	others		Mo	Ni	Cu	Sn	Sb	Ti
0,01	0,35	0,35 (Cr+Mo+Ni+Cu+V)	200, R220, R260, R260Mn	0,02	0,10	0,15	0,030	0,020	0,025
0,01	0,35	0,16 (Ni+Cu)	320Cr	0,02	0,10	0,15	0,030	0,020	0,025
0,04	0,35	0,25 (Cr+Mo+Ni+Cu+V)	350HT	0,02	0,10	0,15	0,030	0,020	0,025
0,04	0,35	0,20 (Mo+Ni+Cu+V)	350LHT	0,02	0,10	0,15	0,030	0,020	0,025

1.7)Tramway railway

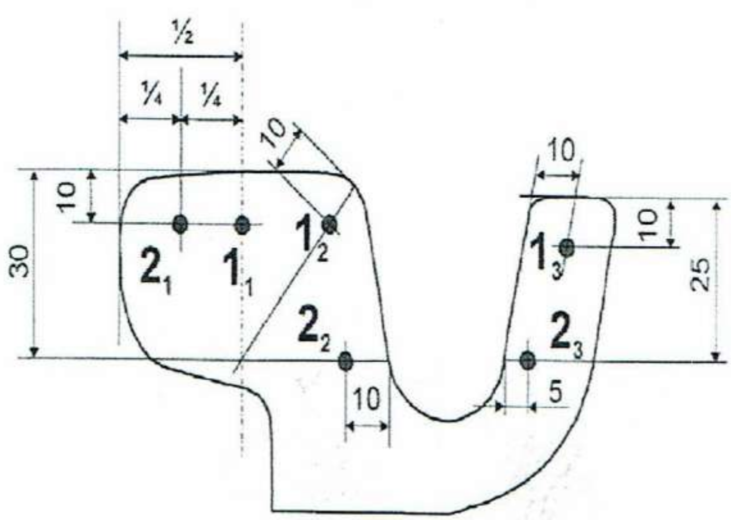
The (figuresI.17) represent a cross-section of the tramway rail.



FigureI.17: *tramway rail [5]*

1.7.1)Rail form manufacture

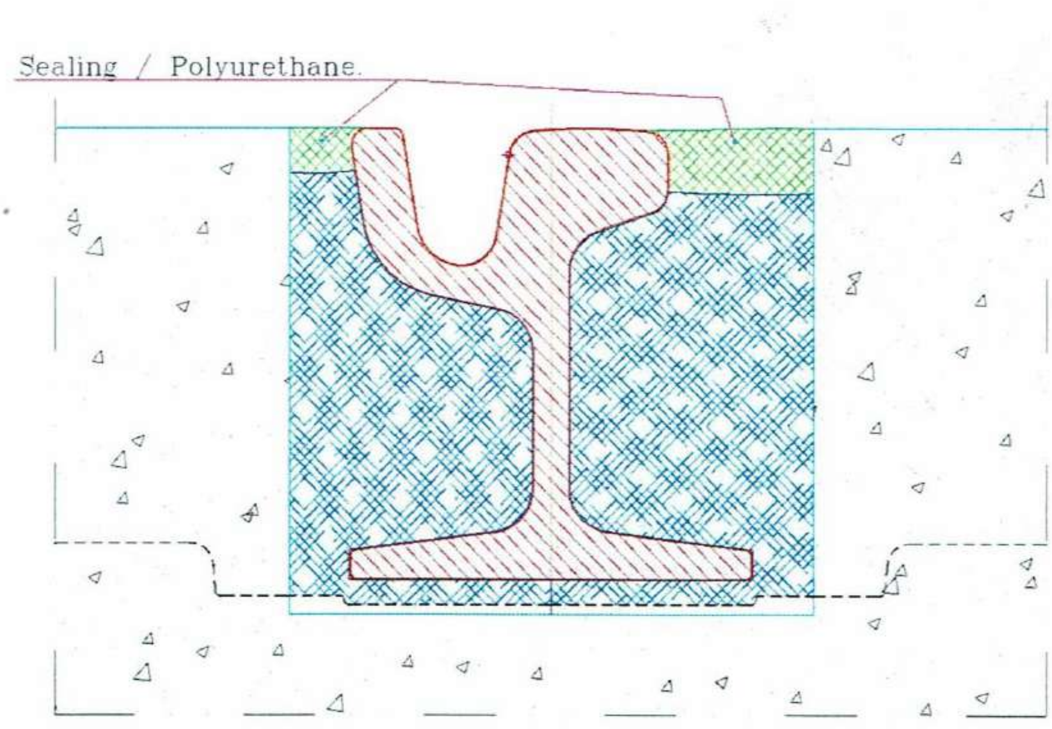
The following figure represents the technical drawing of the front side head of the tramway rail.



FigureI.18: *Manufacturing process of wheel*

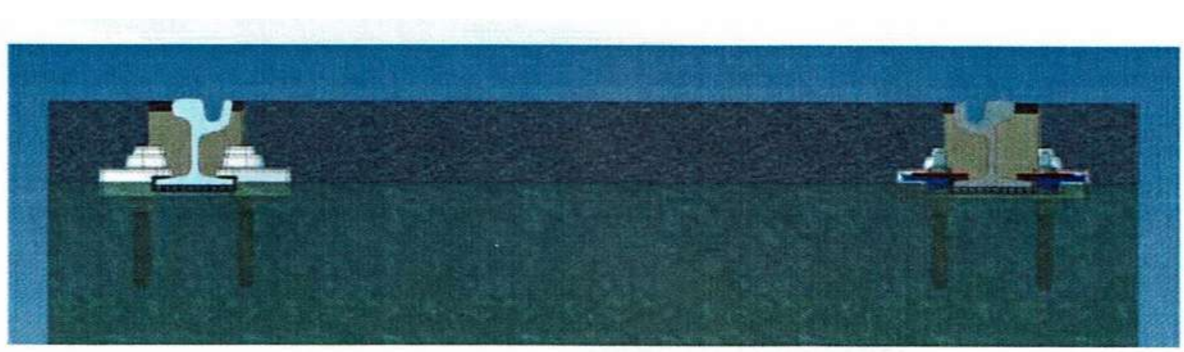
1.7.2)Set position

Depending on the type of finish desired (asphalt or cobblestone greenway), the type of jointing chambers may vay.



FigureI.19: *Set position*

The upper of the foams has half sections wich allow, once the track is finished, their tearing off to leave the space which will contain the final seal between the rail and the roadway.



FigureI.20: *Concrete finish*

I.7.3) Chemical composition

TableI.3: *Tramway railway chemical composition*

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Ergebnis der Prüfungen/ Test results/ Resultat des essais

Schmelze-Nr. / Cast No. / No de coulée	Walz-Nr.: / Rolling No. / Numero courant	Probe/ sample/ echantillo # ∅ 10 mm / Block Nr. / Bloom N / No. de lingot	Streck-grenze / Yield stress/ limite d'elasticité (N/mm²)	Zug-festigkeit / Tensile strength/ Résistance à la traction (N/mm²)	Dehnung / Elongation/ Allongement $L_0 = 5d$ (%)	Brinell härte / Brinell-Hardness (0,5 mm unter Fahrfläche) HB 30	C %	Si %	Mn %	P %	S %	Al %	H ppm	Cr %	Cu %	Mo %
		Zugversuche / Tensile tests/Essais de traction					Chemische Analyse/ Chemical composition / composition chimique									
469912	192	103	511	953	13,4	282	0,74	0,29	0,92	0,024	0,019	0,001	1,5	0,02	0,03	0,003
471000	547	102	509	954	14,4	278	0,71	0,29	0,96	0,021	0,021	0,001	1,6	0,03	0,03	0,002
471005	548	303	513	955	13,2	287	0,73	0,31	0,97	0,015	0,019	0,001	1,5	0,03	0,03	0,003
470997	549	301	499	948	13,9	274	0,71	0,26	0,97	0,013	0,018	0,001	1,9	0,02	0,03	0,002
469462	550	303	483	954	13,8	285	0,71	0,32	0,96	0,019	0,019	0,001	2,1	0,02	0,03	0,002
366618	551	202	504	962	13,4	283	0,73	0,30	0,95	0,023	0,020	0,001	2,3	0,02	0,02	0,002
366619	552	101	536	974	13,1	283	0,72	0,31	0,98	0,022	0,019	0,001	2,3	0,02	0,02	0,002
366620	553	202	510	955	14,0	285	0,72	0,31	0,97	0,020	0,021	0,001	2,0	0,02	0,02	0,002
471001	554	201	516	960	13,9	291	0,72	0,30	0,99	0,019	0,018	0,001	1,5	0,03	0,03	0,003
470999	555	102	526	971	14,2	287	0,73	0,30	0,98	0,015	0,019	0,001	1,5	0,02	0,03	0,002
471003	556	201	502	943	13,8	281	0,72	0,30	0,97	0,013	0,019	0,001	1,7	0,02	0,02	0,002

1.8)Rail Failures

Types of Web Configuration :

Typical web configurations of the wheels (5) are shown in figure 18.

II Hub Resultant Resultant Web Rim L V 1(a) 1(b) 1(e) 1(d) 1(e) web Offset

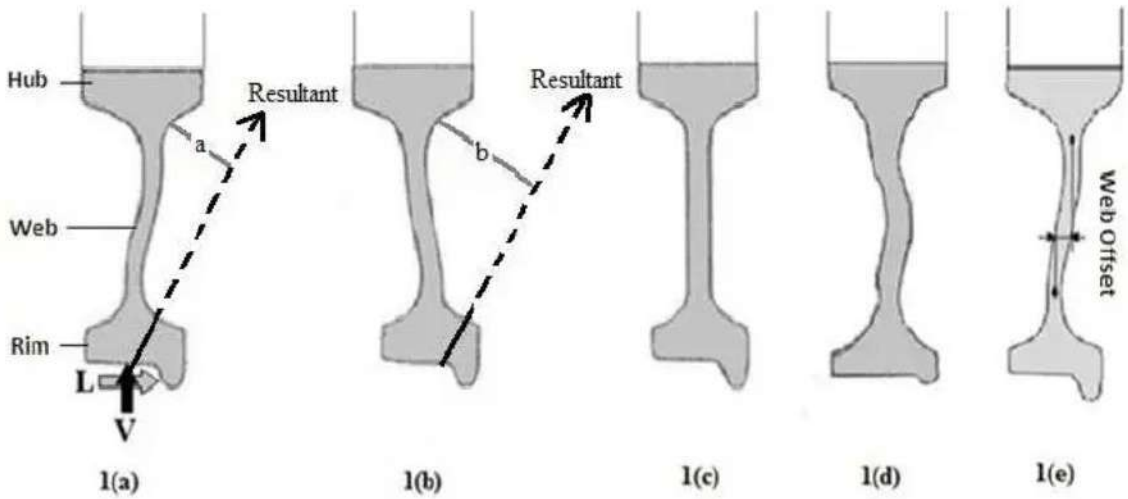


Figure I.22 *:(a): Inside Web, (b) Outside Web, (c) Straight Web, (d) Double Curved Web*

A wheel is subjected to lateral load L during curve negotiation, hunting and/ or nosing on straight track also, These loads are also important for the stability analysis (such as derailment criteria) and riding comfort. The resultant of the two forces acts in an upward direction at the contact point with the rail, inclining toward the inside of the wheel set. The maximum stress in the web is generated at the huby web transition. Since the arm length of Type A is shorter than that of Type B, the bending moment 'a' of Type A, is less than b' that of Type Beven when the loading conditions are the same. In other words, the web configuration of Type A is superior with respect to strength . Configuration of Type B is designed for creating a space inside of a driven designed generally for a wheel equipped with disc brakes on both sides. Thermal Load Due to Tread Braking In addition to its primary task of carrying load, in most cases the wheel also has to act as a brake drum. The frictional heat depends on the type of braking. Temperatures can reach the 600-700" C runge in drag braking and during stop braking temperature range is 100-300' C. Therefore drag braking produces higher web stresses. The frietional beat transferred to the tread tends to expand the rim radially . This 'expansion is restrained by the web which is at a lower temperature; consequently stresses are produced in the web. These stresses are much higher than those induced by mechanical loading. The magnitude of the stresses and the position of maximum stress depend on the geometrical shape of the web.**[6]**

