Shunting of track circuits: a prospective study

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Summary

→ Signalling system: principles and track circuit

→ Shunting malfunction: a system problem

→ Innovative design method: presentation & application to the problem

→ Roadmap of actual and future actions
The continuous train detection is realized on the network with track circuits.

Role of track circuits:

- Track circuit is an electrical circuit which allows:
  - To detect there is no traffic on a track section called zone
  - To ensure mechanical continuity with control of electrical continuity
  - Eventually transmit information on rolling stock

This information is used by most of automatism of railway operation. This is an essential element for railway security. The information is used for:

- Keeping distance between trains, Command of switches, Call at road crossing, The following of trains

...
Signalling principle: continuous train detection

→ Track circuit principle:

→ The track is free:
Without train, current from emitter is sufficient to feed the receptor and maintain the track relay excited

→ The track is occupied:
When the train is on the track circuit, train axles are **shunting** the current from the generator. The receptor is not enough feded to maintain the track relay excited.

→ 2 track circuits family in France:
UM 71 for lines
ITE in stations zone
Shunting malfunction : a system problem

- Conditions for good shunting:
  - Infrastructure specifications: optimized settings and maintenance of track circuits (and the track).
  - Rolling stock specifications: TCA, sanding, axles specifications...
  - A good quality of the wheel/rail contact in standard conditions (application of SAM S 004 to control the wheel/rail contact quality).
  - A good quality of the wheel/rail contact in real conditions.

There is still difficulties to understand wheel/rail electrical contact behaviour and to maintain good quality in real conditions.

Shunting malfunction: the track relay becomes excited whereas the train is still on the zone because of bad wheel/rail conditions.
Main reasons for shunting malfunction:
- Pollution of rail (sand, grease, leaves)
- Problem on the rolling stock (TCA, shoe problem, ...)
- Oxidation of rail
- Specificity of certain rolling stocks (light, with disc brakes only) coming from 2004
- Difficulty on tracks with low traffic flow

There is stopgap measures to control the consequences of shunting malfunction.

Need new ideas to manage the situation. Innovative design method.
Innovative design method

DISRUPTIVE INNOVATION // INCREMENTAL INNOVATION

Regular design
- Management by project
- Project management rules

Innovative design approach
- New thinking
- New tools
- New management of activities
- At the end: Back to regular design

Applied by C. Brogard (SNCF I&R/INO)
Innovative design method

DKCP© METHOD

- KNOWLEDGE SHARING
- DESIGN PHASE
- PROPOSITIONS, PROJECTS, PROTOTYPES

IDENTIFICATION OF THE PERIMETER
Preparation of phase K

Fixing knowledge

CONCEPTS

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Innovative design method

C (Concept)  K (Knowledge)

C₀

C₁,₂,ₙ

Exchanges between C & K

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A group of person at SNCF from:

- infrastructure department,
- rolling stock department,
- innovation and research department and operation department

as applied the method

Proposition of the following target for the C0 concept:

A rolling stock detected in all situations by track circuits
A rolling stock detected in all situations by track circuit

- Suppressing shunting malfunction
  - Helping current flow in the system (rolling stock + infra)
    - Improving rolling stock
    - Improving the track
    - Improving current flow between rail & wheel
  - Improving generator
  - Improving receptor

- Managing situations conducing to shunting malfunction
  - Identifying situations conducing to shunting malfunction
  - Operating specifically zones conducing to shunting malfunction
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A rolling stock detected in all situations by track circuit

Suppressing shunting malfunction

Helping current flow in the system (rolling stock + infra)

Improving rolling stock

Improving the track

Improving current flow between rail & wheel

Managing situations conducing to shunting malfunction

Improving generator

Improving receptor

Identifying situations conducing to shunting malfunction

Operating specifically zone conducing to shunting malfunction

Roadmap
Roadmap

Finality

BRANCH 1

Suppressing shunting malfunction
Helping current flow in the system (rolling stock + infra)

Helping current flow in the rolling stock

Multicriteria study of parameter that can influence the ability of shunting of a rolling stock

Modification of surface state of wheels: Cleaning, rugosity...

Modification and improvement of the design of axles

Multicriteria study of the ability of shunting

Taking account admission but also behaviour during rolling stock life

Modification of specifications for new rolling stock

Specifications for the wheels: cleaning systems, chemical products

Electrical characterization of axles

Definition and development of a protective metallic coating for axles
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Finality

Helping current flow in the rolling stock

Solutions to force the current flow at the wheel/rail contact

Multicriteria study of the ability of shunting

Taking account admission but also behaviour during rolling stock life

BRANCH 1

Suppressing shunting malfunction
Helping current flow in the system (rolling stock + infra)

New generation of TCA

Design of new induction devices

Direct current injection in axles

New electrical architecture
Roadmap

Finality

Improving current flow between rail & wheel

Cleaning of rail: by trains or dedicated equipments, by commercial trains

Limitations of pollutions on rail (leaves, sand,...)

