People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific research
University of Kasdi Merbah Ouargla
Institute of Technology
Department of Applied Engineering

End of study thesis
To obtain a Professional Bachelor degree

Field: Sciences and Technologies
Sector: Applied engineering
Specialty: Measurement, Metrology and Quality

Theme:

the contribution of the improvement of preventive maintenance to ensure the tolerance of mechanical parts (case of tramway Ouargla)

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University year: 2022/2023

ALLBASMALAH

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Acknowledgment

First and foremost, we give Allah praise for providing us the perseverance, strength, and guidance throughout our life to get to this point and be able to carry out this humble Work.

Without his assistance, none of this would have been possible, thus we sincerely appreciate and thank Mr.Lemnaouer for making this task feasible and helping us during our work period.

We also thank the responsible for the tram maintenance centre Mr.KHOUILDI Lakhder for allowing us to complete our internship and for creating a positive work environment. We also thank Mr.Hayour Lakhder,

Mr.TAHA Bennaser and Mr.KHALOUI Youssef for assisting us with our internship and giving us all the information we required.

DEDICATION

The first thing I want to say is praise to Allah for providing me the strength and endurance to get through all the roughest and most challenging times in order to complete this little effort, I dedicate this work to my father Mohammed Lahcen and My mother Samia Benchikhe and all my family members because they shaped who I am now, and without them, I would not be where I am today.

I want to thank my friends and classmates and everyone who helped, especially my partner Nasri Imad.

DEDICATION 2

Allhamedelallah

I want to dedicate this work to my adored parents, my precious father Mohammed and my dear mother Salem Yamina for their unwavering support and inspiration throughout my life. Without them, I would have been nothing.

I want also to dedicate this first diploma in the family to my brothers Zakariya and Lokman and to my sisters Firyal and Bouchra, and also to my ankles. Without forgetting my partner Youcef Salah

And to my class mates and also my best friend Mostafa and to the all good people that I know.

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List of Abbreviations

CIT: Citadine" (urban transport)

AL: Algeria

EMA: Algerian Metro Company (Enterprise Metro d'Alger)

SNTF: The National Railway Transport Company (Societe National des Transports Ferroviaires)

MR: Maintenance of Rolling Stock

ED: Maintenance of Industrial Depot Equipment

INFRA : Infrastructure

CFA : Low Curent (Curant Faible)

(**CFO**) : High Curent (Curant Forte)

(**LAC**) : Overhead Contact Line (Ligne Aériennes De Contact)

HSE : Health and Safety Executive

HR : Human Resources

PCC : Central Communication Post (Post Centrale de Communication)

AFNOR: French Association of Standardization (Association Française de Normalization)

PLC : Programmable Logic Controller

PV : Periodic Verification

RP : Reprofiling of wheels and suspensions adjustments

BIPM : International Bureau of Weights and Measures

Qr: flange gradient

RNG20: Reprofiling New Generation 20 tons at the axle Machine

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Table

General introduction

Transportation plays a fundamental role in our daily lives, meeting our displacement needs and enabling efficient mobility. In the vast landscape of transportation options, tramway systems have emerged as a crucial component of urban transportation networks. Trams, operating on rail lines, offer passengers a unique combination of convenience, comfort, and well-being. These systems incorporate advanced equipment and sophisticated systems, ensuring a smooth and enjoyable journey for commuters and travelers alike.

However, to maintain the reliability and longevity of tramway systems, proper maintenance practices are imperative. Preventive maintenance assumes a strategic role within businesses, serving the critical purpose of ensuring the seamless operation of production instruments. This field continually evolves, driven by technological advancements, the development of new management techniques, and the ongoing pursuit of reducing production costs. Today, maintenance encompasses not only fixing the work tools but also achieving metrology standards by anticipating and preventing failures.

Within the realm of tramway maintenance, particular attention must be given to the tram's wheels—an essential and highly significant component. Given the daily exploitation of trams, the surface of their wheels experiences the wear and tear of friction, corrosion, cracks, and strains. These factors can significantly impair wheel performance, posing potential risks such as brake issues, auxiliary friction, or wheels pulling away from the rail, ultimately compromising the safety of passengers and operations. To mitigate these risks and ensure optimal performance, periodic maintenance and vigilant attention are essential for preserving the integrity of tramway wheels. Regular cleaning and comprehensive inspections are necessary to identify and address any issues promptly. One invaluable tool employed in preventive maintenance is the RNG 20 (WHEEL REPROFILING MACHINE). This specialized equipment aids in maintaining the correct wheel profile, rectifying any abnormalities, and restoring optimal functionality.

Chapter 1

Tramway Transportation Ouargla site

1 Introduction

Because of its ability to meet the displacement needs of human beings and facilitate their mobility, transportation has become essential in our daily lives. We use a variety of types and modes of transportation to do that, including Tramway on rail lines. This means of transport offers passengers a great comfort and well-being thanks to the use of many advanced equipment and systems.

So

-What are the components of the tram and its types?

2 Tramway

2.1 History

The origin of the tramway can be traced back to the plateways used in mines and quarries to ease the passage of horse-drawn wagons, but the first street tramway in a city was the New York and Harlem line of 1832, coining the American term still used today, street railway. Remarkably the world's second horse tramway, in New Orleans (1835), is still in use for electric cars today, after over 150 years of continuous service.

American promoters brought the tramway to Europe, Paris in 1853 and Birkenhead in England in 1860, followed by London in 1861 and Copenhagen in 1863. The 1870s were a boom time for the construction of horse tramways, but the limitations of animal power were obvious, and promoters soon turned to investigating mechanical traction. Steam trams were developed, but were not very suitable for urban use, although they ran on many suburban and rural light railways. Compressed air, gas and petrol engines were tried; cable tramways enjoyed considerable success for a time (and survive in San Francisco). However most of these technically suspect or expensive options faded quickly once electric traction became a possibility.

The first electric vehicles were battery powered, but it was the development of a practicable dynamo by Werner von Siemens, demonstrated in Berlin in 1879, which provided the way ahead for electric traction by generating power at a fixed point and supplying it to a line by conducting rail or overhead wire. Siemens & Halske opened the first electric tramway to provide public service in Berlin in 1881, using current at 180 volts fed through the running rails.

The first lines in the United Kingdom were the Portrush and Bushmills (later Giant's Causeway) tramway in Ireland, and Volks Railway at Brighton in 1883; the latter seafront line still runs today.

For safety reasons electrified running rails were unsuitable for a street environment, and in the UK overhead wire was first used on the Bessbrook and Newry line in Ireland in 1885. Slotted tube overhead was tried in Paris in 1881, and other European cities, including Frankfurt in 1884, and the latter now has the longest period of continuous electric street tramway operation anywhere in the world (conventional overhead wire has been used since 1906). Underground conduit was an alternative to overhead current collection, sometimes preferred for aesthetic reasons since poles and overhead were not required, and surviving until the end of tramway operation in London in 1952, and in Washington DC until 1962. The Blackpool tramway, operated on the overhead system since 1899, opened with conduit operation in 1885, and is Britain's oldest street tramway still operating today.

However, the overhead wire with trolley pole collection was soon shown to be the most practicable solution, and the first city tramway network was that installed by the American, Sprague, in Richmond, Virginia, in 1887. By 1900 almost all US horse tramways had been converted to electric traction, and European cities were not far behind. Siemens developed the bow collector as an alternative to the trolley pole, and this lead in turn to the pantograph which is most common today. Before the end of the century electric tramways had appeared around the world, in cities such as Kyoto, Japan; Bangkok, Thailand; and Melbourne, Australia. Tramways in Britain or with a British heritage usually used double-deck trams to maximise capacity. In continental Europe a single-deck tram towing a trailer was more common, while American systems soon progressed to larger trams mounted on two bogies.[1]

3 Tramway CITADIS

Alstom Citadis is a family of low-floor trams (trams) and light rail vehicles built by Alstom. In 2017, more than

2,300 Citadis trams have been sold and 1,800 trams are in commercial service worldwide, with operations on six inhabited continents. An evolution of Alstom’s first TFS vehicle, most Citadis vehicles are manufactured in Alstom’s factories in La Rochelle, Reichshoffen and Valenciennes, France, and in Barcelona, Spain and Annaba, Algeria and it consists of several families.

It is important to note that Citadis trams with their integral low floor and side doors will facilitate passenger movement and access for all, especially for people with reduced mobility. The trams are equipped with air conditioning, surveillance cameras and spaces for strollers and wheelchairs.[1]

3.1 Types of Citadis trams

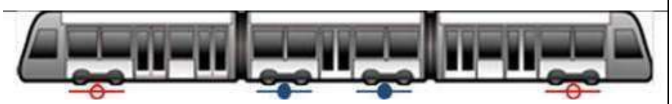
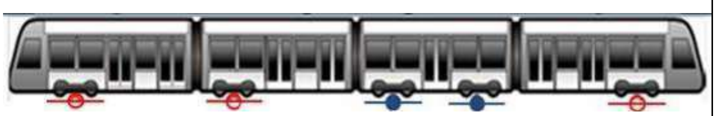
Model and some places installation	Architecture	Length
Citadis™ 202 (Melbourne)		20 m
Citadis™ 301 (Orleans, Dublin)		27 m
Citadis™ 302 (Adelaïde, Lyon, Bordeaux, Paris T2, Valenciennes, Rotterdam, Buenos Aires, Madrid, Melbourne, Nice, Murcia, Barcelone, Jérusalem, Toulouse)		33 m
Citadis™ 304		33 m
Citadis™ 401 (Montpellier, Dublin)		39 m
Citadis™ 402 (Bordeaux, Grenoble, Paris T3, Tours)		44 m
Citadis™ 404		43 m
Legend :	: motorized non-pivoting bogie . : motorized pivoting bogie. : carrier bogie (non-motorized) non-pivoting. : carrier bogie (non-motorized) pivoting.	