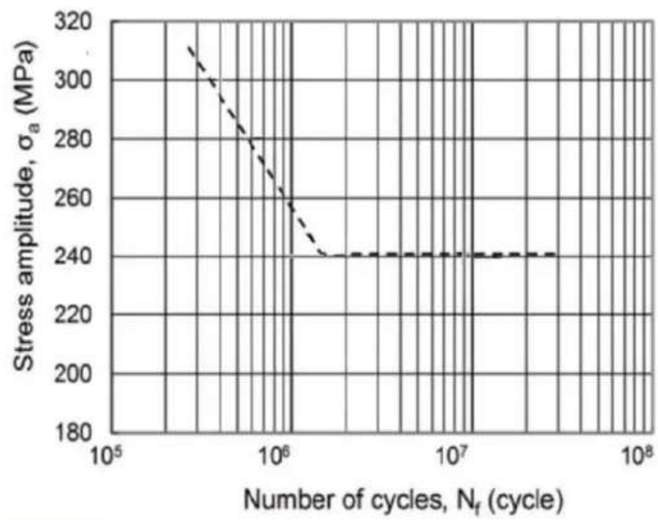
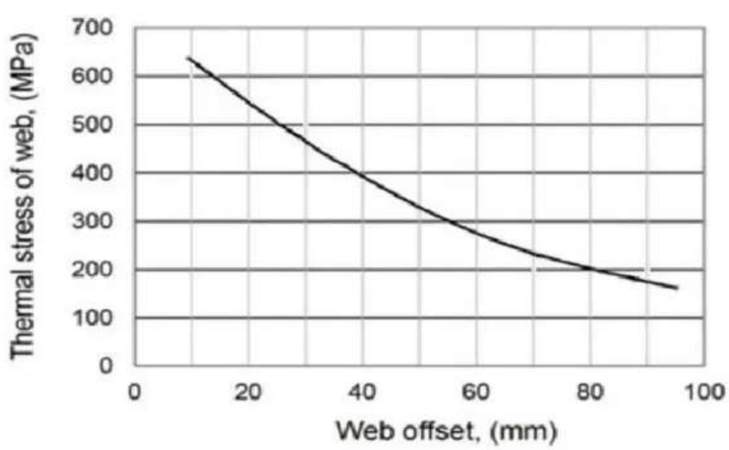


Figure I.23*: Fatigue test result of the domestic wheels*

Fatigue Strength of Web Since cyclic mechanical stresses are exerted on the web, the web material must have sufficient fatigue strength to withstand the stress cycle. Hirakawa et al. **[6]**, conducted fatigue test with full size wheels. As shown in Figure 19, stress amplitude initially reduces with increasing cycles of application and then stabilizes at 240 MPa at cycles above 10°. In other words the fatigue strength is approximately 240 MPa. Normally an allowable stress of 157 MPa is considered for web design, which has a factor of safety of 1.5.**[6]**



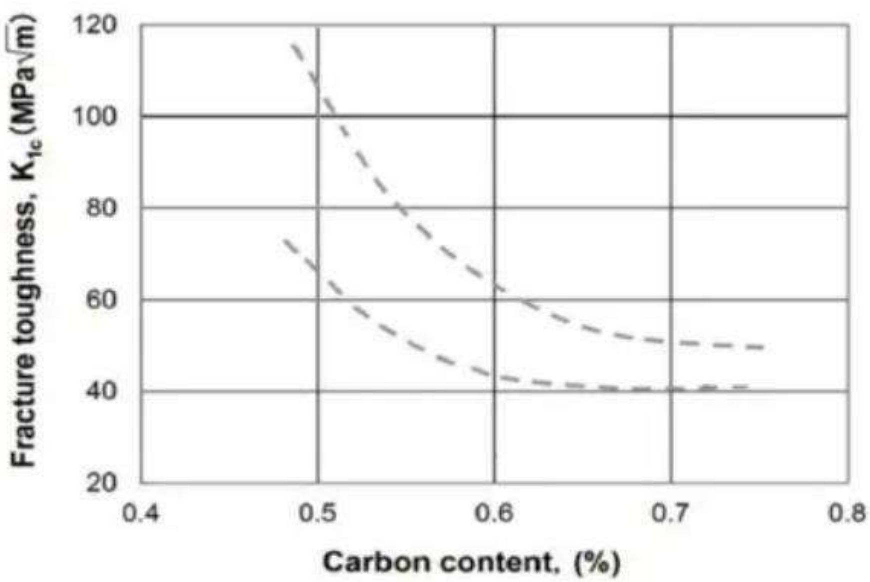
FigureI.24: *Thermal stress of web depending on web offset*

Reversal Change of the Residual Stress Tread braking results in rise of tread temperature due to friction. Stop braking usually does not influence the performance of the wheel. Whereas, drag braking when running a long downhill or a stuck brake shoe due to malfunction of a braking system heats the whole rim section to a high temperature. Because of the thermal expansion of the rim, the rim pulls the web outward, and then tensile radial stress is generated in the web area. When this thermal radial stress exceeds the yield stress of the web material, outward plastic deformation of the web takes place. After the brake shoe is released and the wheel is cooled, the rim tends to shrink; however, the expanded web disturbs the rim to shrink. As a result, the web pushes the rim outwardly, and then causes the tensile stress in the rim. The compressive residual stress is originally given by heat treatment, during the wheel manufacture. However, this initial residual stress changes from the compression side to the tension side due to thermal input by braking. In general mean tensile stresses are detrimental and compressive mean stresses are beneficial to fatigue life of wheel. This is the "reversal change in the rim residual stress." Once this happens, small thermal cracks on the tread surface start to propagate and result in a brittle fracture of a wheel in the worst case. Accordingly, stress in this situation is very dangerous. However, according to studies conducted, it was found that this change in residual stress can be controlled by improving the web configuration. The key parameter is the web offset, as shown in figure 20(e). As is clear from the graph in the figure 20, the thermal stress reduces from 600 to 200 MPa when the web offset is increased to 80 mm. This means that the web offset can reduce the plastic deformation of the web because of yielding. Therefore, the shrinking of the rim is not disturbed by the web when cooling, and consequently, the reversal change in the residual stress in the rim does not occur. A High Toughness (HT) wheel was developed on this concept by the then Sumitomo Metal Industries.**[6]**

1.9) Rim - Wheel Material

A rim has to be resistant towards wear, thermal cracks, fracture and rolling contact fatigue. Earlier wheel material was low carbon steel (carbon content of around 0.5%). It was estimated that increase in carbon content would be effective to give the wheel a longer life; however, it might shorten the rail life. Rail Wear and Wheel Hardness Dr. Saito et al. conducted trials with 1/3 scale model wheel-carriage in the premises of the Sumitomo Metal Industries; they measured the amounts of wear of rails and wheels for various combinations of materials.

After around seven years of investigation, they concluded that the increase in the carbon content of a wheel reduces not only the wheel wear but also the rail wear. Comparative investigation of wheel materials and of their influence on rail wear was also done by Deutsche Bahn . These trials were conducted on full size wheel-rail testing rig as well as on actual trains. On the basis of these trial Impact. **[6]**



I.10) Rail- Wheel Interaction

FigureI.25:*Fracture toughess depending on carbon content*

Mutton and Epp (11) found that on 20 tonne axle load tests, the wear rate of standard carbon rails at high flanging stresses is higher even with softer wheel materials. According to them the increase in rail wear rate is partly due to the deterioration of wheel flange profile by both wear and plastic flow, which give rise to more severe contact conditions. Therefore higher strength materials are likely to retain profiles for longer periods. In other words rail-wheel interaction does not deteriorate due to less wear, hence better performance. [**6]**

I.11) Thermal Crack Resistance and Fracture Toughness of the Rim

In case of a wheel with tread brake, even under normal braking condition, initiation of very fine thermal cracks at the tread surface layer cannot be avoided because of cyclic heating and cooling and they lead to a brittle fracture. Fracture resistance varies with type of material. Fracture toughness is an indicator of this resistance. Figure 21 shows the relationship between the fracture toughness of the rim and carbon content . There is a drop in fracture toughness from 90 to 50 with an increase in carbon % from 0.5 to 0.6. Subsequent increase in carbon % does not effect appreciably. In other words low carbon % has better thermal crack resistance and fracture toughness, but has less resistance against wear. Railroad vehicle is a guided vehicle therefore rail-wheel contact geometry is important for stability and safety. Wear of geometry of rail and wheel contacting profiles effects the negotiability and hence life and performance. So low carbon percentage, which is less resistance to wear is not considered for use.**[6]**

1.12) Manufacturing Of Wheels

Manufacturing Process Superior quality scrap is melted in electric arc furnace, after checking chemical composition; molten metal is tapped in a ladle. Micro cleanliness and micro alloying is done in the ladle. Chemical composition is checked., the ladle is put in John Mohr Pit where a pre-treated graphite mould is filled by upward pressure pouring (Figure 22). Then this cast wheel is subjected to sprue wash, hub cutting, heat treatment and various checks. These are given in Figure 22.**[6]**

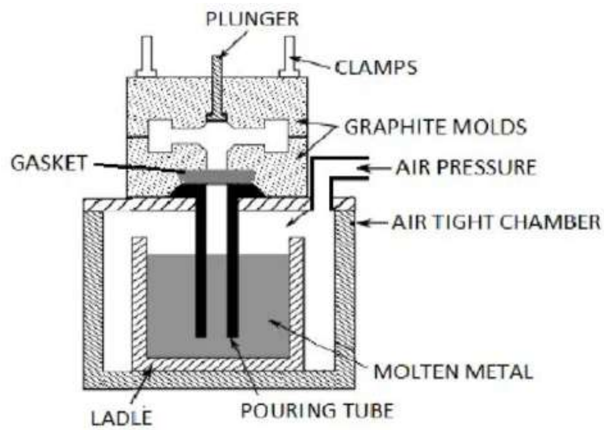
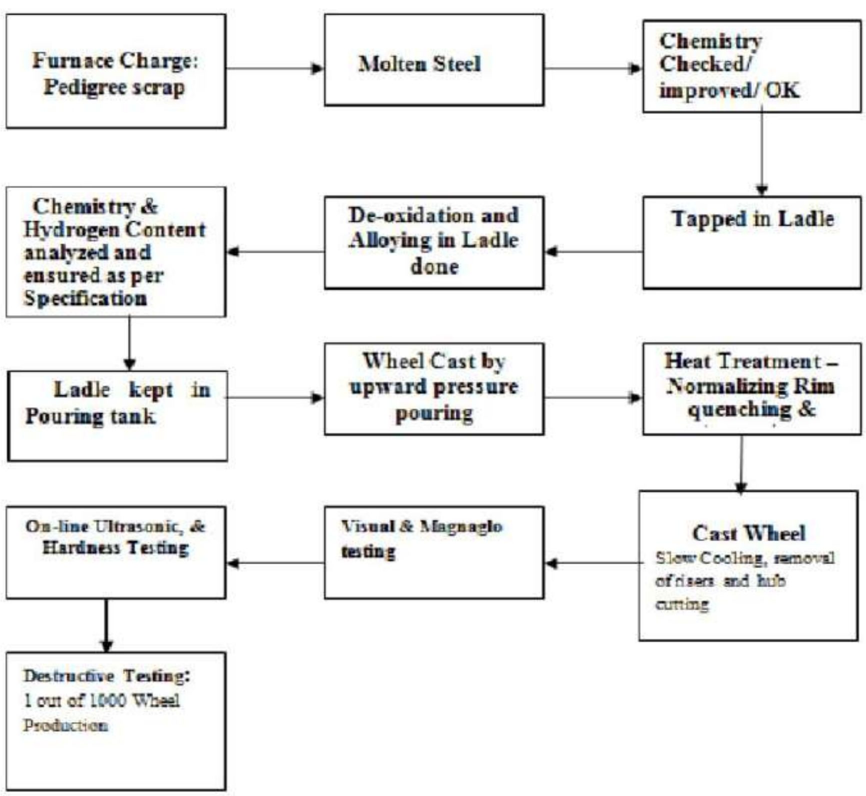


Figure I.26: *Pressure poured casting wheel*

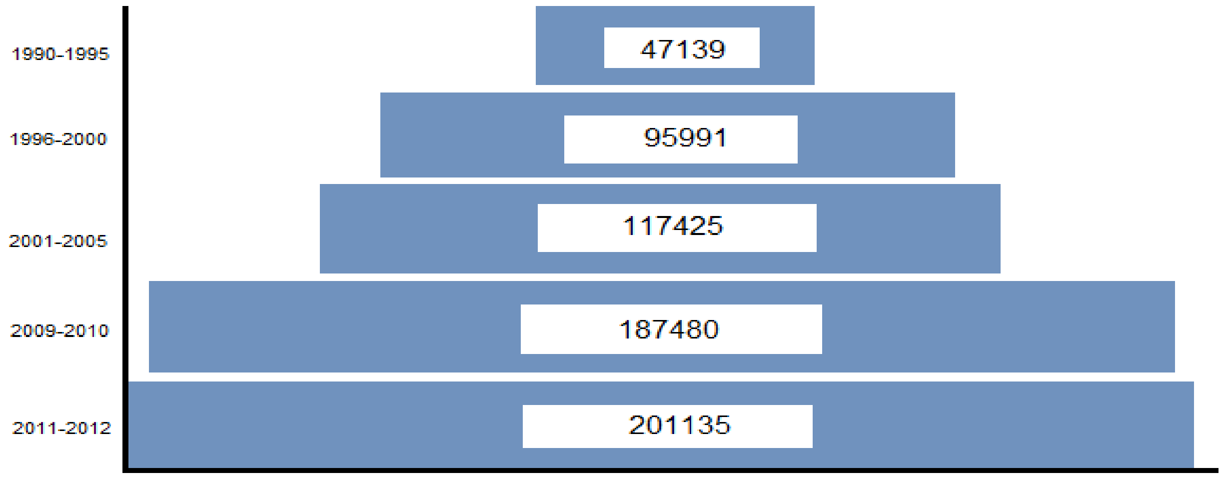
I.13) Flow diagram of wheel manufacture



FigureI.27: *Manufacturing process of wheel*

Production of wheels

The following figure represents the wheel production pyramid during the period between (1992-2012).