Design of the track (impedance adaptation, ...)

Benchmark of cleaning solutions

Laser cleaning solutions, chemical products, heavy trains which cleans rust

Solutions for optimized sanding process as a function of velocity, type of sand...

Stick for lubrication of the wheel flange or for better electrical wheel/rail contact

Management of vegetation

Impedance adaptation of UM71

Modification of specifications for new tracks: ballast, rails, crosspiece...

BRANCH 1

Suppressing shunting malfunction
Helping current flow in the system (rolling stock + infra)
Roadmap

Finality

BRANCH 1

suppressing shunting malfunction
helping current flow in the system (rolling stock + infra)

Improving current flow between rail & wheel

Study of the mechanical wheel/rail contact to improve shunting (dynamic, adhesion…)

Optimization of the wheel/rail contact parameters (contact profile, size of the contact ellipse)

Correlation study between shunting malfunction phenomena and adhesion problems

Study of the impact of sliding zones in the wheel/rail contact surface on shunting

Electric characterization of 3rd body between wheel / rail

Characterization of 3rd body to find chemical and electrical solutions to eradicate it

Creation of a new contact between rail et rolling stock dedicated to shunting
Roadmap

A rolling stock detected in all situations by track circuit

Suppressing shunting malfunction

Managing situations conducing to shunting malfunction

Helping current flow in the system (rolling stock + infra)

Improving generator

Improving receptor

Identifying situations conducing to shunting malfunction

Operating specifically zone conducing to shunting malfunction

Improving rolling stock

Improving the track

Improving current flow between rail & wheel
Roadmap

Finality

BRANCH 2 & 3 | Suppressing shunting malfunction Improving the track circuit

- Improve the performance of the generator
- Design of a configuration with generator in the rolling stock
- Analyse the signal at the receptor to improve detection

Modification of the power of the signal
Design of a smarter receptor (variable threshold, variation of residual voltage)

Identification of best parameters to control the power of the generator
Receptor analysing de variation of residual voltage
Receptor with a variable threshold: identification of the parameters to control the threshold
Relay which analyse another signal: chaining with the next track circuit
Roadmap

Finality

BRANCH 2 & 3 | Suppressing shunting malfunction
Improving the track circuit

- Design rolling stock with receptor onboard
  - It implies suppression of Track circuit
    - Solution is not interoperable

- Modify link between generator and receptor
  - Modification of the shape of the emitted signal

- Frequency scanning

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A rolling stock detected in all situations by track circuit

Suppressing shunting malfunction

Managing situations conducing to shunting malfunction

Identifiying situations conducing to shunting malfunction

Operating specifically zone conducing to shunting malfunction

Helping current flow in the system (rolling stock + infra)

Improving generator

Improving receptor

Improving rolling stock

Improving the track

Improving current flow between rail & wheel

Roadmap
Roadmap

Finality

BRANCH 4 | Managing situations with stopgap measures

Identify, in advance or in realtime, situations conducing to shunting malfunction

Installation of equipements to improve the knowledge of the behaviour of rolling stocks

Electric wheel/rail contact diagnostic on board

Installation of equipements to improve the knowledge of the behaviour of rolling stocks

Electric wheel/rail contact diagnostic on track

Improving the knowledge of infrastructure

infrastructure solutions : measurement of rail impedance, state of cleanliness of rail

Management of both together shunting malfunction and degraded adhesion

Watch on traffic and real tonnage

Evaluation of wheel/rail adhesion by image analysis

Correlation analysis between shunting malfunction and degraded adhesion database
Roadmap

Finality

BRANCH 4 | Managing situations with stopgap measures

- Operating specifically zone conducing to shunting malfunction
- Study on the rules for category of operating
- Installation of new equipements to make easier or to suppress operating procedures associated to bad shunting rolling stock
- Study on actual categories of rolling stocks
- Creation of categories by line for some sensitive itinerary
- Creation of specific zones Redundancy with axle counter
- Creation of specific zones for some sensitive itinerary
- Study on the categories for rolling stocks
Conclusions

- Shunting malfunction context has been briefly presented
- An innovative design method has been applied to the problem
- As a result, a Roadmap of actions has been proposed
- New ideas has been bringing and will help to manage the situation