Table 1- 1Different trams in the Citadis™ range [2]

4 General organization

The Algerian metro corporation is organized as follows:

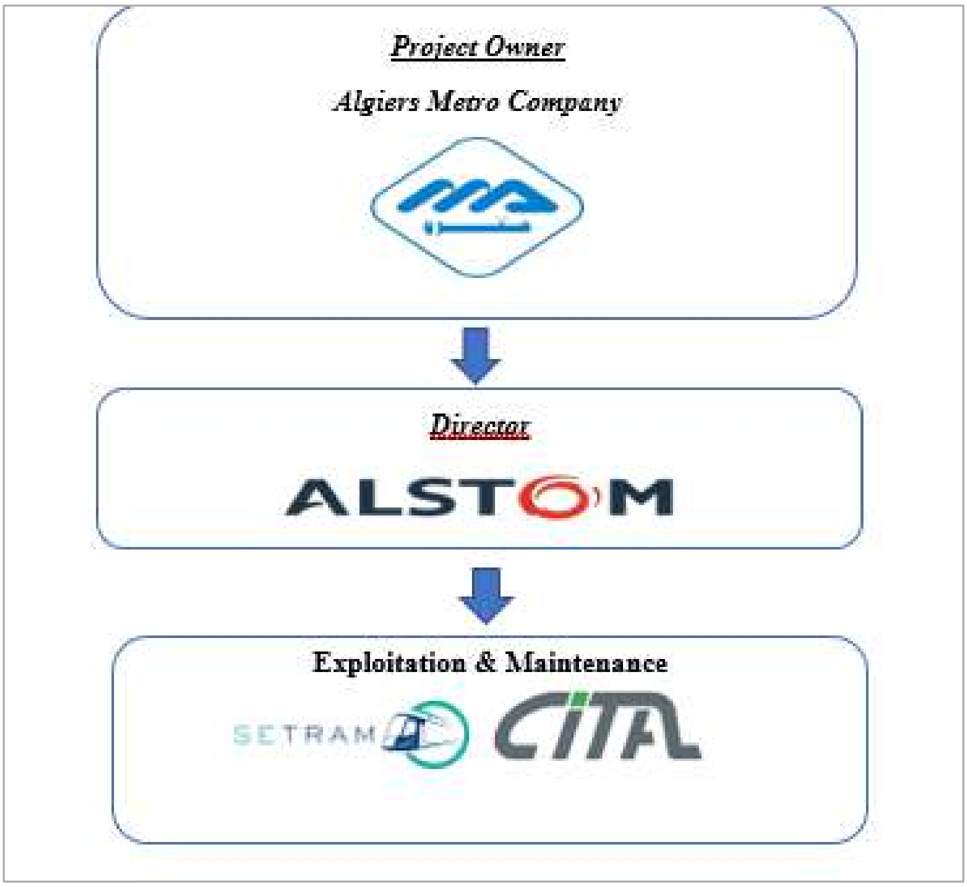


Figure 1- 1 The Algrian metro corporation organization

5 CITAL corporate description :

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

*CIT: means the abbreviation for "Citadine" (urban transport).

*AL: stands for "Algeria."

This railway transport maintenance company based in Algeria was created in 2010 and started its activities at the end of 2012, it is a company associated with the capital.

It has 6 maintenance sites: Algiers, Constantine, Oran, Setif, Ouargla and Sidi Bel-Abbas in addition to the tram assembly center in Annaba.[3]

5.1 History :

• 14 November 2010: Signing of the Framework Agreement and the Shareholders' Agreement

• 2011: Expansion of the Maintenance activity (Tram Algiers)

• 15 March 2011: Creation of CITAL unit for the assembly and maintenance of Citadis 302 and Citadis 402 tram sets

• 13 December 2012: Signing of the Rolling Stock Supply Programme (EMA) Contracts

• May 12, 2015: Inauguration of the Annaba plant.

• 10 April 2016: Signature of the framework agreement between Alsthom, Ferrovial, EMA and SNTF for the extension of CITAL's activities to the Cordai hybrid train family.

5.2 Ouargla site:

The Ouargla site is a centre for tram maintenance. This centre is located next to passenger transport station, on the road to Ghardaïa.

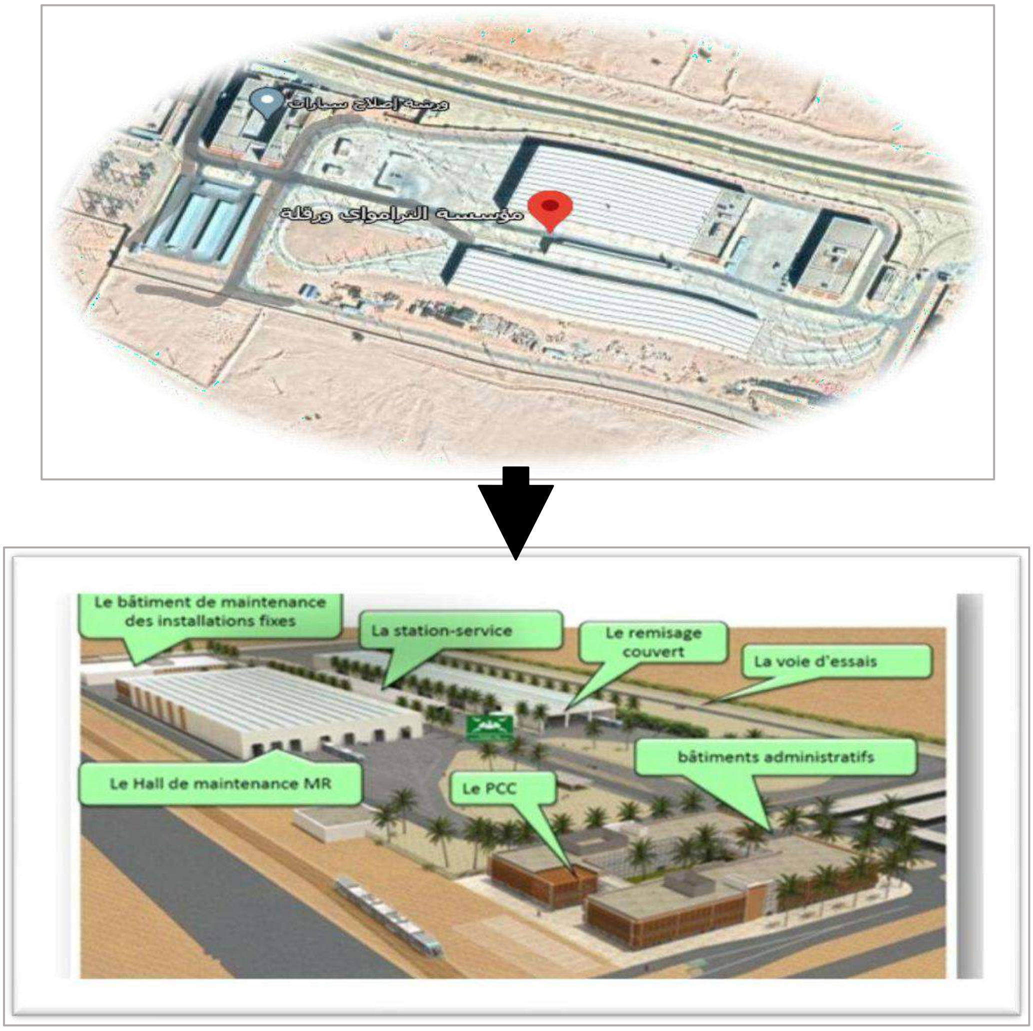


Figure 1- 2 Setram Ouargla location

5.2.1 Ouargla Site Organization Chart

We will explain the organizational structure of the CITAL company as following

CITAL SPA at the Ouargla site is responsible for performing the following maintenances [2]:

- Maintenance of rolling stock (Tramway)= MR
- Maintenance of industrial depot equipment = ED
- Infrastructure Maintenance = INFRA
    - Low Current (CFA)
    - High Current (CFO)
    - Overhead Contact Line (LAC)
- Servicing Rames and Depot = SERVICING

Below is the structure (organizational chart of the company):