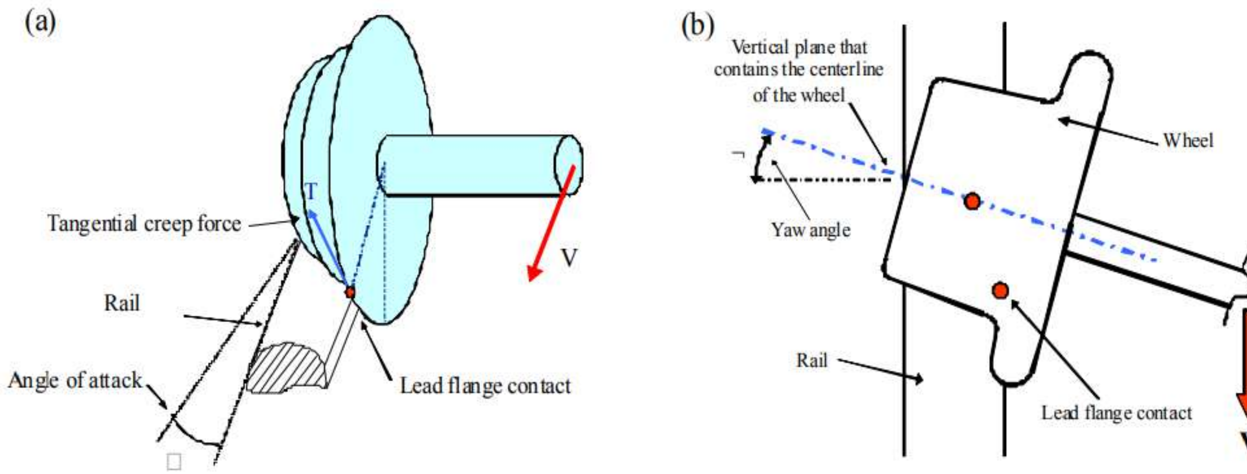


FigureI.28: *wheel production*

So far no online - failure of these wheels has taken place. In other words these cast wheels are more reliable. With this success locomotive and coaching stock wheels were also produced between 2000-2004. Initially these were having casting defects. Then casting simulation software was used to modify locations and size of risers. With these modifications casting produce were sound. There after finite element analysis using NISA software was done and these wheels were got tested at Transportation Test Centre Inc. (TTCI) USA. Indian Railways uses multiple wear wheels. TTCI found FEA analysis ok and wheels very sound for use. **[6]**

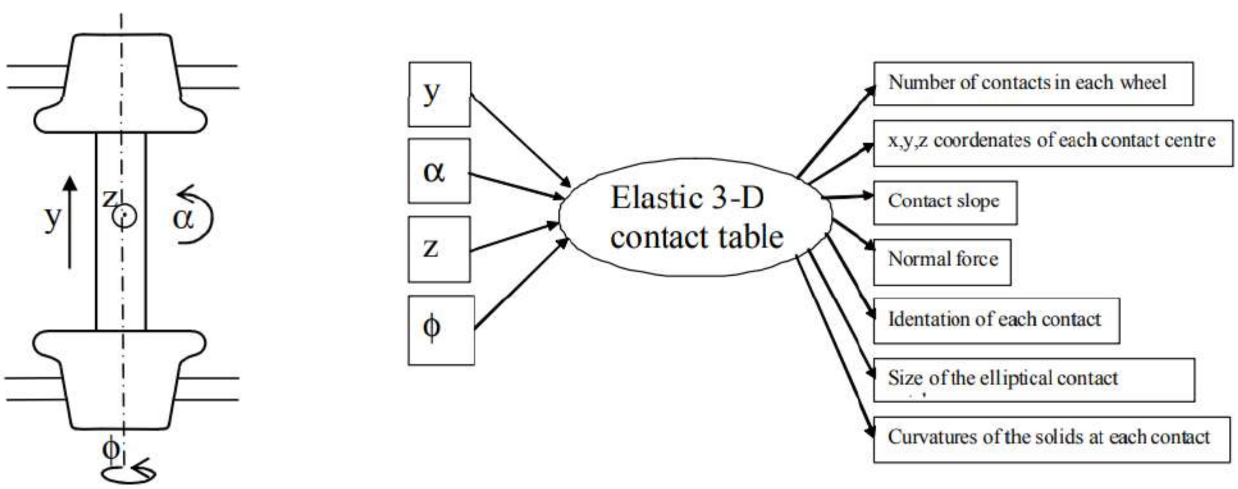
I.14)Wheel-rail failure

The following (figureI.29) represents the factors affecting the point of contact of the wheel with the rail from the two perspectives, the front (a) and the top (b).



FigureI.29: *wheel yaw angle*

The (FigureI.30) presented Wheel-rail contact point when the wheel set rotates at yaw angle α on the top view of the double contact point scenario with a large yaw angle. The contact patch on the wheel thread is located on the wheel's vertical diametral section, whereas the flange contact patch is displaced longitudinally. This paper presents a method to solve the wheel-rail contact problem that deals with the double contact point in 3-D .



FigureI.30: *factors affecting the wheel*

I.15)Turnout Definition

I.15.1)Turnout Function

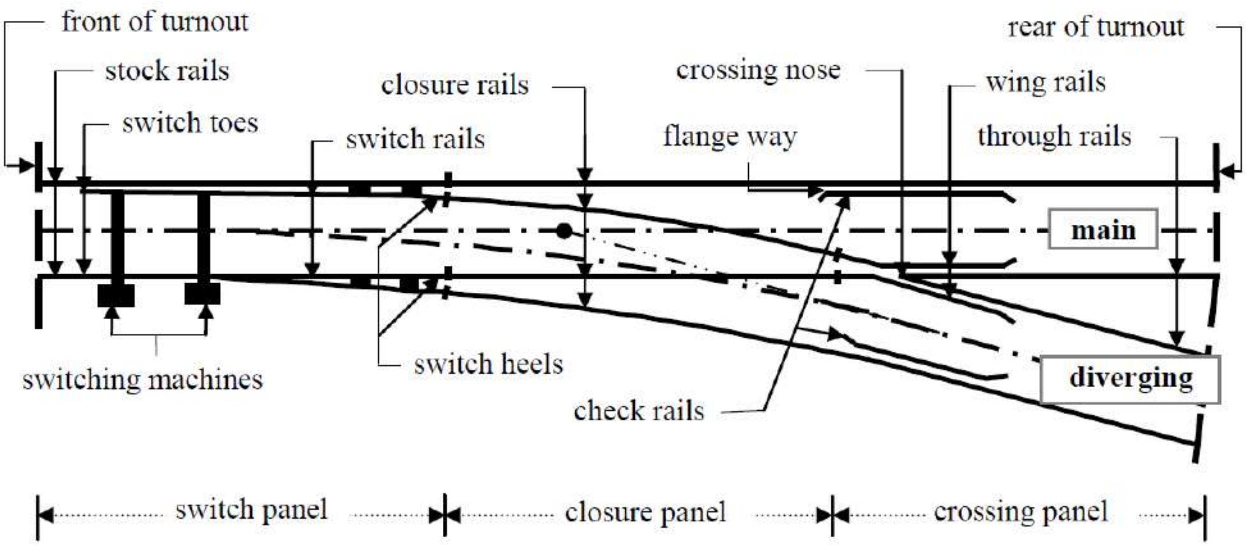
Turnouts are the devices which use to divide one track into two or three tracks. They allow tracks to intersect at the same level. Also, they provide movement in a straight or divergent direction.

I.15.2) Turnout Components

Turnouts consist of the following major parts:

1. Rail :

- Set of switches
-Two switch blades
-Two stock rails
- Closure rail
- Common crossing
-Through rail
-Check rail
-Wing rail
-Nose
-Sleepers (bearers)
-Ballast
-Substructure (subgrade)
-The exact position of turnout components can be seen in(Figure I.31)



Standard right-hand Turnout

Figure I. 31: *Typical railway track system and its components*

1.16) Rail failure types

I.16.1) Kidney-Shaped Cracks

This type crack usually initiates from manufacturing defects which show up when the rail starts to age. Accumulative tonnage borne or progressive cracking of the rail head leads to kidney-shape flaw

Figure I.32: *Illustration 'Kidney-shaped' crack in rail head*

I.16.2) Transverse Rail Foot Cracks

This is described as a progressive fracture in the base of the rail which develops substantially on a transverse plane. Transverse cracks are usually initiated from the outer edge of the foot (Galling) due to wear and/or corrosion at the rail support. As a result of relatively high bending, torsional and residual stresses, very small underside foot cracks can lead to complete rail fracture

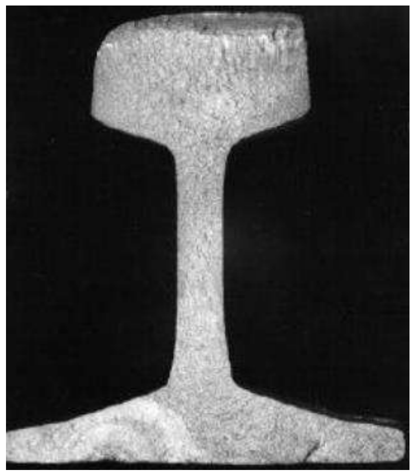
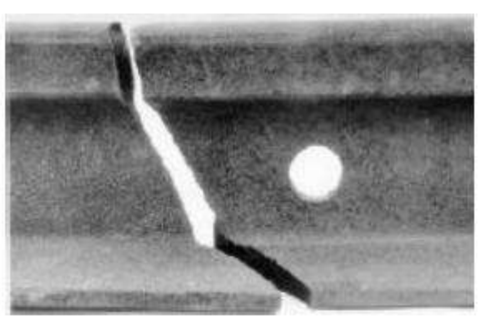


Figure I.33: *Rail foot crack starting from a corrosion pit at a foot underside.*

I.16.3) Longitudinal Rail Foot Cracks

This defect is thought to be caused by improper seating of the rail or poor manufacturing. The defect usually starts as a vertical longitudinal split which can be seen away from the center line of the foot that probably causes a piece of the foot to break away, and more severe damages happen near the center line of the foot by causing a complete fracture of the rail.



