Implementation of Rail Grinding on IR- key technical issues

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The benefits and economics of using Rail Grinding Machines are well proven and established throughout the developed world railways. On Indian Railways as we are in the process of introducing Rail Grinding, the key technical issues related with its implementation, which have been addressed or being addressed are as under :

1. Selection of RGM routes
2. Planning of running of RGM with following decisions:
    - Target profiles
    - Speed of grinding
    - Number of passes
    - Pattern to be used
3. Pre and Post Grind Inspections.
    i) Establishment and monitoring of test sites.
    ii) RDSO's technical monitoring Performa.
    iii) Necessary tools, skills and equipments for monitoring & inspections

1. RGM Routes

The routes of two Rail grinding machines have been decided on the basis of the following:

i) Introduce one RGM on high speed passenger dominated and high density, high GMT route of NDLS-HWH and the other on heavy haul routes of MAS – HWH including CC+8+2 & 25 Tonnes laterals. So all 22.82 tonnes axle load sections and 25 tonnes axle load sections were analysed and maximum have been covered for grinding.

ii) Leave the routes where rail foot corrosion is severe. Due to this consideration the entire coastal route of MAS- HWH was later abandoned in favour of 25 Tonne axle load routes of SWR & SCR. Specially the Iron Ore routes Sanoverdam-Hubli-Hospet-Bellary-Guntakal-Rennigunta-Chennai & Guntakal-Nandyal-Guntur-Krishna Canal are selected.

iii) Availability of support and infrastructure facilities at the base stations of RGM. In this regard we have two working CPOH of the track

machines. One at ALD/NCR and other at RYP/SCR so these depots were decided to serve as base stations and SCR & NCR were classified as owning Railway. Planning on IR basis done with owning Railway and detailed plan includes how the machines will work on owning railway and on other railways.

iv) Even after choosing NDLS-HWH section, The RGM has extra capacity to grind so there were following two options:

- Extend grinding on Delhi-Ambala-Ludhiana section
- OR grind heavy haul routes of SER including HWH-Kharagpur-Chakradharpur-Jharsuguda

In this regard preference was given to the first option i.e the NDLS-UMB-LDH section due to number of derailments on account of fractures and their enquiry reports. Early introduction of Rail grinding was a commitment given to Parliament and it weighed heavily in favour of 1st option.

v) Interaction with LORAM and NRC coupled with study of RGM utilization pattern on American Railways led to plan the work in a loop so that we come back to selected stretches at a pre determined GMT interval. The grinding strategy of Preventive Gradual grinding also calls for strict discipline in this regard and number of cycles of grinding are required for permanent solutions desired.

vi) Type of grinding strategy proposed by NRC i.e. Preventive Gradual Grinding Strategy initially and move to preventive grinding in planned and phased manner. Considering a purely Preventive grinding strategy the gap between two cycles of grinding was planned to be of the order of 45 to 55 GMT approximately and considering a speed of 15 kmph of grinding and normal availability of traffic blocks the Northern cycle was planned as covering.

LDH-UMB-NDLS-GZB-TDL-CNB-ALD-MGS-GAYA-DHN-ASN-HWH-KGP-CKP-JSG-MURI-BKNA-Garwa Road-Son Nagar And UMB-SRE-MB-LKO-MGS sections.

But based on NRC inputs the grinding cycle was reduced to cover the following sections in phase -1 of grinding.

ALD-CNB-TDL-GZB-DLI-UMB-LDH-UMB-SRE-MB-LKO-MGS-GAYA-MGS-ALD . In this section MB-LKO shall no be ground in the initial two rounds. With this route the gap between two cycles is reduced to maximum of 30 GMT.

This forms a loop and it is planned that initial two cycles of grinding shall be performed on this section.

For RGM working on SCR the MYS division was removed from 1st phase of planning and Koraput- Singapur Road section is also to be left

out. In this section, there are more spurs in addition to the planned loop but these are unavoidable. The grinding loop in Southern region is

BPQ-KZJ-DKJ-MUGR-KZJ-SC-WADI-GTL-KLU-DMM-GTL-BAY-UBL-SVM-GTL-NDL-GNT-KCC-GDR-MAS-AJJ-RU-GY-NDL-KCC and KK line on ECoR.