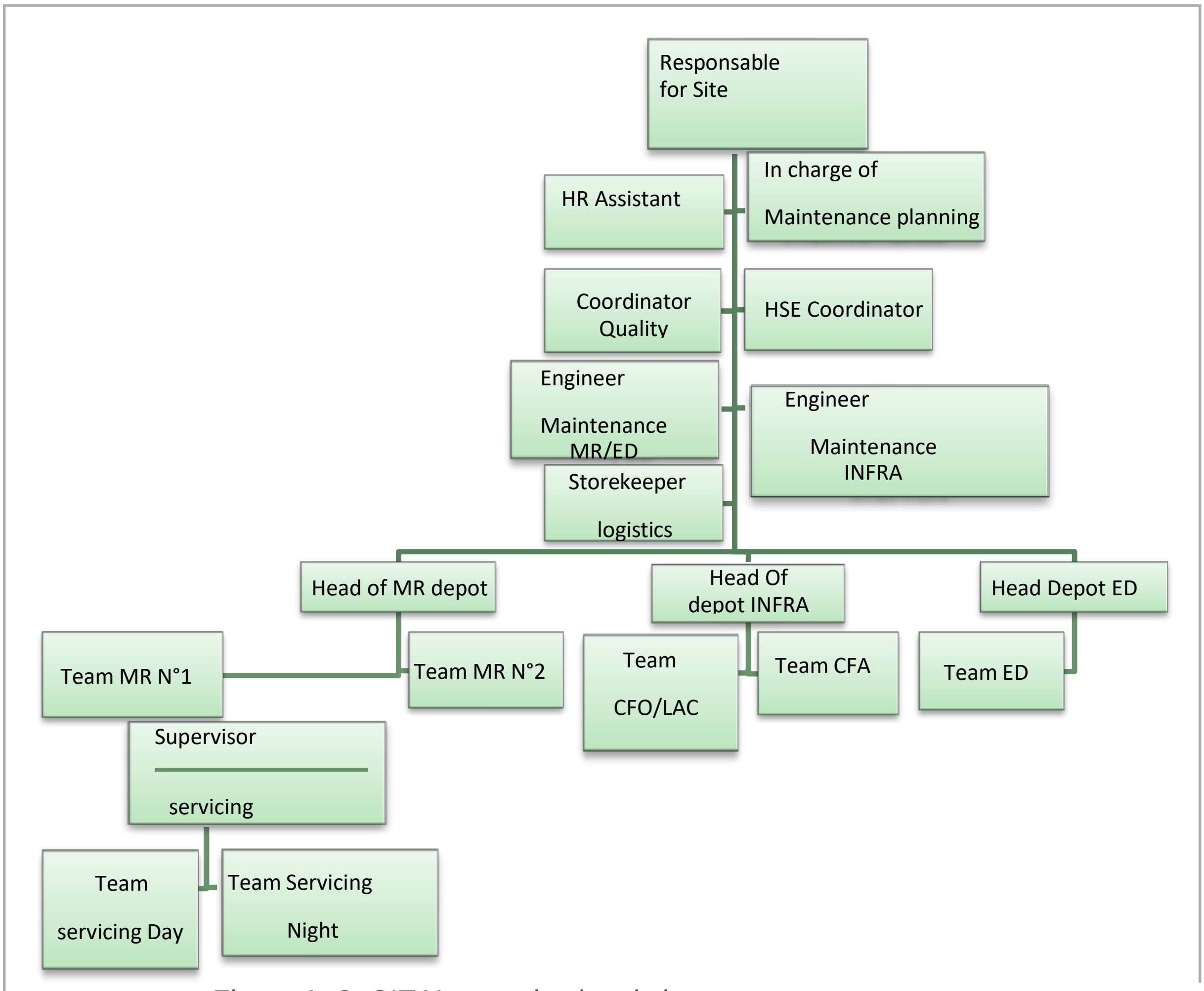


Figure 1- 3 CITAL organizational chart

5.3 Work Mode

- ❖ MR teams: MR teams are responsible for the maintenance of the trainsets (corrective maintenance, preventive maintenance) and are divided into two teams (morning and evening teams) each team is composed of a team leader and technicians.
- ❖ SERVICING teams are responsible for:
    - o Daily inspection and maintenance of trains after and before operation
    - o Internal and external cleaning of trains after operation
    - o Cleaning of premises (workshops and offices)
- ❖ The CFO/LAC team: consists of a team leader, a CFO/LAC engineer and the CFO technicians and the LAC technician. They work day and night depending on the maintenance performed.
- ❖ The CFA team: consists of a team leader, a CFA engineer and CFA technicians. They work day and night depending on the maintenance performed.
- ❖ The ED team: consists of a team leader and the ED technicians. they work only during the day.[4]

6 Conclusion

In this chapter we provided a brief of the Tram and gave an overview about CITADIS then CITAL's history, their Ouargla site and the internal organizational chart as well as the company's work mode.

CHAPTER 2:

Maintenance and Metrology Ensuring Precision and Performance

1 Introduction:

2 What is maintenance?

2.1 A little history about maintenance

The word "maintenance," derived from the Latin Manus and Tenere, first emerged in the French language in the 12 century, the etymologist WACE identified the maintainer form as the one that supports; it was first used in 1169.

Therefore, the Anglo-Saxon users of the term are later, in modern times, the word reappeared in the military vocabulary «keeping in combat units, personnel and equipment at constant levels», interesting definition, since the industry took it over by adapting it to the production units assigned to an "economic fight".

With the expansion of railways, vehicles, aviation, and munitions throughout the two world wars, the notion of maintenance is employed from 1900 to 1970.

Beginning in 1970, the advent of high-risk industries and contemporary instruments prompted the adoption of maintenance.[5]

2.2 The definition of maintenance:

According to the AFNOR definition, maintenance is intended to maintain or restore a property in a specified state so that it is able to provide a specific service. Maintenance thus gathers the actions of troubleshooting and repair, adjustment, revision, inspection and verification of hardware equipment (machines, vehicles, manufactured objects, etc.) or even intangible (software).[6]

All technical, administrative and management actions during the life cycle of a property, aimed at restoring it to a state in which it can perform the required function. (Norm AFNOR X 60- 010).[7]

and thus, the definition of maintenance exposes three ideas:

Maintain: which entails observation and monitoring;

Restore: it suggests the idea of fixing a flaw;

Optimal cost: This places a priority on economic efficiency in every operation. Therefore, a company's maintenance function has the responsibility to: ensure the most possible equipment availability at the highest possible performance while adhering to the budgetary constraints.

3 Maintenance methods:

Methods of the maintenance policy must be followed when choosing between different maintenance techniques, and the firm management must be in accord.

In addition to knowing the operation and characteristics of the equipment, the behavior of the equipment in operation, the conditions of application of each method, maintenance costs, and production loss costs, it is necessary to be informed about management objectives and maintenance policy decisions.

3.1 There are different types of maintenance:

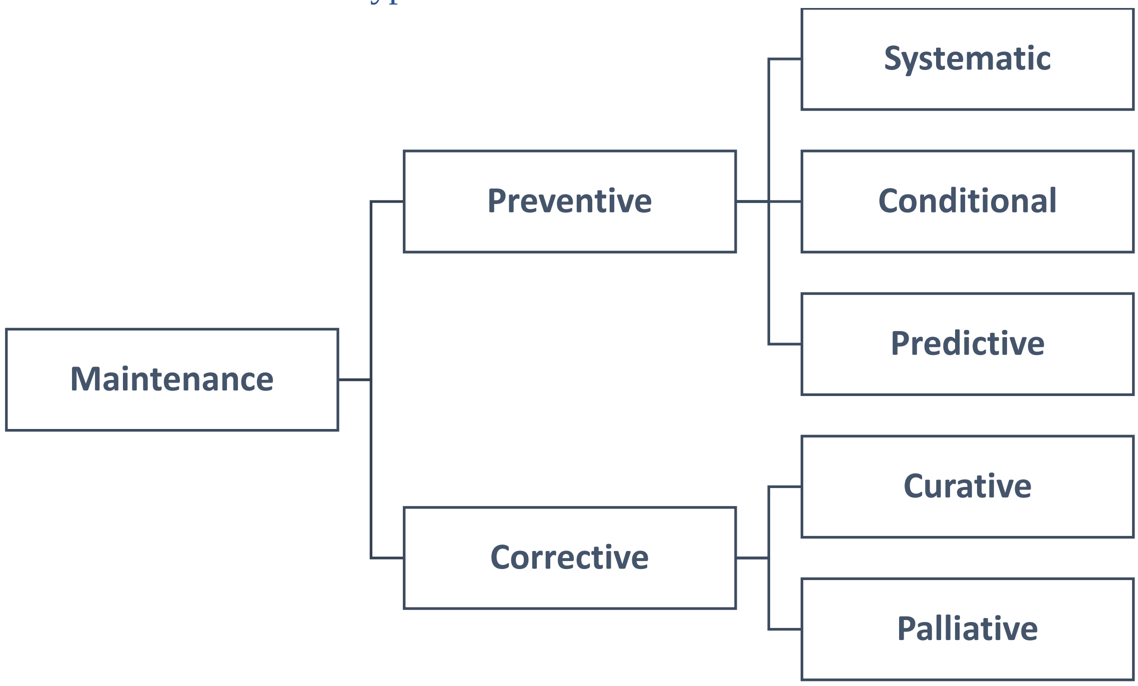


Figure 2- 1 Maintenance types

3.2 Corrective maintenance:

All actions taken to restore a property's ability to fulfill a necessary function, at least temporarily, once it has failed or lost its ability to do

These tasks include locating the problem and diagnosing it, restoring functionality with or without change and controlling it.[6]

3.2.1 Palliative maintenance:

consists of momentarily reducing the impact of a failure to permit the continued exploitation of the asset without addressing the underlying reasons. Almost usually, the action taken is a diagnostic one.

We are prompted to observe the repeat of the failure in issue and talk of repetitive failure if this maintenance is not accompanied by a substantial action aimed to address the fundamental cause.[7]

3.2.2 Curative maintenance:

Permanent improvements, alterations, or renovations are made. When the system is unavailable for serious implications or when there are few safety restrictions, this maintenance is employed.

3.3 Preventive maintenance:

Preventive maintenance works to lower the likelihood of failure. On the other hand, if the costs associated with performance loss are considerable and the costs of repair and inspection are comparably low to the former, then the cost should not be used as a criterion for evaluation.

Preventive maintenance can be Systematic, Conditional or Predictive.[7]

3.3.1 Systematic Maintenance:

Systematic maintenance is preventative maintenance that is carried out at regular periods. The maintenance procedure is carried out in accordance with a timetable, which was predetermined.

Nothing happens before the deadline that has been set.

The ideal way to optimize a systematic preventive maintenance program is to establish a maintenance schedule that considers time, the number of working cycles, and the production of components.[6]

3.3.2 Conditional Maintenance:

It is a preventative maintenance activity subject to a certain kind of event (self-diagnosis, sensor data, wear assessment, etc.).

The identification of weak areas is a defining feature of this methodology. Depending on the circumstances, it may be preferable to place them under observation. From there, we can opt to intervene when a certain threshold is achieved, but the controls must continue to be methodical.[6]

3.3.3 Predictive maintenance:

Predictive maintenance is preventative maintenance that is carried out based on an estimation of the right operating period left before the observation of the dreaded occurrence. Predictive maintenance can consider a hardware's age that is not always determined by a calendar, such as the running time since the previous inspection.[6]

3.4 The purpose of the preventive maintenance:

1. Increase the life of equipment

2. Reduce the likelihood of service failures
3. Reduce downtime in case of overhaul or failure
4. Prevent and also provide for costly corrective maintenance
5. Enable corrective maintenance to be decided under good conditions
6. Avoid abnormal consumption of energy, lubricant, etc.
7. Reduce maintenance budget
8. Eliminate causes of serious accidents.[7]

3.5 Preventive maintenance operations:

They can be grouped into 3 families: inspections, controls, visits. They make it possible to control the evolution of the real state of the material. They can be performed continuously or at intervals, predetermined or not, calculated on the time or the number of usage units.[7]

3.6 Corrective maintenance operations:

The operations of corrective maintenance result in 2 types of troubleshooting, repair interventions aimed at enabling a property to fully fulfill its required function.[7]

3.7 Advantages and Disadvantages of Preventive and Corrective Maintenance:

Although preventive maintenance carries a lot of advantage over corrective maintenance. However, it has certain drawbacks that should be reduced (see Table 2-1).