FigureI. 34: *Fracture due to a longitudinal crack.*

I.16.4) Longitudinal Vertical and Horizontal Cracks

Cracks in the web usually originate from poor manufacturing. These can be in a vertical (piping) or horizontal direction leading to rail fractures. They are initiated at shrinkage cracks at the outer edge of the weld collar. Typically, impact loading is a contributing factor

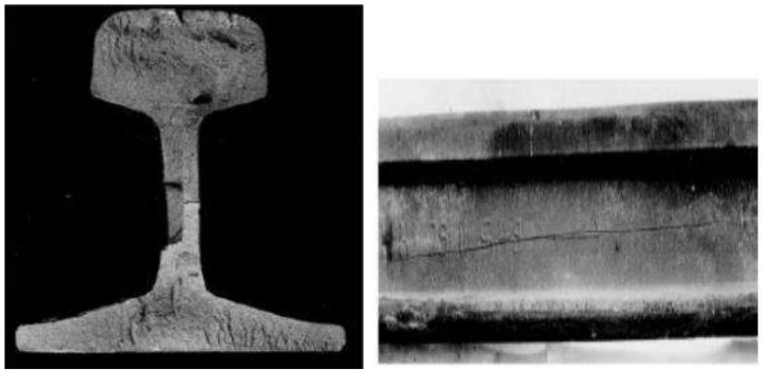


Figure I.35:*Left: vertical web crack, Right: Horizontal web crack*

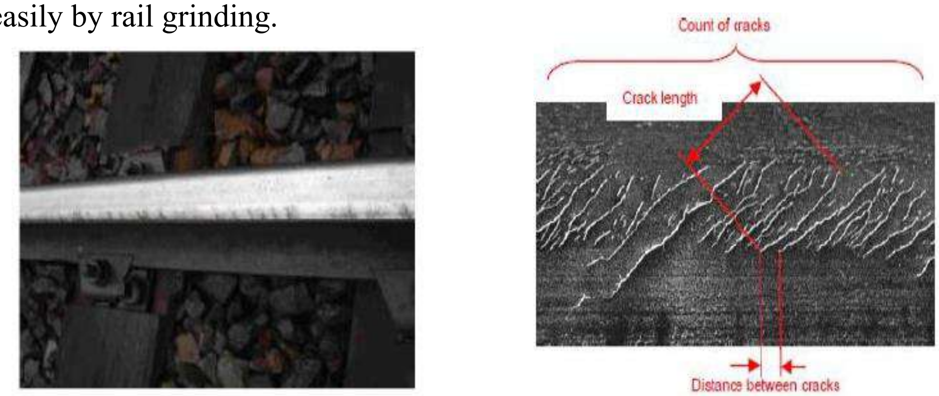
I.16.5) Point and Splice Rails Separating

Due to failure to check fastenings and crossing bolts, or to control the rail creep in abutting track and the effects of traction force, separation of the point and splice rails of a fabricated common crossing is likely to occur. Prior to installation of the new crossing, it will be necessary to find and correct the underlying cause of the separation of the point and splice rails.

Figure I.36: *Point and Splice Rails Separating*

I.16.6) Head Checks

Surface fatigue originates from the stress-exhausted surface layer of the material. As wear rates on the rails are low, the metal remains in place longer and finally reaches the fatigue limit which lead to head check cracks. Head checks are groups of fine surface cracks at the running (gauge) corner of the rail with a typical interspacing of 0.5–10 mm. They run initially into the interior of the rail at an angle of 15-30° against traffic direction. Head check cracks normally shallow and removed quite easily by rail grinding.



FigureI. 37: *Head Checks*

I.16.7) Squats

This type of failure is characterized by the appearance of micro cracks below the surface of the tracks. Squat cracks occur due to high dynamic load of track leading to rolling contact fatigue. At first, these cracks look like a small dark dot. They then become enlarged from the bottom of the dot and grow at a shallow angle in the longitudinal direction. Sometimes the growth of cracks under the surface is in direction to the gauge corner that is common in moving cross frogs. Cracks finally turn down vertically and can eventually result in a rail breakage. The significant characteristic of squats usually appears on the running surface and less commonly from the gauge corner.

FigureI.38: *Squat Defects*

I.16.8) Rail Corrugation

Rail corrugation is a frequently occurring rail wear pattern which appears as an irregularity developing on the running surface of rail. The term corrugation is considered with wavelengths of less than about 1 m. For the purpose of maintenance, it can be convenient to categorize the corrugation according to wavelength: short wave in the range of 0-100 mm, medium wave in the range of 100-300 mm, and long wave in the range of 300-1000 mm. Joints and weld are known to be a common source of excitation, especially if there is acceleration or braking force in this area. Corrugation often propagates from such irregularities. Plastic flow on mixed traffic railways which is due to excessive wheel/rail contact stresses is one of the most common causes of corrugation on heavy haul railways. Disturbed (white) ballast due to the vibration of short wave corrugation and rough riding are known as the consequences. A useful rectification would be to grind the existing corrugated rail over a length of a few hundred meters.

Figure I.39: *Rail Head Corrugation*

I.16.9) Switch Rail Shelling

Fine fatigue-induced cracks at the gauge corner of the rail, form a network on the surface of the rail. These Specific cracks under the gauge corner lead to a breaking out of material (gauge corner shelling**).** Remedial grinding is known as a rectification.

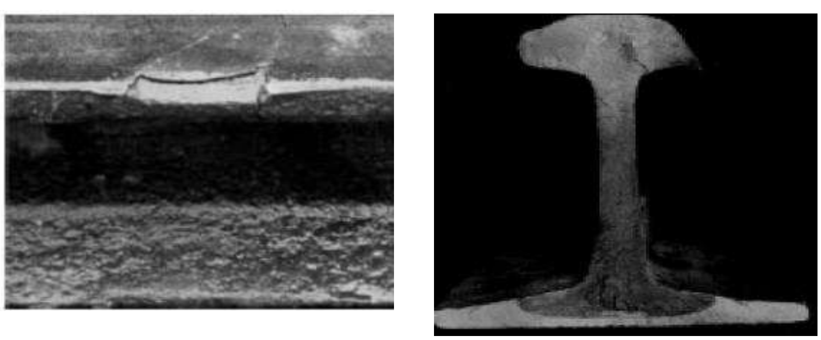


Figure I.40: *Transverse crack propagation starting from gauge corner shelling*

I.16.10) Stock Rail Head Wear

Severe headwear, leading to lipping of the stock rail , could cause the switch rail to stand proud of the stock rail, leading to a switch splitting type of derailment, or at least failure of the switch and stock rail to provide correct locking an detection to the signaling system. A remedial grinding is suggested in primary stage and in sever headwear replacement could be as a rectification.

FigureI.41. *Stock Rail Headwear Associated with a Used Switch Rail*

I.16.11) Sharp Gauge Corner

The sharp corner which has formed on the switch rail occurs most commonly. It causes the wheel to subsequently derail. In addition, as a result of a wheel strike, a deformed nose might form, which leads to a change in check rail gauge dimension, especially when there is a loose bolt. Sharp corners should be removed by grinding.

Figure I.42. *Switch Rail with a Sharp Gauge Corner Profile*

I.16.12) Damaged Crossing Nose

Due to inherent defects in the casting or as a result of strikes because of inadequate guidance from the check rails, some damages appear in crossing nose. Depending upon the resulting shape of the crossing nose it might remove excess lipping by means of an angle grinder and weld repair or replacement of the crossing.

Figure I.43. *Damage crossing nose*

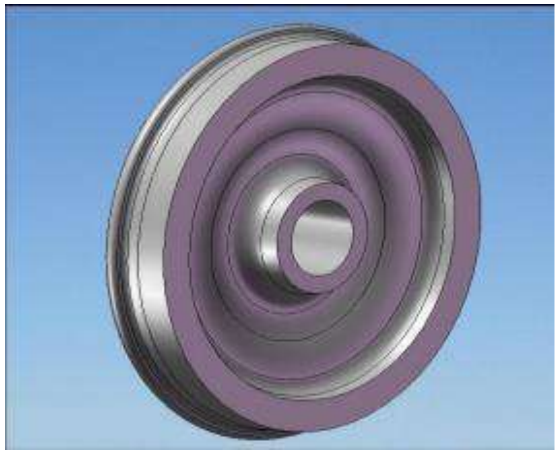
I.16.13) Plastic Flow

Plastic flow refers to plastic deformation of the stock rail (near switch rail) due to cyclic loads and high rail stresses called lipping. Plastic flow of rail material appears often on the low rail in sharp curves. This could result in a reduction of gauge width. Overall, Plastic flow and development of lip usually occur in different components of turnout. In such a situation a remedial grinding is suggested as a rectification.**[7]**

FigureI.44. *Lipping*

I.17)Wheel failure

The wheel has gone through many developments to make it more resistant to stress until the current coins made of steel are obtained, which are still exposed to factors that result in failure.



I.17.1) Vertical Split Rim

VSR failures are characterized as a large portion of the front rim face fracturing off. Occasionally it is the back rim face including the flange that fractures off which is then called a VSF

FigureI.46: *Vertical Split Rim*

I.17.2)Shattered Rim

Shattered rim failures are characterized as a large subsurface fatigue crack created by Hertzian contact stress resulting in a characteristic "bullseye" fatigue fracture.

FigureI.47: *Shattered Rim*

I.17.3)Broken Flange

Broken flanges are characterized by portions of the flange being broken out due to an excessively thin flange.

Figure. 48: *Broken Flange*

I.17.4) Thin Rim Overload Failure

A thin rim overload failure is characterized as a portion of the front rim face fractured off due to a thin rim and a large wheel/rail impact. This failure mode differs from a VSR failure type because it is 100 percent overload. **[15]**

Figure. 49: *Thin Rim Overload Failure*

I.18) CONCLUSION

In this chapter, we got acquainted with the most famous means of transportation, specifically railway transportation, which was the subject of our study, which included the shape of the railway, its components and the way it works, as well as its most important features, as the damages that may occur when the wheel rubs together with the railway were studied.

Chapter II

Measurement of the wheel-rail contact surface finish

II)Introduction

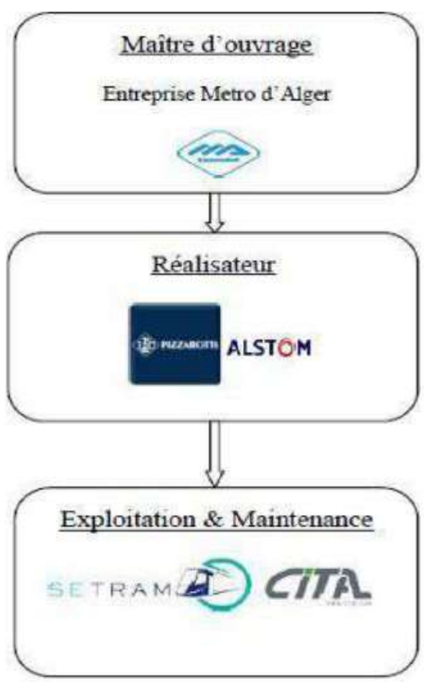
The tramway is an urban and effective means of transportation for people within cities. Its movement depends on the contact of the wheels with the rail. The latter is exposed to several factors, including friction, which affects the security of equipment and people. For the purpose of identifying more about this phenomenon, the railway contact surface was monitored using a surface roughness measurement device.

II.1) tramway definition

A system of transport using trams (electric vehicle that go along metal tracks in the road) a vehicle that hangs from and is moved by cable (a thick, strong wire) and transport people or goods up steep or above an a area of land .**[17]**

II.1.1) Company presentation

General description of the company The Society Metro Algeria is organized as follows:



FigureII.1:*Organization of the company Metro Algeria[11]*

The Ouargla tramway, which came into service in March 2018, is the first tramway in the desert. It has been designed to withstand extreme weather conditions. The line connects Sid Rouhou and **Chenine Kadour** terminuses via the new city and bus station, making the tramway a central transport line in the city. It has a total of 16 stations and extends over 9.6 km.**[11]**

II.1.2) Local society

This work is carried out in collaboration with the company CITAL (site d'Ouargla)

-Description **CITAL**

The name CITAL is a term composed of two words CIT and AL.

-CIT: designates the abbreviation of "Citadine" (Urban Transport).

-AL: designates the abbreviation of "Algeria."