Table 2- 1: Advantages of Corrective and Preventive Maintenance

Corrective Maintenance	**Preventive Maintenance**
•Low maintenance cost	• Avoid major machine breakdowns by using well-thought-out maintenance techniques. • Reduce when it stops. • Preserve the integrity of the machine

Table 2- 2: Disadvantages of Corrective and Preventive Maintenance

Corrective Maintenance	**Preventive Maintenance**
• Significant repair cost. • Poor worker safety. • Important parts storage. • High repair time. • High production loss.	• Depending on the equipment purchased and the level of requirement desired, these • Techniques require a high level of staff training. This therefore implies freeing up training time and finding competent personnel, capable of adapting to the rapid changes in these techniques. • The big disadvantage is that the maintenance cost alot of money.

3.8 Purposes of maintenance:

- Increase the life of equipment.
- Decrease the probability of failures in service.
- Reduce downtime in the event of overhaul or breakdown.
- Prevent and also plan costly corrective maintenance interventions.
- Allow to decide the corrective maintenance in good conditions.
- Avoid abnormal consumption of energy, lubricant, etc.
- Improve the working conditions of production staff.
- Reduce the maintenance budget.
- Eliminate the causes of serious accidents.

3.9 Levels of maintenance:

The maintenance levels are defined according to the complicity of the works. AFNOR identifies 5 levels of maintenance [8].

Table 2- 3: the five levels of maintenance

Level	Types of work	Staff Concerned	Examples
1	Simple adjustments - no dismantling or opening	Operator of the property	Resetting a PLC after stopping Emergency
2	Troubleshooting by standard exchange - minor preventive maintenance operations	Authorized technician	Changing a relay - checking fuses - resetting of Circuit breaker
3	Identification and diagnosis of faults - repair by standard exchange - minor mechanical repairs - preventive maintenance (e.g. adjustment or realignment measuring devices)	Specialized technician	Identification of the faulty element, search for the cause, elimination of the cause, replacement
4	Major corrective or preventive maintenance work except renovation and reconstruction - adjustment of Measuring devices	Team with specialized technical supervision	Intervention on equipment whose return to service is subject to Qualification
5	Renovation - reconstruction - major repairs	Means close to manufacturing	Compliance according to regulations heavy equipment

3.10 Preventive rams Maintenance Plan:

In order to maintain and guarantee a longer service life and assure good performance to lower the percentage of breakdowns and, consequently, the reduction in costs, this scheme is used by a specialized team for vehicle maintenance at CITAL[4] (see Table 2.4).

Table 2- 4:Plan of rams maintenance

PV	Range of maintenance	index	Commentaries
PV15000 km	15000 km	A	Inspection and testing of pipe cabs Inspection roof inspection underframe inspection interior passenger rooms Checkout and inter-checkout inspection
PV30000 km	30000 km	B	
PV60000 km	60000 km	C	
PV120000 km	120000 km	D	
PV180000 km	180000 km	E	
PV300000 km	300000 km	F	
PV600000 km	600000 km	G	
RP25000 km	25000 km	RP	Reprofiling of wheels and suspensions adjustments

4 Metrology and Maintenance:

4.1 What is Metrology?

Metrology is the scientific study and practice of measurement. It involves the theoretical and practical aspects of measurement, including the development of measurement standards, techniques, and instruments. Metrology plays a crucial role in ensuring accuracy, consistency, and reliability in various fields such as manufacturing, engineering, science, and commerce. The goal of metrology is to establish a reliable and consistent system of measurement, enabling precise and accurate comparisons of quantities. This involves defining measurement units, creating reference standards, developing calibration procedures, and establishing traceability to recognized measurement standards. Metrology covers a wide range of measurements, including length, time, mass, temperature, pressure, electrical quantities, and more. It encompasses both fundamental aspects of measurement theory and practical applications in various industries. Accurate and traceable measurements are essential for quality control, product development, scientific research, and international trade. National and international organizations, such as the International Bureau of Weights and Measures (BIPM) and national metrology institutes, work together to maintain measurement standards and promote consistency in metrology practices globally.[9]

4.2 Types of metrology:

4.2.1 Industrial Metrology:

Industrial metrology's purpose is to ensure that instruments, used in a wide variety of industries, are functioning properly. An example of this type of metrology might be seen in the production of products for the commercial industry, the testing and designing of aircraft, the functioning of large machinery, or even in factories using rotating equipment during the manufacturing of their products.[10]

4.2.2 Scientific metrology :

Scientific metrology is concerned with the establishment of units of measurement, the development of new measurement methods, the realization of measurement standards, and the transfer of traceability from these standards to users in a society. This type of metrology is considered the top level of metrology which strives for the highest degree of accuracy. The BIPM maintains a database of the metrological calibration and measurement capabilities of institutes around the world. These institutes, whose activities are peer-reviewed, provide the fundamental reference points for metrological traceability. In the area of measurement, BIPM has identified nine metrology areas, which are acoustics, electricity and magnetism, length, mass and related quantities, photometry and radiometry, ionizing radiation, time and frequency, thermometry, and chemistry. As of May 2019, no physical objects define the base units. The motivation in the change of the base units is to make the entire system derivable from physical constants, which required the removal of the prototype kilogram as it is the last artefact the unit definitions depend on. Scientific metrology plays an important role in this redefinition of the units as precise measurements of the physical constants is required to have accurate definitions of the base units. To redefine the value of a kilogram without an artefact the value of the Planck constant must be known to twenty parts per billion. Scientific metrology, through the development of the Kibble balance and the Avogadro project, has produced a value of Planck constant with low enough uncertainty to allow for a redefinition of the kilogram.

4.2.3 Legal Metrology:

Legal metrology refers to the branch of metrology that deals with the regulatory and legal aspects of measurements and weighing instruments used in trade, commerce, and public transactions. It ensures the accuracy, fairness, and transparency of measurements to protect consumers, facilitate fair trade, and maintain trust in commercial transactions. Legal metrology establishes and enforces regulations, standards, and procedures for measurements and weighing instruments to ensure compliance with laws and regulations.

5 The role of Metrology in Maintenance:

5.1 Measurement is everywhere:

In everyday life, we all depend on reliable measurements which underpin:

In the field of maintenance, metrology plays a crucial role in ensuring the accuracy and reliability of measurement and testing instruments used for maintenance activities. Here are some specific roles of metrology in maintenance.

5.2 Calibration:

Metrology is involved in the calibration of measurement instruments used in maintenance tasks. Calibration verifies the accuracy and reliability of instruments by comparing their measurements to traceable standards. Properly calibrated instruments ensure that maintenance activities are performed with precision and consistency.

Figure 2- 2 Benefits of calibration

5.3 Measurement Assurance:

Metrology provides a framework for ensuring the quality and reliability of measurements taken during maintenance procedures. This involves establishing measurement procedures, selecting appropriate instruments, and verifying the accuracy of the results. Accurate measurements enable maintenance technicians to assess equipment conditions, identify faults, and make informed decisions regarding repairs or replacements.

5.4 Equipment Verification:

Metrology helps in verifying the accuracy and functionality of maintenance equipment such as pressure gauges, temperature sensors, flow meters, and electrical measuring devices. By regularly checking and validating these instruments, maintenance personnel can ensure their proper functioning and reliability during critical tasks.

Figure 2- 3 : Equipment calibration

5.5 Compliance with Standards:

Metrology ensures that maintenance activities comply with relevant standards and regulations. This includes adherence to measurement standards, calibration procedures, and documentation requirements. Compliance with standards promotes: consistency, accuracy, and reliability in maintenance operations.

Metrology techniques and instruments, such as vibration analysis, thermography, and dimensional metrology, are used in maintenance for troubleshooting and fault diagnosis. These techniques provide valuable insights into the performance and condition of machinery and help identify potential issues before they lead to equipment failure or downtime.

5.6 Quality Control:

Metrology supports maintenance departments in implementing quality control measures. By accurately measuring critical parameters and comparing them to specified tolerances, maintenance professionals can ensure that equipment and systems meet performance standards. This helps prevent failures, optimize maintenance schedules, and improve overall operational efficiency.

6 Conclusion :

metrology in maintenance ensures accurate measurements, instrument calibration, compliance with standards, reliable equipment performance, and effective troubleshooting. These aspects contribute to the overall reliability, safety, and cost-effectiveness of maintenance operations.

CHAPTER 3

TRAMWHEELS MAINTENANCE: THE WHEELREPROFILING MACHINE RNG20

1 Introduction

We provided a brief definition of the tram before, and in this chapter, we'll focus on the tram's wheels, one of its most crucial components.

As a result of the daily exploitation of the tram, the surface of the tram wheels is impacted by friction, corrosion, cracks, and strains, which negatively affects wheel performance and raises the risk of accidents due to brake issues, auxiliary friction, or wheels pulling away from the rail.

Periodic maintenance and ongoing attention are necessary to preserve the performance of tramway wheels. Wheels need to be cleaned and checked frequently using the RNG 20 (WHEEL REPROFILING MACHINE) as part of preventive maintenance.