CITAL was born in 2011 from Algeria's desire to acquire modern industrial assembly and maintenance capacities in the railway sector; it is in charge of meeting the tram needs of current and future projects in Algeria. 6 tram systems are maintained by CITAL: Algiers since December 2010; Oran since April 2013 and Constantine since June 2013, Sidi-Bel-Abbès since July 2017, Ouargla since March 2018 and Sétif since May 2018. Soon the maintenance of the Mostaganem trams and that of the CORADIA ALGERIA main line trains will also be provided by CITAL **[8].**

II.2)Sites of Ouargla

II.2.1)-General view

The Ouargla site is a center for the maintenance of trams. This center is located next to the passenger transport station, on the road to Ghardaïa. **[11].**

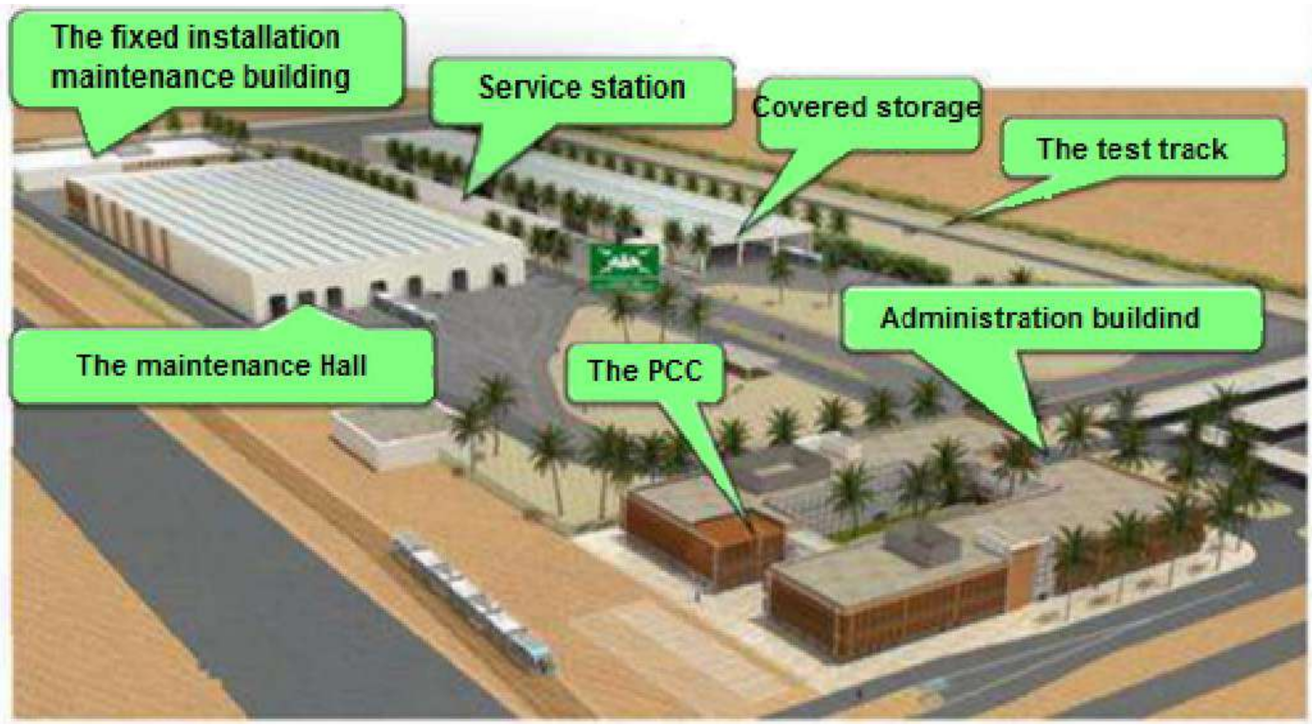
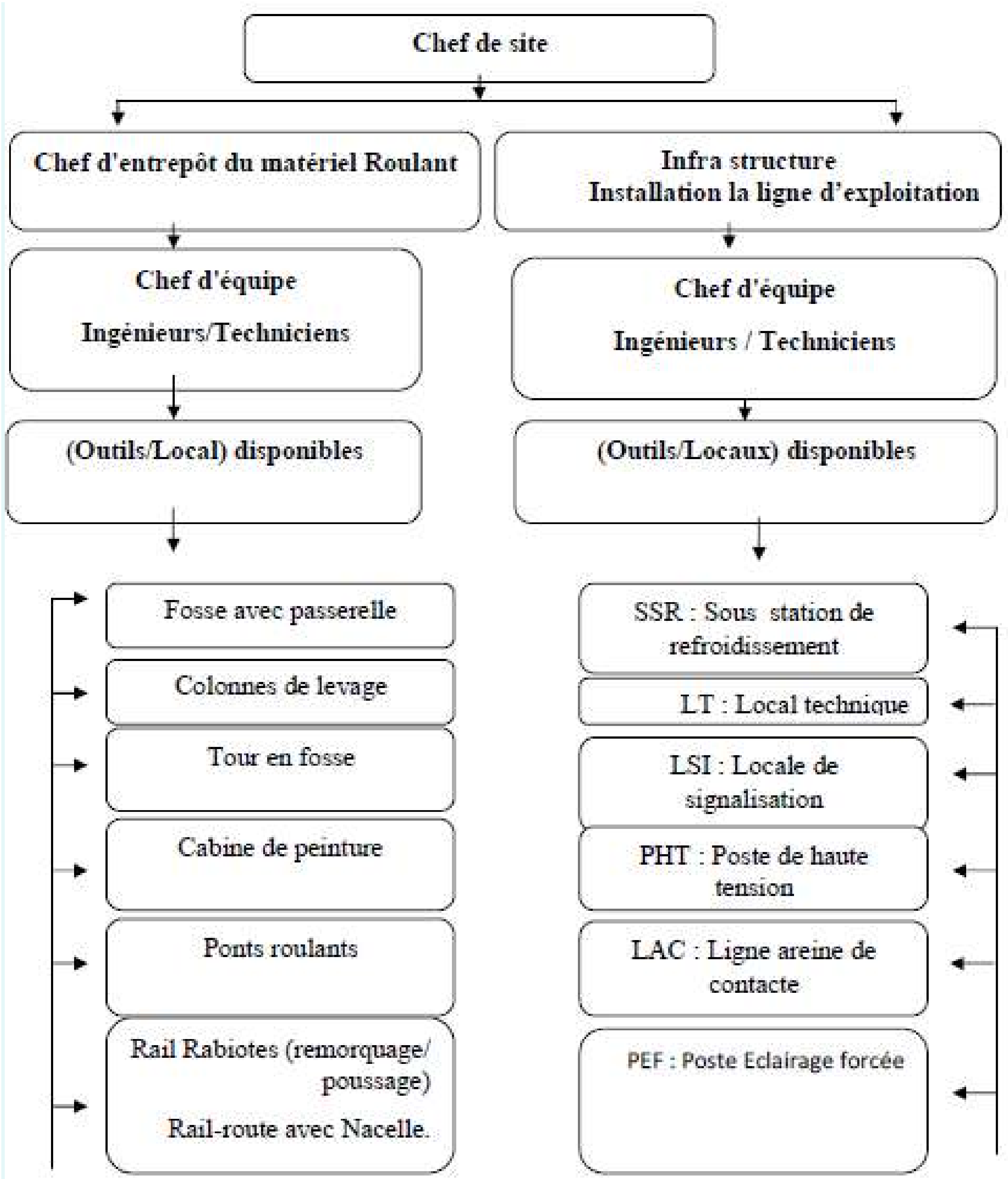


Figure II.2: *CITAL company sites in Ouargla**[11]***

II.3) Site organization chart

We will explain the organizational structure of CITAL Company as follows:



FigurII.3: *Organization chart of the Ouargla site* ***[11]***

FigureII.4: *OUARGLA tramway*

Ouargla Tramway, constructed in the city of Ouargla in Algeria, is a 9.6km-long tramway that connects the old town of El Ksar with the new town of Hai Nasr through downtown Ouargla. The tramway opened in March 2018, operated by Enterprise Metro d'Alger (EMA).

The new tramway passes through major interchange points to connect passengers with other modes of transport, including the Ouargla bus station and SNTF railway station,.

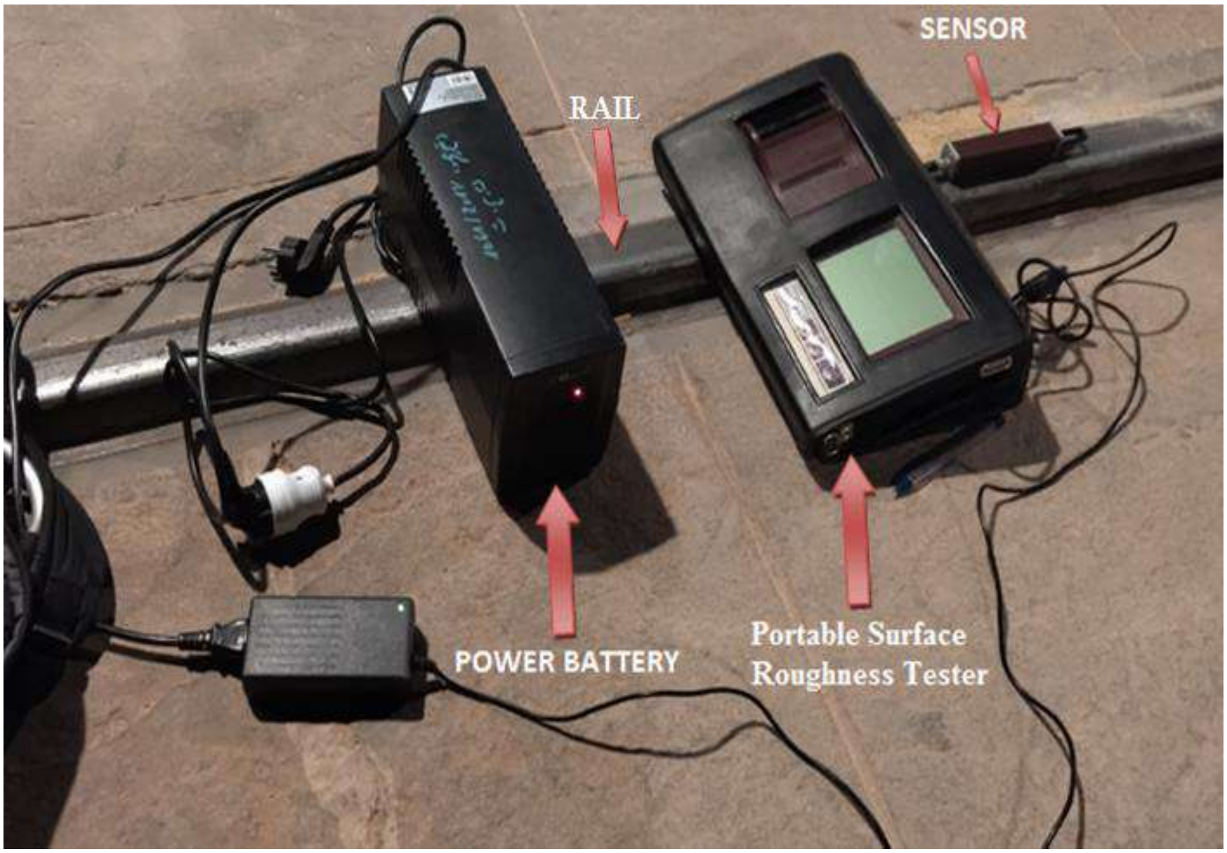
The line enables the transportation of 3,450 passengers an hour in each direction**.[7]**

II.4) Experimental study

The aim of this study is to know the effect of the surface condition between the wheel and the railway on the performance of the tramway movement, depending on the measurement of the degree of roughness of the surface of the railway for the stations. For a deeper understanding of this study, using the Digital Surface Roughness Tester Meter Gauge.