2 Shape and characteristics of the wheel

Tram wheels are essential components that contribute to the movement and stability of tram cars on railway tracks. They are typically made of corrosion-resistant steel and feature a circular design with a large diameter. Careful shaping is employed to achieve precise form and optimal balance, ensuring stability and smooth performance. Regular maintenance is required to inspect for deformities, monitor wear and tear, and adjust side pressure to ensure safety and longevity. Tram wheels play a critical role in providing safe and efficient transportation for passengers on railway tracks.[11]

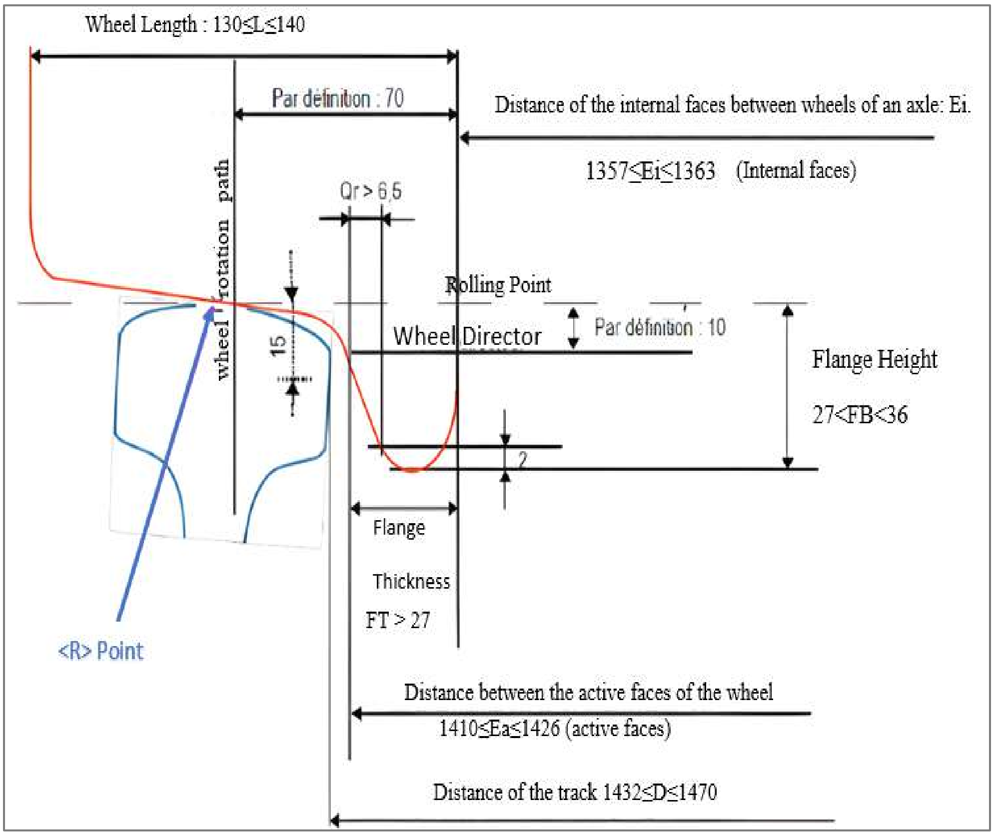


Figure 3- 1 specific dimension of the tram wheel [12]

Figure 3- 2 Tram wheel on rail

Figure 3- 3 Alstom Package of Tram Wheels

3 The wheel reprofiling machine RNG20

The reprofiling machine RNG20* is intended to equip the Maintenance Center for the first tramway line in Ouargla (Algeria).

It is designed and manufactured to carry out the reprofiling of the wheels with tires of ALSTOM trams of the CITADIS type (motor bogies and carriers ARPEGE 350) without the need to dismantle the wheels.

Figure 3- 4 Wheel Reprofiling Machine RNG 20 (not installed) [13]

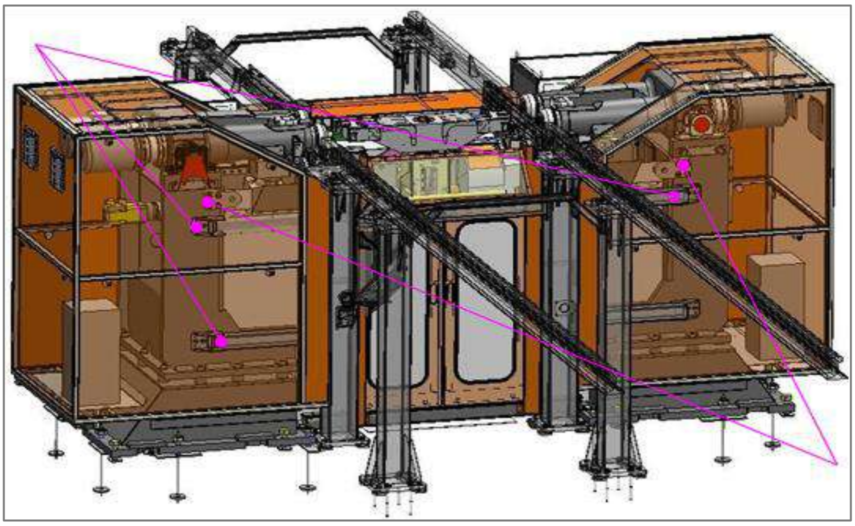


Figure 3- 5 Schematic diagram of the machine RNG20[12]

3.1 Explanation of the term "RNG20"

"R" for Reprofiling.

"NG" for New Generation.

"20" for 20 tons at the axle.[12]

4 Components of the RNG20[12]:

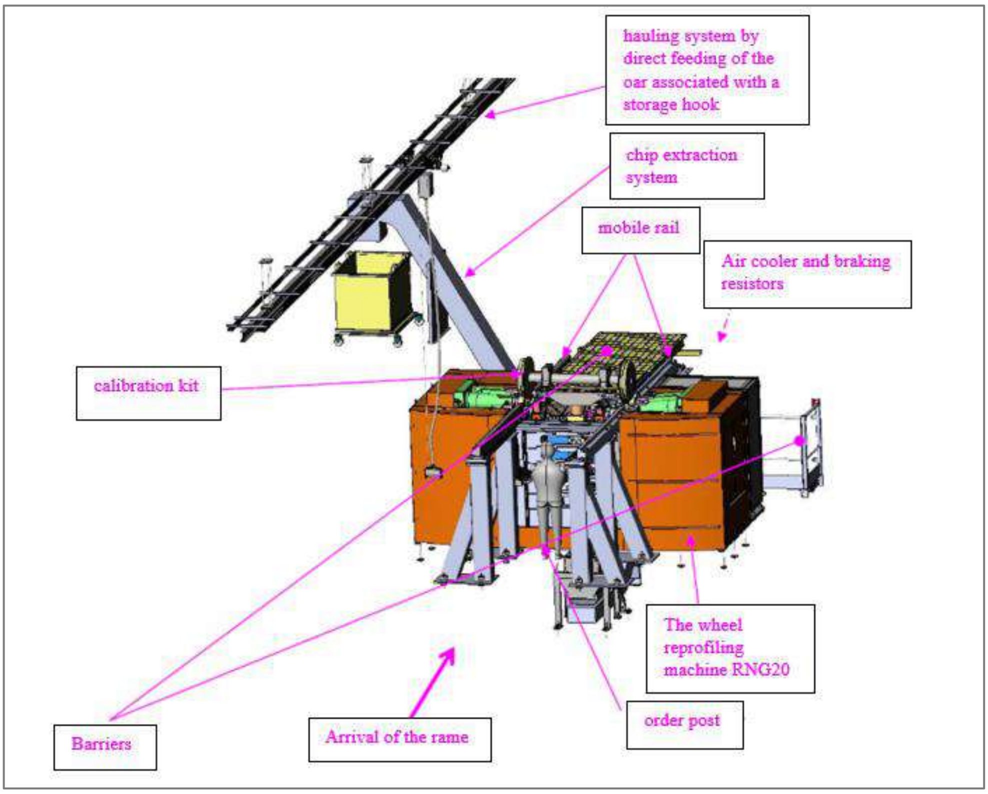


Figure 3- 6 : front side of RNG20

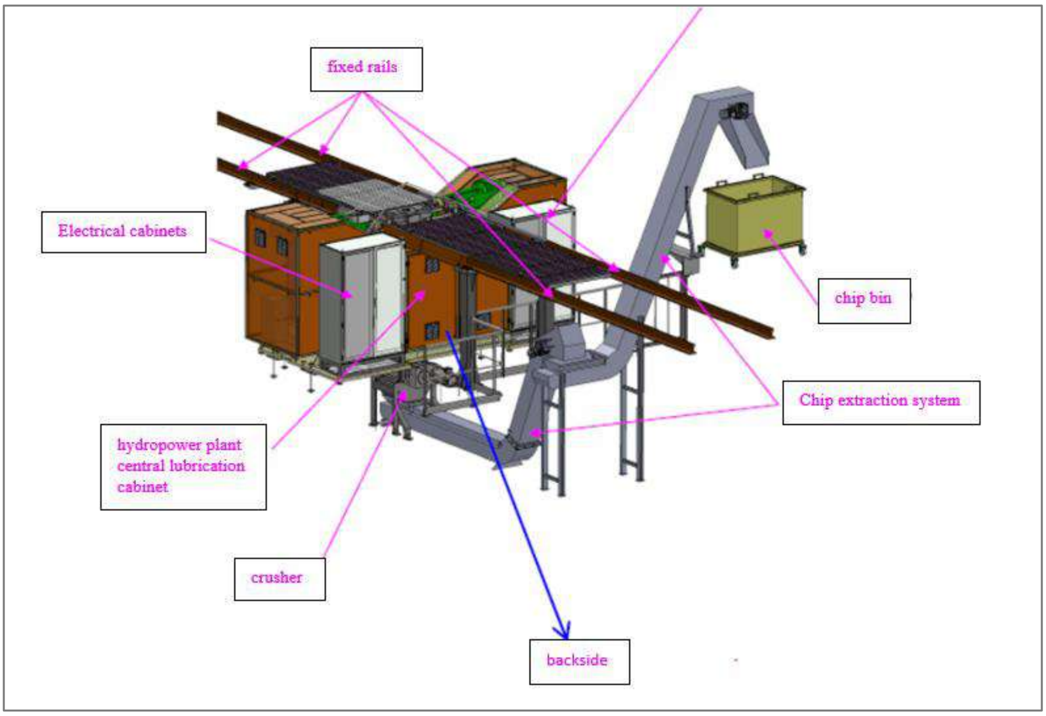


Figure 3- 7:back face of RNG20

The RNG20 includes the following equipment:

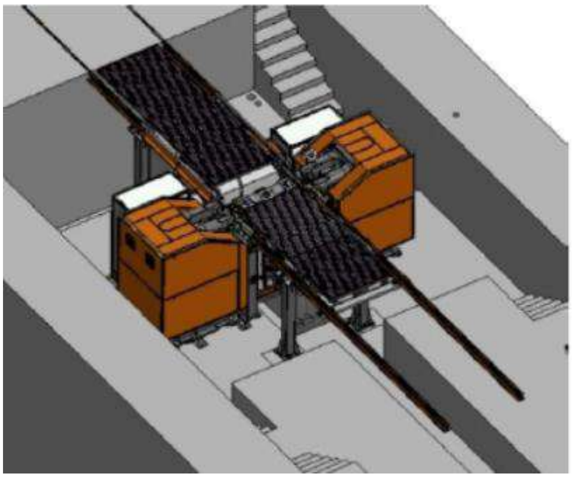


Figure 3- 8:3D render of RNG20

4.1 1 base attached to the bottom of the pit supporting the entire machine

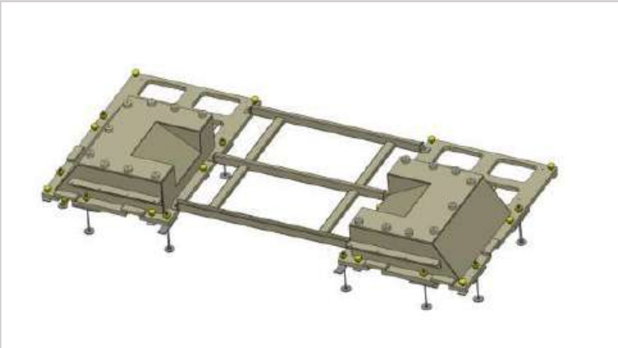


Figure 3- 9:Base support

4.2 2 side buildings supporting each

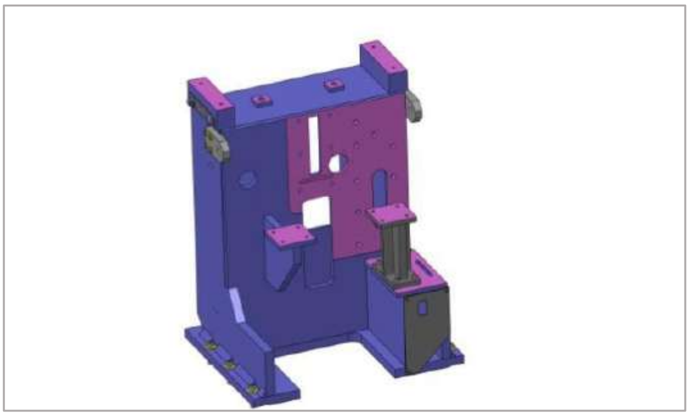


Figure 3- 10:Side support

4.3 1 machine wheel trainer arm with 1 anti-skating system

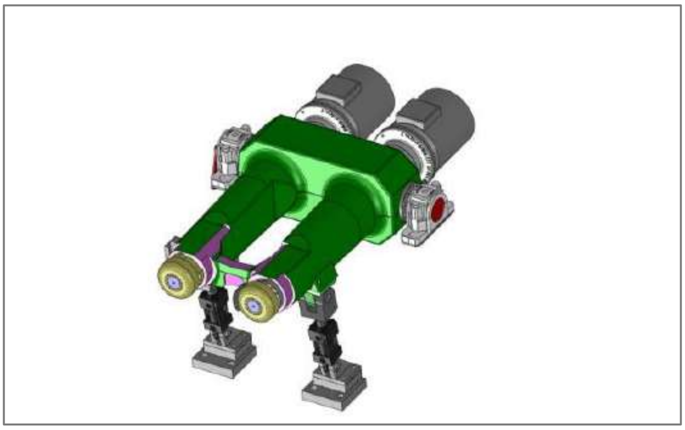


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Figure 3- 11:machine wheel trainer arm

4.4 1 Transversal advance system

Figure 3- 12:Transversal advance system

4.5 1 bar connecting the 2 previous buildings and supporting

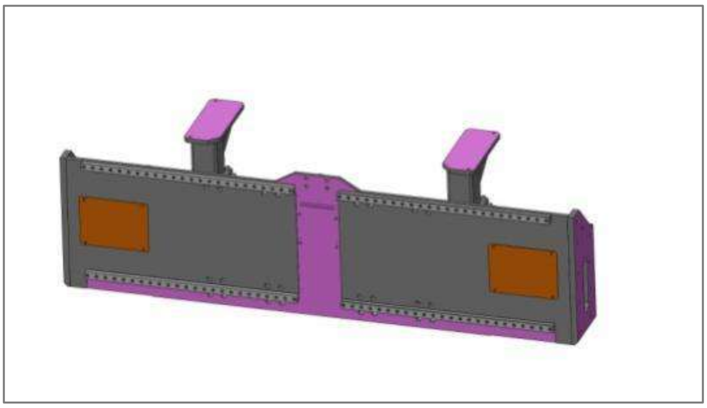

Figure 3- 13:Connection bar

4.6 1 internal pillar cutting system combined with 1 bridging system to increase the cutting section

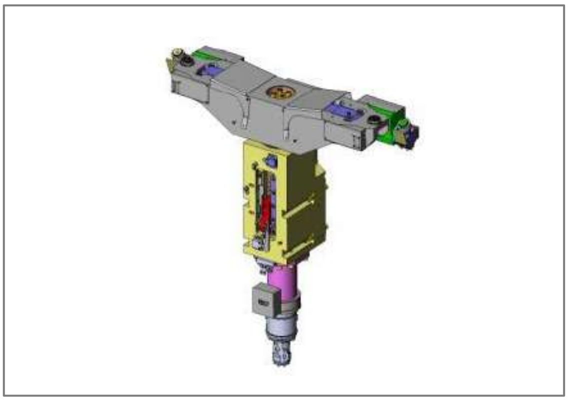

Figure 3- 14:internel pillar

4.7 2 Lateral guidances

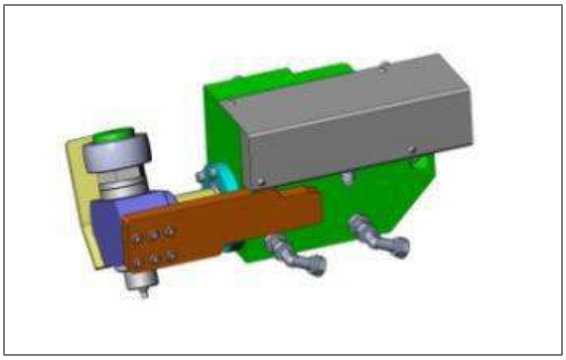

Figure 3- 15:lateral guidance

4.8 2 vertical forwards of the tool carrier (1 per carrier)

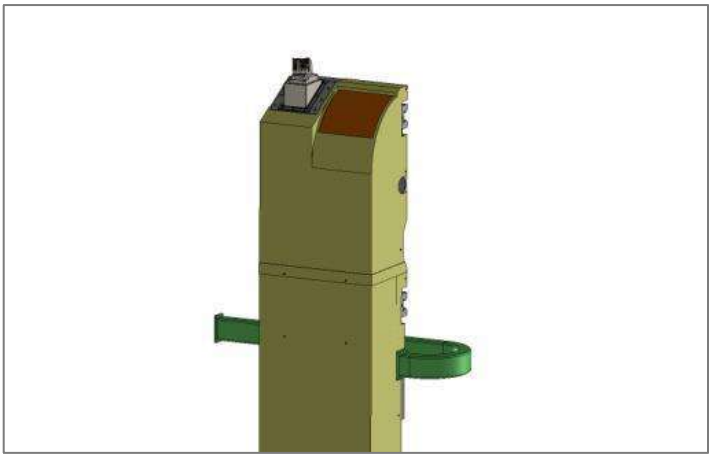

Figure 3- 16:Consisting set

4.9 2 heads of measurement (1 per chariot)

Figure 3- 17:Tool carrier

4.10 2 mobile rail systems associated with support pillars

Figure 3- 18:mobile rail

-1 set of machine and operator protection carters.

-1 straw for quick evacuation to a crusher.
-1 automatic and centralized lubrication unit in a side wardrobe.
-1 unit of pneumatic power.
-1 hydraulic power center on the back of the tower.
-Electric cabinets at the back of the tower and a box of braking resistance of the hallway.

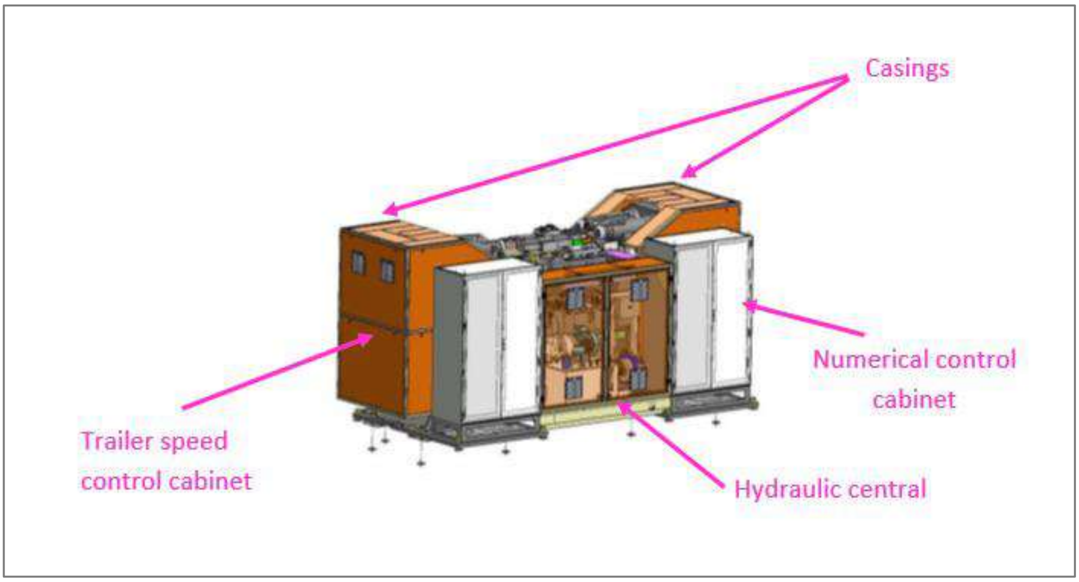

Figure 3- 19:back side of RNG20 with no chip extraction system

Figure 3- 20:eletrical cabinet

- 1 computer-controlled (PC) control console with 1 remote CNC control

(SIEMENS 840D SL). This set includes, among other things, all the parameters of the wheel profiles to be machined, machining by economic profile, self-diagnosis for the management of defects and failures, etc.

Figure 3- 21:Interface human-machine

- 1 hauling system by direct feeding of the oar associated with a storage hook, a Console a in the pit (console hauling described above), a kit of visual and audible warning (located upstream of the pit), a desk at the high level.

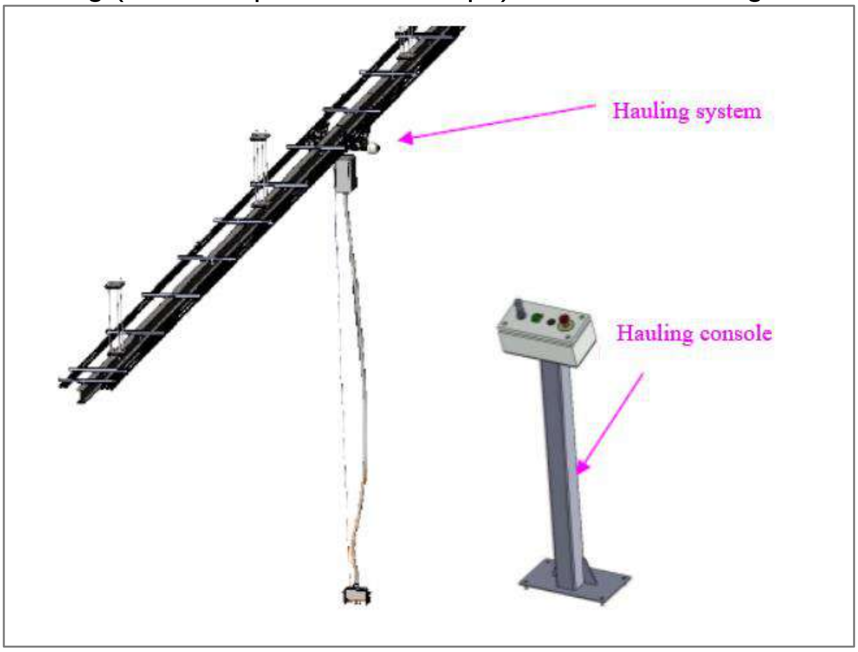

Figure 3- 22:hauling system

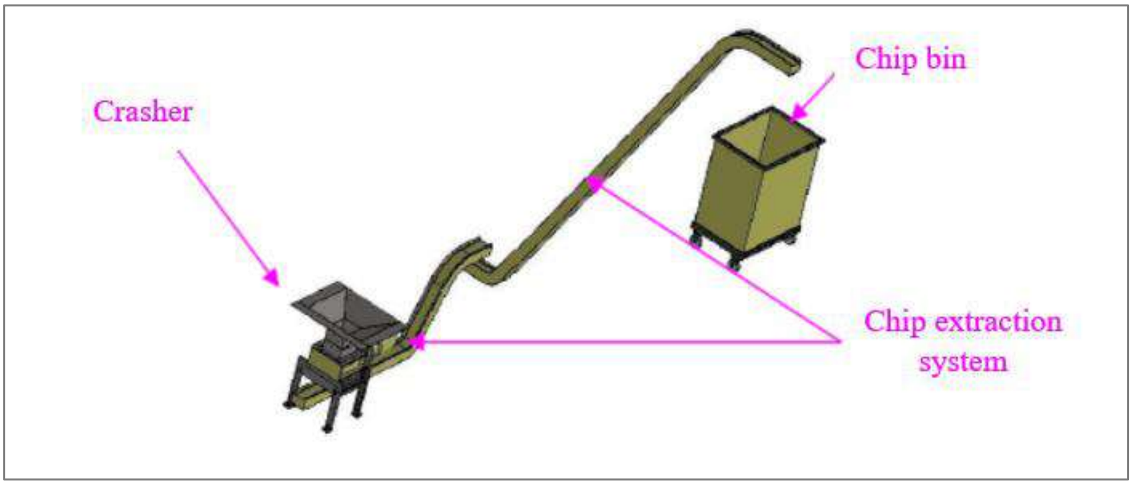

Figure 3- 23:Chip extraction system

1 calibration kits, including:
o 1 standard axle,
o 2 profile control templates,

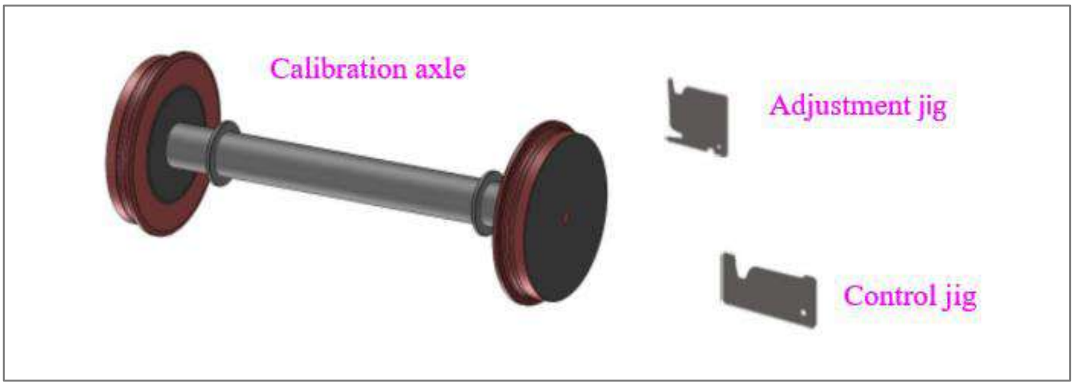

Figure 3- 24:calibration kits

5 The process of reprofiling a tram wheel using the RNG*20[12]

The purpose is to describe, the process followed for the reprofiling of the wheels of a tram set

This cycle follows the following sequences:

1. The operator activates the towing function from the control console located in the pit
2. Operator brings rolling stock into the building on dedicated track
3. The operator stops the tram set at the specified stopping point
4. The operator unprepares the train set by folding the pantograph so that the tram set is no longer powered by the LAC, which makes train set work in battery mode.
5. The operator leaves the tram set and closes the doors
6. The operator sets up and stabilizes the mobile platform in the vicinity of the roof hatch protecting the Stinger connection
7. The operator takes the Stinger plug and climbs into the platform.
8. The operator opens the tram hatch and connects the stinger to the train
9. The operator descends from the platform and puts the platform in its storage location.
10. The operator sits in front of the high-level towing (l'halage) console.
11. The operator moves the tram forward until the axle to be reprofiled is on the turn in the machining position (at the end o, the wheels roll on their flanges ensuring the reference of the axle on the horizontal plane) in way of the drive roller arms. Before that, he prepares the tram in the prefosse.
12. After positioning, the operator moves to the front of the machine and now uses the control console.
13. Operator switches off the towing function allowing the operation of the lathe (towing is no longer allowed).
14. The operator then starts the automatic machining program:
    -The drive rollers of the arms are put in contact with the 2 wheels of the axle without taking them off the track in order to refocus the bogie in the machine axis.
    -The internal pillar comes in contact with the bogie (detection of the position made electrically).

Figure 3- 25:Internal pillar

-Then the arms lift the axle so that the wheels are off the rail so that the moving rails can retract
-Arms lower the axle so that the bogie comes back into contact with the internal pillar.

Figure 3- 26 : machine wheel trainer arm rolling the wheel

-The automatic cycle stops so that the operator places the bogie locking screws on the internal pillar.

Figure 3- 27 : the flash paper to count the cycles number

-After the operator order, the clamping (locking of the previous screws) is done automatically

-The arm drive rollers return to contact on the wheels and exert the stress required for machining.

Figure 3- 28.The arm drive rollers contact on the wheels

-Rotation of the axle with installation of the lateral guides then stop the rotation (The horizontal reference of the axle is then perfectly defined) Measurement of the diameter and profile.
-Diameter and profile measurement.

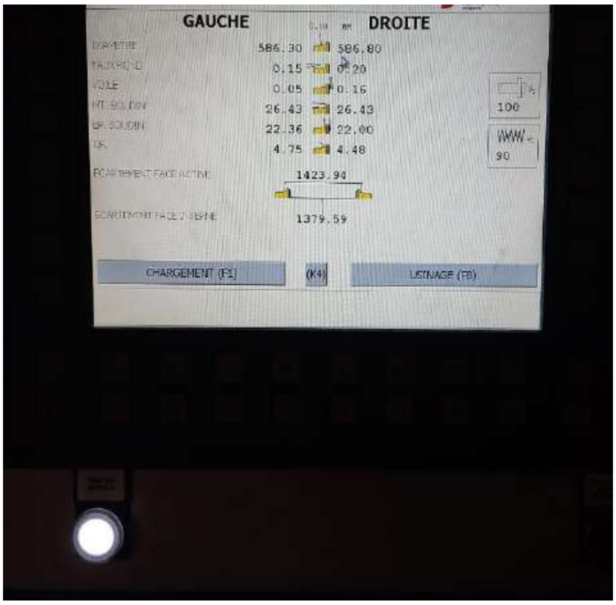

Figure 3- 29 : First measurement

-Machine proposal of machining parameters (most economical machining profile with minimum R-point pass depth) that the operator must validate or modify before proceeding to the next step

Figure 3- 30 : Reprofiling the wheel

-Machining is done.

-A new campaign of diameter and profile measurements and perform (identical to the one before machining). The operator can possibly return to the sequence before machining or continue the cycle.

Figure 3- 31 : table of the wheel standards dimensions

-Removal of side guides.
-Complete descent of the arms to release the wheels.
-Clearing the bogie.
-Manual removal of bogie clamping screws after cycle interruption.
-After operator order, arms lift truck over track.
-Reinstallation of the mobile rail to ensure track continuity.
-Lowering the internal pillar.
-Lowering the arms to put the wheels in contact with the track End of automatic cycle.

After putting the haulage function back into operation, we return to the haulage phase for the next axle and so on until the last axle to be reprofiled from the train.