II.4.1)Equipment used

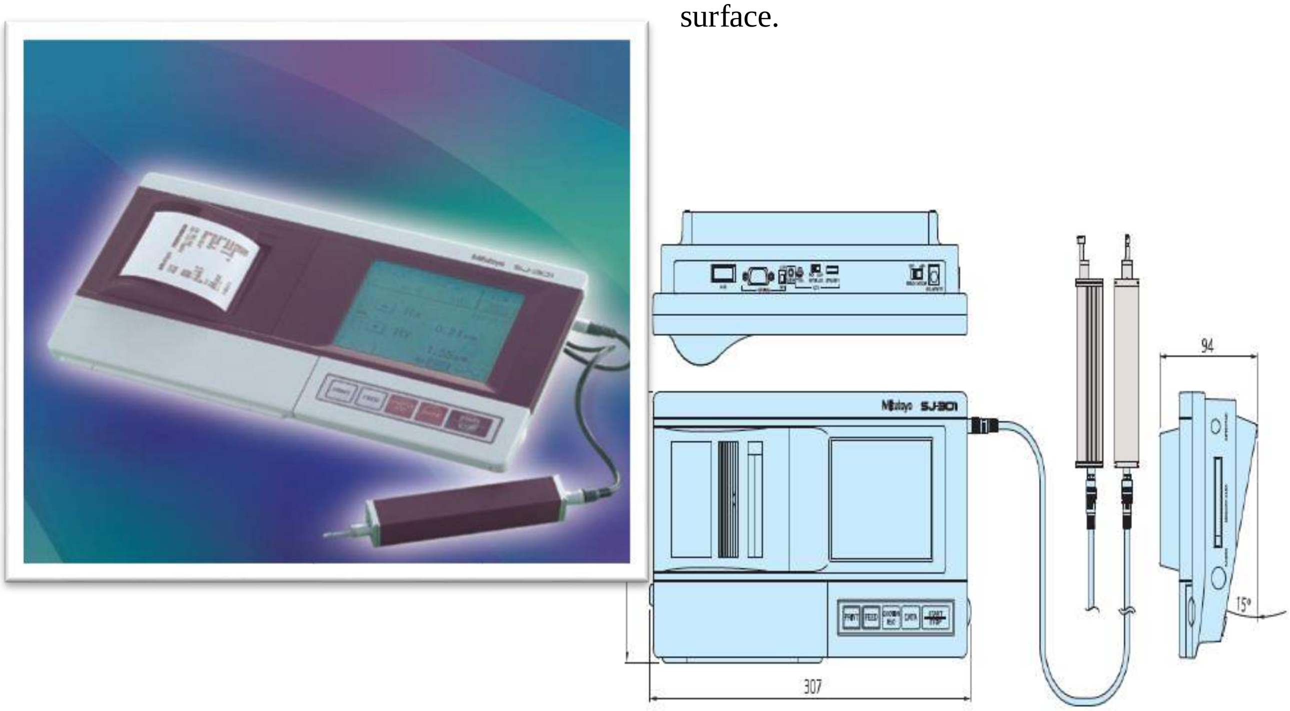
This study was done by using the following tools(Power battery **,**Portable surface roughness tester **,**Sensor)



FigureII.5: *Work Tools*

II.4.2)Portable Surface Roughness Tester

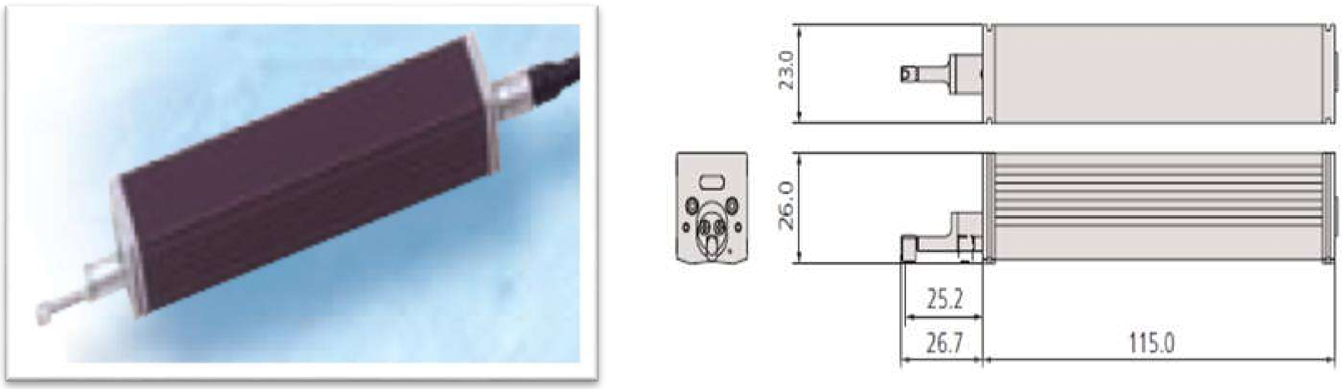
It is a device designed to check the surface roughness with measured values and displayed on digital readouts, attached to an oscillometric device showing the condition of the surface.



FigureII.6: Portable Surface Roughness Tester

II.4.3) SENSOR

A highly sensitive instrument that must be highly manipulated to ensure measurement accuracy and performance is a sliding type in which the recording pen is automatically crossed against a sample and the electro voltaic capture is recorded and converted into numerical values. Capable of performing measurements in any orientation, including vertical and upside-down. Optional accessories, such as a height gage adapter, Allow measurements to be performed efficiently in various situations and setups **[9].**



FigureII.7: *Sensor*

II.5) Measurement methodology

For better understanding understand more about the surface roughness on the movement of the tramway, the roughness of the rail surface was measured at the tramway stations in 3 locations (the station entrance - the center of the station - the station exit) using a Portable Surface Roughness Tester device and this according to the following steps:

II.5.1)Step1:surface cleaning

In order to obtain accurate results, the gauge surface is cleaned with a piece of tissue in order to remove any dust, dirt or oils that may affect the accuracy of the measured results.

FigureII.8: *surface cleaning*

II.5.2)Step2: Measurement stage

The pickup is placed on the measuring surface tangent to the rail, and by pressing the measuring button the recording pen is automatically crossed and records the capture of all the vertical movement peaks.

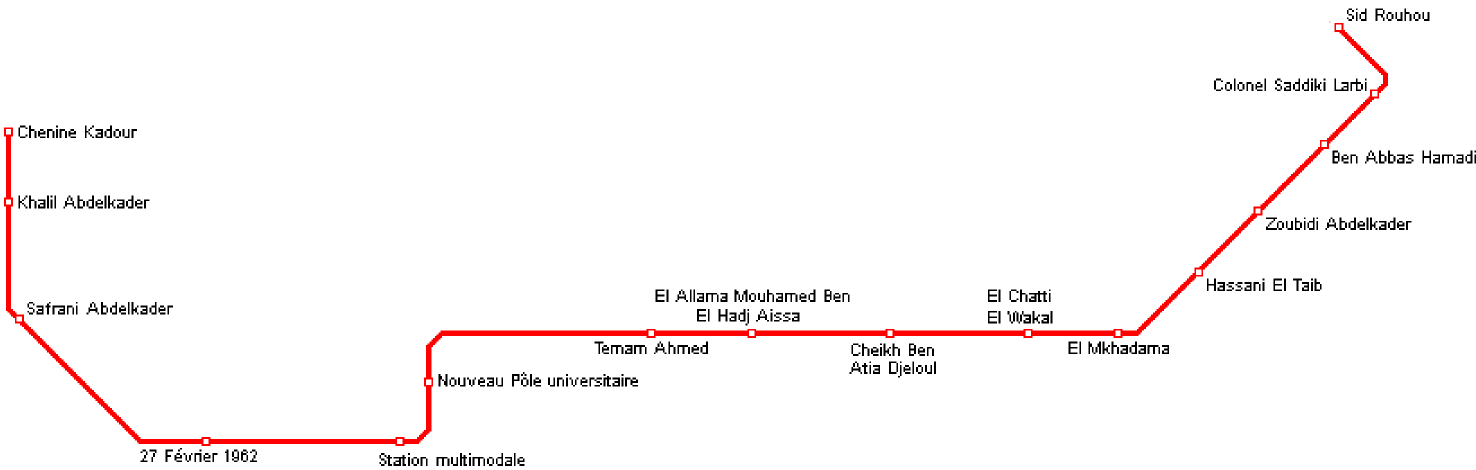
FigureII.9: *Measurement stage*

II.5.3)Step3: Record the results

After recording, we get a value attached to a curve. The results for each station are recorded.

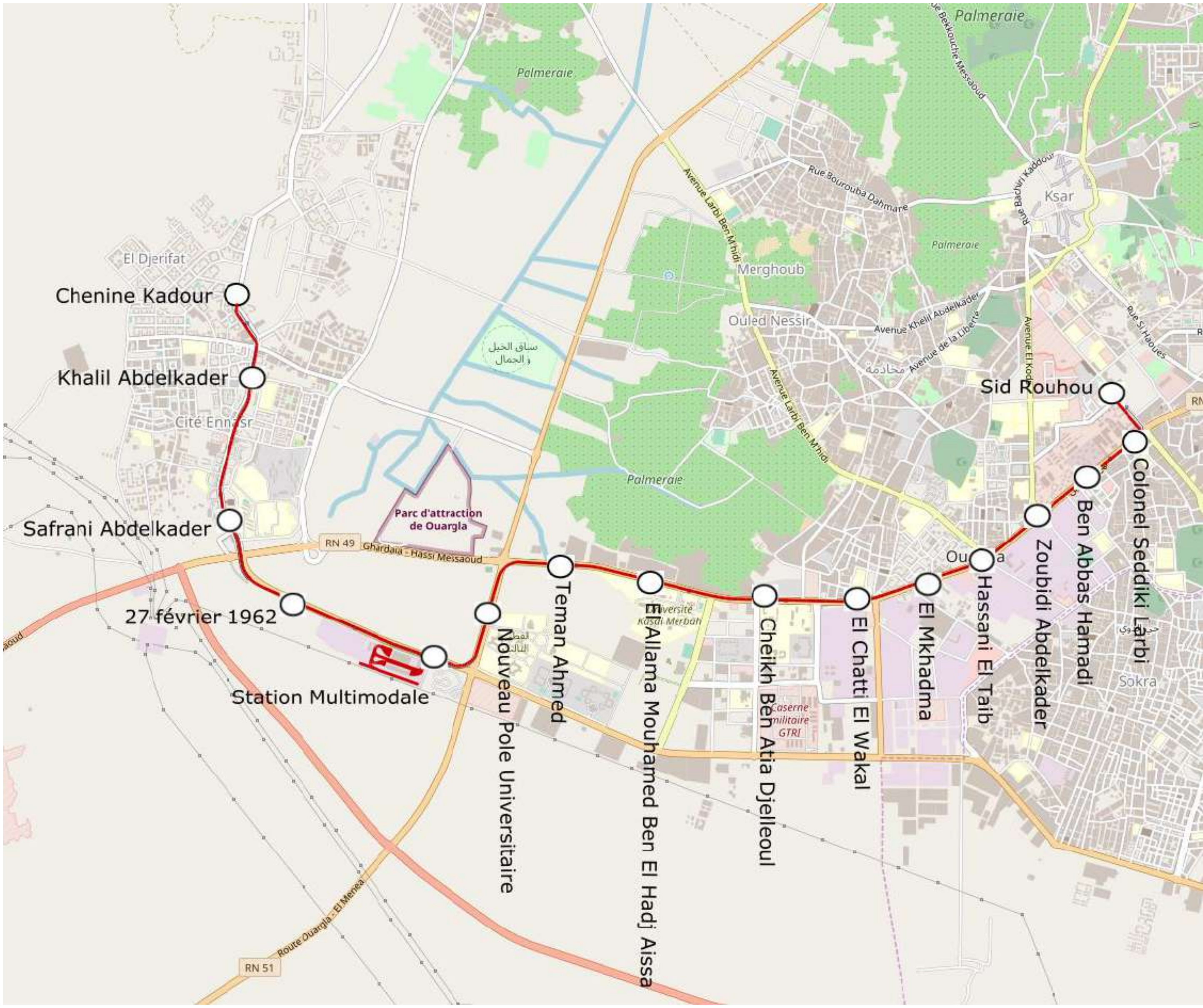
FigureII.10: *Recording the results*

The experimental study made it possible to obtain the results shown in the corresponding curve, which represents the value of the surface roughness for 3 zones in terms of the tramway stations. **[10]**



FigureII.11:*OUARGLA tramway stations line* ***[12]***

Experimental follow-up was carried out from station (Sid Rouho)to station (Chenine Kadour).



FigureII.12:*OUARGLA tramway stations line 2****[13]***

II.6) Conclusion

It can be said that the internship period was beneficial to me, due to the fact that I invested the time required of me with high accuracy, as I was able to get acquainted with the company SEATRAM OUARGLA and the management of the work there and the tramway and its work in the smallest details, as the supervisor professor and the framer played an important role in the success of this process as planned and responsible for it.

This study aims to improve the maintenance process and help maintain the safety of equipment for as long as possible and the security of transportation and passengers.

ChapterIII

Result and Interpretations

III.1)Introduction

After the experimental study, the recorded results were obtained in the following tables, which are attached with curves and histograms.

III.2) Experimental data table

The following table represents the measured surface roughness values for 18 stations over 3 regions (entrance-middle-exit) for the year 2021 and 2022.

TableIII.1*: Experimental data table2021*

POINT	ZONE 01	ZONE 012	ZONE 02	ZONE 022	ZONE 03	ZONE 032
1	0.65	0.41	0.56	0.82	0.67	0.54
2	0.88	0.76	0.88	0.68	0.51	0.57
3	1	0.82	0.76	0.76	0.61	0.72
4	0.71	0.52	0.72	0.48	2.02	0.79
5	0.71	0.59	0.73	0.51	0.73	0.82
6	0.53	0.62	0.65	0.92	0.58	0.82
7	0.48	0.52	0.78	0.94	0.55	0.63
8	0.62	0.49	0.66	0.63	0.52	0.7
9	0.71	0.52	0.79	0.87	0.53	0.57
10	0.49	0.67	0.7	0.57	0.5	0.64
11	0.69	0.49	0.8	0.69	0.65	0.52
12	0.84	0.54	0.52	0.64	0.51	0.5
13	0.54	0.59	0.69	0.74	0.67	0.76
14	0.53	0.56	0.46	0.55	0.82	0.7
15	0.67	0.6	0.66	0.51	0.51	0.53

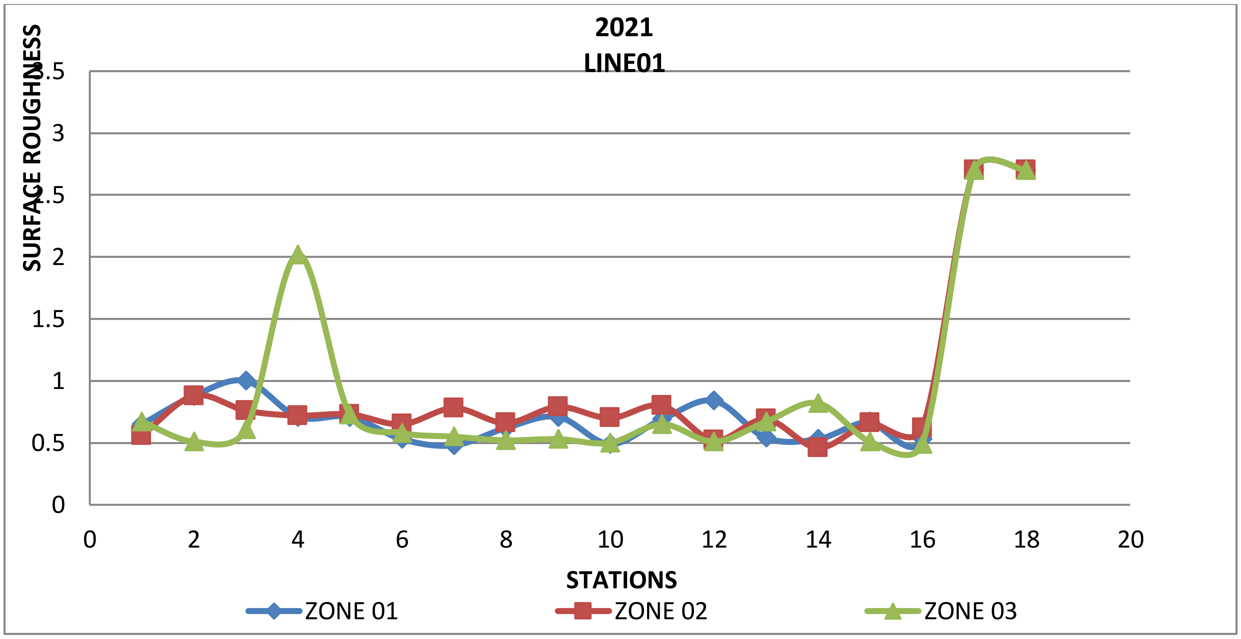
16	0.53	0.53	0.62	0.67	0.49	0.63
17	2.7	2.7	2.7	2.7	2.7	2.7
18	2.7	2.7	2.7	2.7	2.7	2.7

Table III.2: *Experimental data table2022*

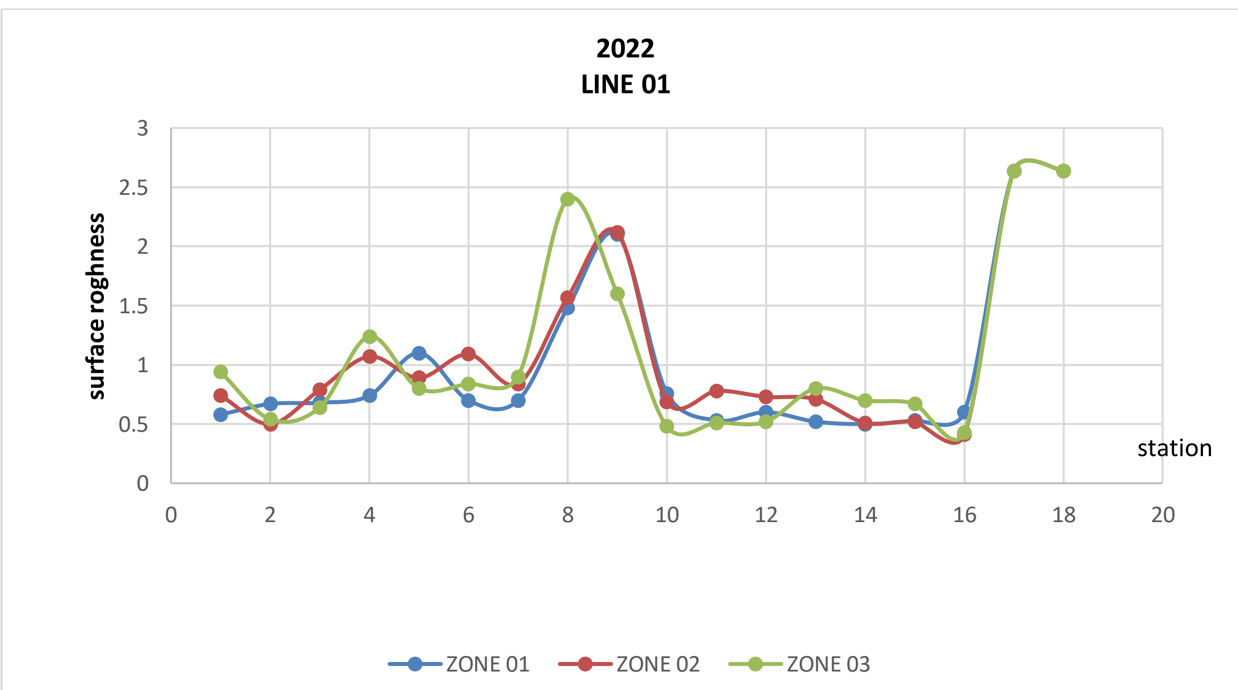
POINT	ZONE 01	ZONE 012	ZONE 02	ZONE 022	ZONE 03	ZONE 032
1	0.58	0.8	0.74	0.62	0.94	0.87
2	0.67	0.67	0.5	0.94	0.54	0.66
3	0.68	0.68	0.79	0.61	0.64	0.6
4	0.74	1.36	1.07	0.91	1.24	0.67
5	1.1	1.08	0.89	1.26	0.8	0.6
6	0.7	0.72	1.09	1.24	0.84	1.56
7	0.7	0.72	0.84	0.8	0.9	1.4
8	1.48	1.62	1.57	2.32	2.4	2.1
9	2.1	2.3	2.12	2.3	1.6	1.4
10	0.76	0.56	0.69	0.54	0.48	0.54
11	0.53	0.61	0.78	0.69	0.51	0.62
12	0.6	0.58	0.73	0.5	0.52	0.61
13	0.52	0.63	0.71	0.6	0.8	0.51
14	0.5	0.64	0.51	0.74	0.7	0.58
15	0.53	0.49	0.52	0.5	0.67	0.55
16	0.6	0.54	0.41	0.4	0.43	0.52
17	2.64	2.64	2.64	2.64	2.64	2.64
18	2.64	2.64	2.64	2.64	2.64	2.64

III.3) Results

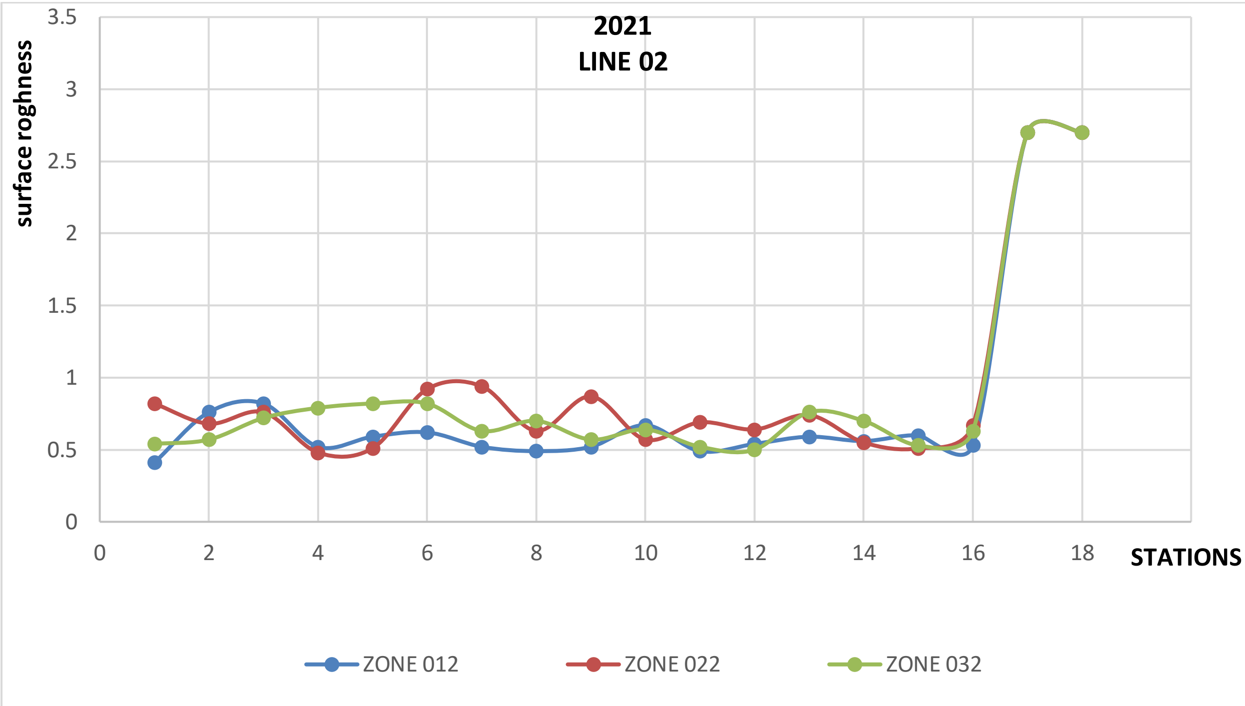
Based on the results of the table, the following curve was obtained, which represents the measured surface roughness in 3 zones in terms of stations.