15. When all the wheels of the trainset intended for reprofiling have been reprofiled, the operator returns the hauling function again.
16. Operator re-installs in front of towing console at high level.
17. The operator pushes the train back to the position at the beginning of the process while performing the operations related to the reprofiling on the tram in the prefosse.
18. The operator sets up and stabilizes the mobile platform in the vicinity of the Stinger connected plug on the tram.
19. The operator closes the tram hatch.
20. The operator exits the platform and hangs the Stinger plug at its storage location.
21. Operator puts the platform in its storage location.
22. The operator enters the train after opening the doors.
23. The operator prepares the trainset by unfolding the pantograph so that the trainset supplied by the LAC.
24. The tram set has exited the building and is placed in a garage.

Table 3- 1 Wheel Dimensions Before Reprofiling [12]

Diameter	Left wheel	Right wheel	The standards
Diameter	586.30	586.80	Between 530 and 610
out of roundness	0.15	0.20	Between 0.3 and 1.5
flange height	26.43	26.43	Between 25.5 and 27.5
flange thickness	26.43	22.00	Between 17 and 22.2
flange gradient	4.75	4.48	Between 2.5 and 5.5
distance of the track	1379.59		Between 1378 and 1381
distance between active faces	1423.94		Between 1417 and 1426

Diameter	Left wheel	Right wheel	The standards
Diameter	585.67	585.88	Between 530 and 610
out of roundness	0.09	0.12	Between 0.3 and 1.5
flange height	25.51	25.58	Between 25.5 and 27.5
flange thickness	22.23	21.84	Between 17 and 22.2
flange gradient Qr	4.69	4.76	Between 2.5 and 5.5
distance of the track	1379.82		Between 1378 and 1381
distance between active faces	1423.89		Between 1417 and 1426

Table 3- 2 Wheel Dimensions After Reprofiling

6 Results commentary

After reprofiling the wheel through machining, we compare the measurements of the reprofiled wheel with the recommended rib measurements at the exit of the machine, using standardized values from the table. This comparison ensures that the reprofiled wheel meets the standard measurements, indicating its readiness for reuse. If the measurements do not meet the required standards, we repeat the machining process until the desired values and measurements are achieved.

7 Conclusion

In conclusion, the tram wheel reprofiling machine (RNG 20) is a valuable tool in the maintenance of tramway systems. Its purpose is to facilitate the reprofiling of tram wheels without the need for wheel dismantling. By utilizing this specialized equipment, tram operators can effectively address issues such as wear, irregularities, and damage on the wheel surface. Regular and preventive use of the RNG 20 contributes to preserving the performance and safety of tramway wheels, ensuring smooth and efficient operation while minimizing the risk of accidents. The implementation of advanced technologies like the RNG 20 underscores the commitment to maintaining the integrity and reliability of tramway systems.

8 General conclusion

Transportation plays a pivotal role in our daily lives, catering to our need for movement and facilitating efficient mobility. Amidst the vast array of transportation options, tramway systems have emerged as a crucial element of urban transport networks. Operating on dedicated rail lines, trams offer passengers a unique blend of convenience, comfort, and well-being, thanks to the integration of advanced equipment and sophisticated systems.

However, ensuring the reliability and longevity of tramway systems necessitates the implementation of proper maintenance practices. Within the realm of maintenance, preventive measures assume a strategic role, enabling the seamless operation of production instruments. This field is characterized by constant evolution, driven by technological advancements, the emergence of innovative management techniques, and the ongoing pursuit of reducing production costs. Modern maintenance practices extend beyond mere repairs, encompassing the achievement of metrology standards by proactively anticipating and preventing failures.

Within the domain of tramway maintenance, special attention must be devoted to the wheels, a critical and highly significant component. The daily utilization of trams exposes their wheels to the effects of friction, corrosion, cracks, and strains, which can significantly compromise their performance. Such issues pose potential risks, including brake malfunctions, auxiliary friction, or wheels disengaging from the rail, thereby jeopardizing passenger safety and operational efficiency. To mitigate these risks and ensure optimal performance, regular maintenance and vigilant inspections are indispensable for preserving the integrity of tramway wheels. Thorough cleaning and comprehensive assessments are imperative to promptly identify and address any anomalies.

An invaluable tool in the arsenal of preventive maintenance is the RNG 20, also known as the Wheel Reprofiling Machine. This specialized equipment plays a crucial role in maintaining the correct wheel profile, rectifying any irregularities, and restoring optimal functionality. By employing the RNG 20, tram operators can effectively address wear, irregularities, and surface damage on the wheels without the need for wheel dismantling. Regular and preventive use of this advanced technology significantly contributes to the preservation of tramway wheel performance and safety, ensuring smooth and efficient operations while minimizing the risk of accidents.

The deployment of advanced maintenance technologies like the RNG 20 underscores a steadfast commitment to upholding the integrity and reliability of tramway systems. By embracing comprehensive maintenance practices, tram operators can optimize the overall effectiveness and longevity of their networks, ensuring the continued provision of safe and efficient transportation services to passengers.

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10 Abstract

Transportation is an essential part of our daily lives, providing the necessary means for movement and efficient mobility. Tramway systems have become vital components of urban transport networks, offering passengers convenience, comfort, and well-being due to their advanced equipment and sophisticated systems. However, maintaining the reliability and longevity of tramway systems requires the implementation of proper maintenance practices. Preventive maintenance plays a crucial role in ensuring seamless operations and involve anticipating and preventing failures rather than just repairs. In the field of maintenance, metrology plays a crucial role in ensuring the accuracy and reliability of measurement and calibrating instruments used for maintenance activities. Tramway wheels, being critical components, require special attention due to the daily wear and tear they endure, which can compromise performance and pose safety risks. Regular maintenance, thorough cleaning, and comprehensive inspections are necessary to identify and address any issues promptly. The RNG 20, also known as the Wheel Reprofiling Machine, is a valuable tool in preventive maintenance. It maintains the correct wheel profile, rectifies irregularities, and restores optimal functionality without dismantling the wheels. The use of advanced maintenance technologies like the RNG 20 demonstrates a commitment to maintaining tramway system integrity and reliability. By embracing comprehensive maintenance practices, tram operators can optimize network effectiveness, ensure passenger safety, and provide efficient transportation services.
Key words: Tramway, Preventive maintenance, Preventing Failures, Metrology, Calibrating, Tramway Wheels, RNG20.

Resumé

Le transport est une partie essentielle de notre vie quotidienne, fournissant les moyens nécessaires pour se déplacer et assurer une mobilité efficace. Les systèmes de tramway sont devenus des composants essentiels des réseaux de transport urbain, offrant aux passagers praticité, confort et bien-être grâce à leurs équipements avancés et leurs systèmes sophistiqués. Cependant, maintenir la fiabilité et la durabilité des systèmes de tramway nécessite la mise en œuvre de bonnes pratiques de maintenance. La maintenance préventive joue un rôle crucial en assurant des opérations fluides et en anticipant et en prévenant les pannes plutôt qu'en se limitant aux réparations. Dans le domaine de la maintenance, la métrologie joue un rôle crucial en garantissant l'exactitude et la fiabilité des instruments de mesure et d'étalonnage utilisés pour les activités de maintenance. Les roues de tramway, en tant que composants critiques, nécessitent une attention particulière en raison de l'usure quotidienne qu'elles subissent, ce qui peut compromettre les performances et présenter des risques pour la sécurité. Une maintenance régulière, un nettoyage approfondi et des inspections complètes sont nécessaires pour identifier et résoudre rapidement tout problème. Le RNG 20, également connu sous le nom de machine de reprofilage de roues, est un outil précieux dans la maintenance préventive. Il maintient le profil correct des roues, rectifie les irrégularités et restaure une fonctionnalité optimale sans démontage des roues. L'utilisation de technologies de maintenance avancées telles que le RNG 20 démontre un engagement envers

l'intégrité et la fiabilité du système de tramway. En adoptant des pratiques de maintenance complètes, les opérateurs de tramway peuvent optimiser l'efficacité du réseau, garantir la sécurité des passagers et fournir des services de transport efficaces.
Mots clés: Tramway, Maintenance préventive, Prévention des pannes, Métrologie, Calibrage-Etallonage, Roues de tramway, RNG20.

ملخص

يعد النقل جزءًا أساسيًا من حياتنا اليومية، حيث يوفر الوسائل اللازمة للحركة والتنقل الفعال. أصبحت أنظمة الترام من المكونات الحيوية لشبكات النقل الحضري، مما يوفر للركاب الراحة والراحة والرفاهية بسبب معداتهم المتطورة وأنظمتهم المتطورة. ومع ذلك، فإن الحفاظ على موثوقية وطول عمر أنظمة الترام يتطلب تنفيذ ممارسات الصيانة المناسبة. تلعب الصيانة الوقائية دورًا حاسمًا في ضمان عمليات سلسة وتتضمن توقع الأعطال ومنعها بدلاً من مجرد الإصلاحات. في مجال الصيانة، تلعب المقاييس دورًا مهمًا في ضمان دقة وموثوقية أدوات القياس والمعايرة المستخدمة في أنشطة الصيانة. تتطلب عجلات الترام، لكونها مكونات مهمة، اهتمامًا خاصًا بسبب التآكل والتلف اليومي الذي تتحمله، مما قد يضر بالأداء ويشكل مخاطر على السلامة. الصيانة الدورية والتنظيف الشامل والتفتيش الشامل ضرورية لتحديد ومعالجة أي مشاكل على الفور. تعتبر RNG 20 ، المعروفة أيضًا باسم آلة إعادة تشكيل العجلات، أداة قيمة في الصيانة الوقائية. يحافظ على الشكل الصحيح للعجلة، ويصحح المخالفات، ويعيد الأداء الوظيفي الأمثل دون تفكيك العجلات. يوضح استخدام تقنيات الصيانة المتقدمة مثل RNG 20 الالتزام بالحفاظ على سلامة نظام الترام وموثوقيته. من خلال تبني ممارسات الصيانة الشاملة، يمكن لمشغلي الترام تحسين فعالية الشبكة، وضمان سلامة الركاب، وتقديم خدمات نقل فعالة.

الكلمات المفتاحية: تراموي، صيانة وقائية، منع الانهيار، القياس، معايرة المعايرة، عجلات الترام، RNG20.