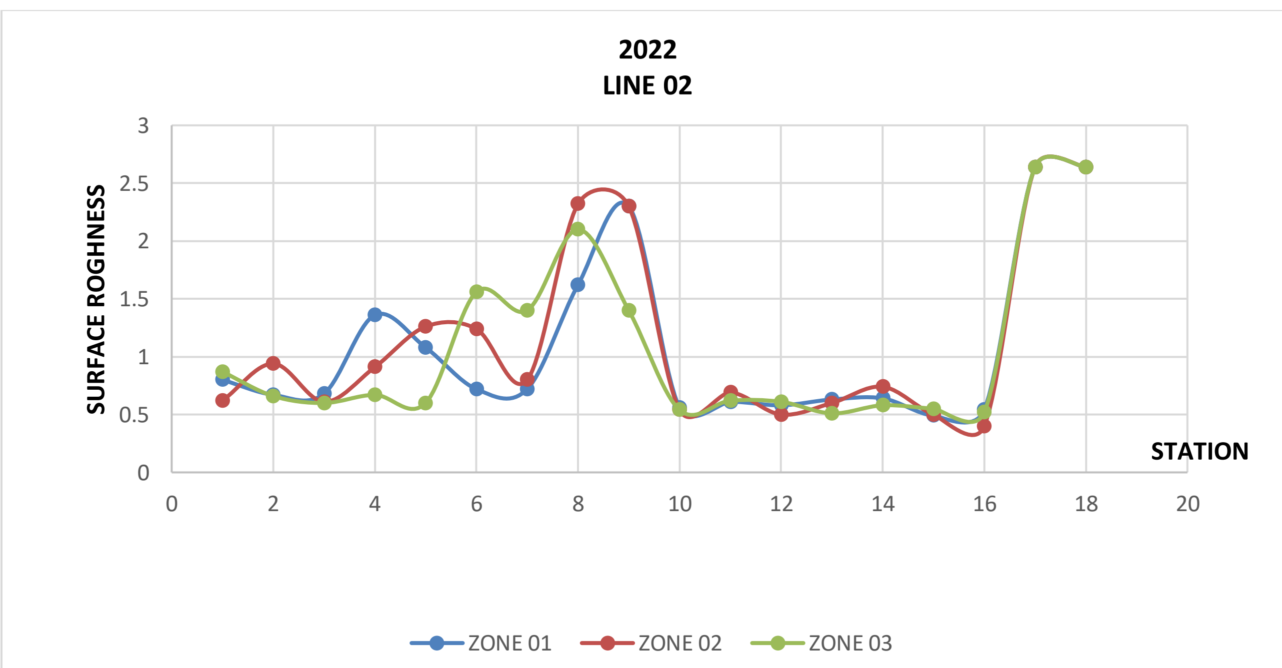
FigureIII.1*: result curve line01 (2021)*



FigureIII.2: *result curve line01 (2022)*

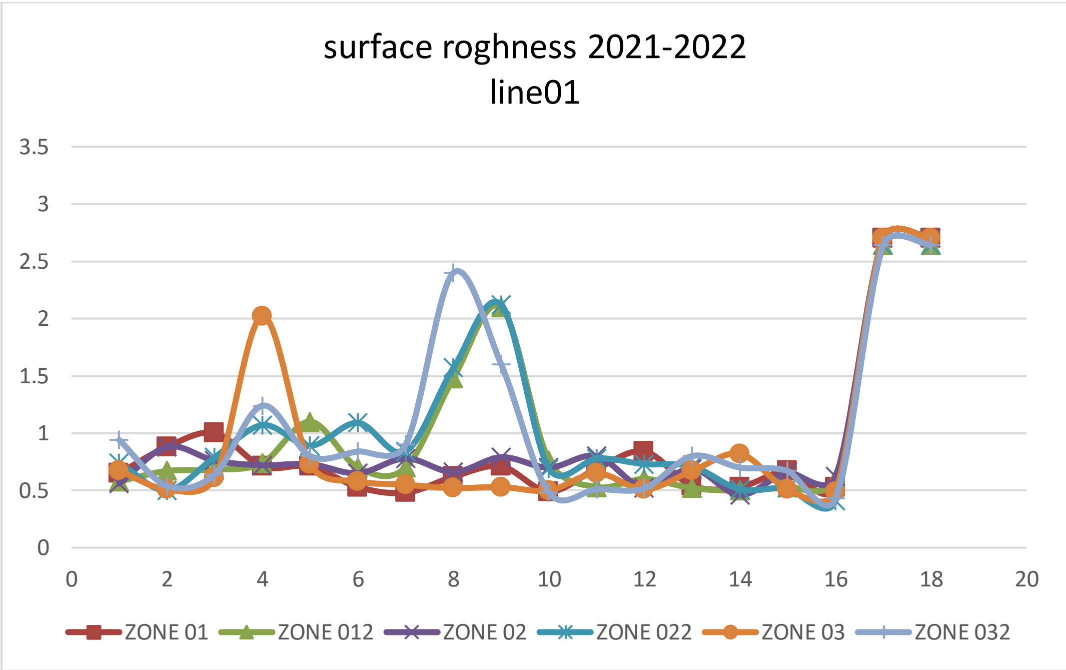


FigureIII.3:*result curve line02 (2021)*

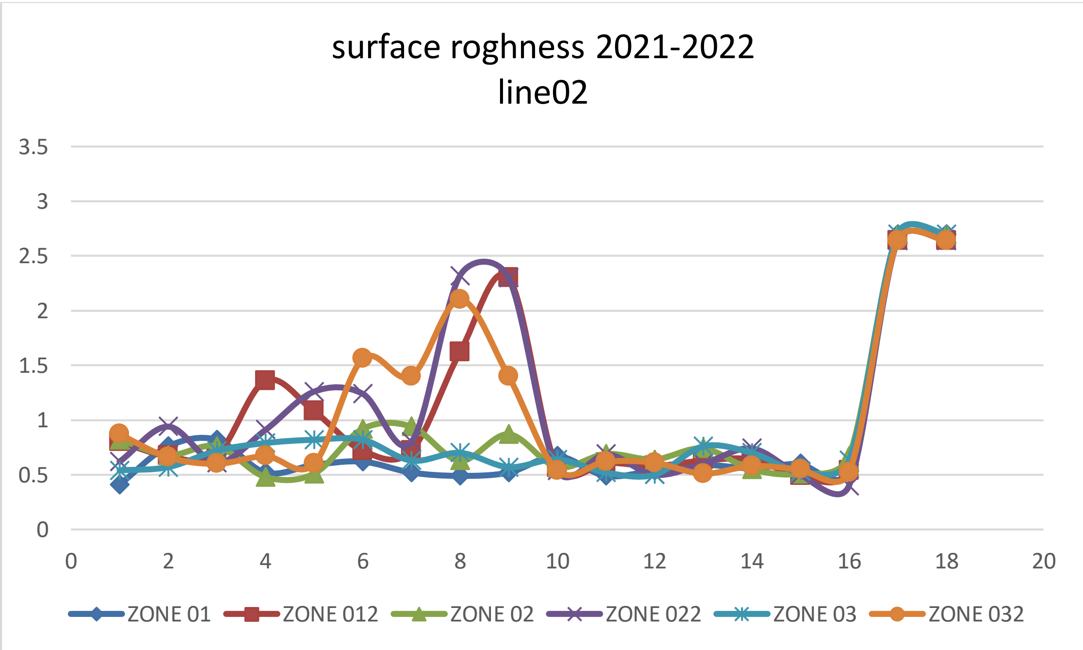


FigureIII.4: *result curve line02 (2022)*

III.4.1) comparison of surface roughness of line 01 and 02 between years (2021-2022)
The figure represents a curve of the surface roughness of Line 1 over the years 2021-2022



***FigureIII.5:** surface roughness line 01 between 2021-2022*



***FigureIII.6:** surface roughness line 02 between 2021-2022*

III.4) Histogram Comparison between line 1 and line 2

The low figures represents Comparison Histogram a of the surface roughness of line 1 and 2 over the years 2021-2022.

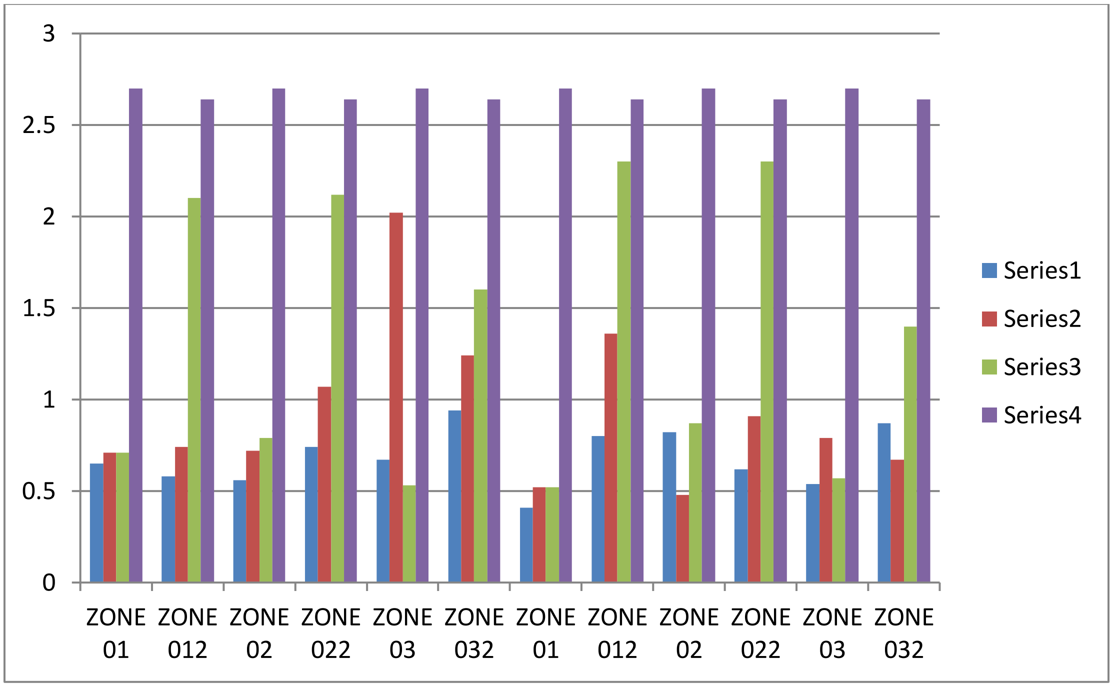


FIGURE III.7: *Histogram Comparison between line 1 and line 2*

III.5) Interpretation

After the experimental study, values were obtained to measure the surface roughness and draw the graph attached with bar graphs in terms of the stations between the years 2021/2022, where we notice the appearance of a large agreement in the roughness between the stations except for two differences in the year 2022.

-The first difference

In stations 2 (Khalil Abdelkader) and 3 (Safrani Abdelkader), where the decrease in the roughness of the surface, which was estimated at about**(0.3 µm)**, is due to the sudden braking of the tramway due to heavy traffic

-Second difference

In stations 08 (Med Ben El HadjAissa) and 09 (Cheikh Ben AtiaDjelleoul), we notice an increase in surface roughness estimated at**(2 µm),** due to the maintenance process of special restoration in the two stations.

Important note

The surface roughness in the first Station(Chenin kadeur) and last station(Sid Rouhou)is ideal due to the absence of phenomena that reduce the rate of roughness (pressure stress and low mass and weight, speed, braking stress, low fatigue due to less frequent wheel contact).

III.6) Conclusion

The analysis of the table data and the interpretation of the curve allowed the conclusion that there are factors affecting the roughness of the railway surface, where the roughness is an important factor for the performance of the tramway and the safety and comfort of passengers, and this calls for the periodic follow-up of the surface contact and the proper organization and management of traffic.

General conclusion

Rail transport was considered one of the most important means of transport, because it is an important and supportive element for the economic movement of countries of all Transport kinds.

The field training in the company SETRAM OUARGLA allowed to identify the most important factors affecting the tramway and the maintenance methods adopted in this by studying the friction surface between the wheel and the railway and processing the measured data, the importance of the surface roughness was confirmed to ensure the stability of the tram's movement, which in turn ensures the comfort and safety of passengers.

Tramway is exposed to many mechanical factors, causing some stress, including (wears, plastic flows, and squats).

Through processing the measured data, more was known about the phenomenon of friction and the factors affecting it, which confirms that the surface roughness is an essential and important element in the movement of the tramway and the comfort of passengers.

This work aims to extract data aimed at restructuring the railway line for better traffic and developing the bladder of the tramway line.

Abstract:

The means of transportation is a special form of transportation with a basic distinction of the vehicle used and therefore the infrastructure that runs it, whose characteristics change by changing the mechanical factors.

Based on measuring the degree of roughness of the railway surface for stations, using a surface roughness measuring device.

Key words: Onarga tram, surface roughness, surface roughness tester.

Résumé:

Un mode de transport est un mode de transport particulier caractérisé principalement par le véhicule utilisé, et donc par l'infrastructure qui le met en œuvre. Cette étude vise à connaître les facteurs affectant le contact en étudiant l'état de surface entre la roue et les rails de la ligne de tramway de Ouargla, à partir de la mesure du degré de rugosité de surface des gares. Pour mieux comprendre cette étude, l'étude pilote a été réalisée à l'aide d'un appareil de mesure de la rugosité de surface.

Mots-clés: Tramway d'Ouargla - rugosité de surface– rugosé mètre.

ملخص:

وسيلة النقل هي شكل خاص من أشكال النقل يتميز بشكل أساسي بالمركبة المستخدمة ، وبالتالي بالبنية التحتية التي تنفذها. تهدف هذه الدراسة إلى معرفة العوامل المؤثرة علي تلامس من خلال دراسة حالة السطح بين العجلة والسكك الحديدية لخط ترام ورقلة ، بناءً على قياس درجة خشونة سطح سكة حديد المحطات. للحصول على فهم أعمق لهذه الدراسة ،تمت الدراسة التجريبية باستخدام جهاز قياس خشونة السطح.

الكلمات المفتاحية: تراموای ورقلة - خشونة السطح - مقياس الخشونة.

Resources

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