With these two loops the complete planning of both RGMs has been done in consultation with NRC/LORAM and conveyed to Rlys. The Planning conveyed to concerned railway zone in MS Excel spreadsheets named "16 Sep 2010 RGM SCR & NCR" covers the selected routes and their sequence, speed of grinding, number of passes required, type of target profile to be used and GMT interval between two cycles. One very important aspect is the pattern to be used and it is not yet planned. However in this planning there are following assumptions:

(i) 10% of the section length has been assumed as curve and balance 90% is straight (tangent).

(ii) Availability of traffic blocks is assumed as 25 shifts of approx. 2.5 hrs. in a month.

As the machines starts working, correct data need to be fed in the planning MS excel charts circulated by RDSO and dynamic planning is required. This is required to keep record of exact GMT gap between two cycles. .

2. Planning of Running of RGM

a) Target Profiles:

Decision of target profiles is a complex exercise and it depends upon number of inputs. The important inputs collected by NRC/LORAM are as under:

i) Miniprof profile measurement of Rails and wheels.

ii) Visual inspection of tracks and wheels- following two observations are important:

- Presence of RCF defects on Rail gauge corners on vast IR network.
- Hunting noticed due to weld imperfections.

iii) Rail and wheel maintenance practices-The quality of Rail lubrication- Lack of any scientific method of lubrication compounds the problem on the curves.

Wheels are regularly being turned at a frequency of 9 months for passenger wheel to 18 months for goods wheels.

iv) Use of Track geometry data:

Absolute values of track parameters of gauge, crosslevel, alignments & unevenness at every 30 cm intervals were processed from data collected by TRCs for all RGM routes and used for evaluating target profiles on the routes using sophisticated software of Rail Wheel interaction modelling.

v) Stiffness of wagons and coaches along different axes.

vi) Different wheel profiles- as the wheels are worn – depending upon their flange thickness, we use different worn wheel profiles. Wheel gauge, wheel diameter etc details were also provided.

vii) Rail & wheel metallurgies and their physical properties.

viii) Pummelling analysis done- specialized, statistical software to find out the relative frequencies of different points of contact of Rail & Wheel and arrive at correct decisions- What is the point on Rail Wheel contact plane where chances of contact are maximum given one particular Rail/wheel profile.

ix) Contact stress calculations on the chosen Rail wheel contact planes at the contact points using Hertz formula and software.

x) Stability and Safety calculations specially L/V ratio on the different scenario of contact using software.

Having given all these inputs finally following four rail profiles have been finalized for IR.

i) **CPC**- Contact Point Centre- To be used on tangents and low rails of mild curves. And all 52 Kg tangent sections.

ii) **CPF**- Contact Point Field- To be used on tangents and low rails of sharp curves.

iii) **HM**- High Mild- To be used on high rails of mild curves.

iv) **HS**- High sharp- To be used on high rails of sharp curves.

All curves with curvature < 1.25º are classified as Mild Curves. And curves ≥ 1.25º are sharp.

The four profiles have been circulated to all concerned zonal railways along with NRC report vide RDSO letter dated 05th October 2010. The NRC report is dated 28th Sep 2010.

As the CPC & CPF are to be distributed half and half on the tangents, it has been proposed that the CPF be used on all UP line tangents and CPC on the

down line tangent sections. Used on tangents, the contact points are separated by 14mm in these two profiles. On 52 Kg rail sections only CPC is to be used as the head width is lesser. On single line sections the CPC and CPF are to be distributed in equal halves. The separation between contacts reduces to 8mm when CPC & CPF are used on Low rails of curves.

Both HM & HS are conformal profiles as the gap is limited to 0.4mm but the gauge corner region is relieved of stresses. On a sharp curve 48° contact of the leading wheel on high rail and CPF contact on the low rails will cause larger wheel diameter contact of the wheel on the high rail and smaller diameter contact on the lower rails- this will create the required rolling radius differential on a sharp curve for better steering of wheels. The rolling radius differential in mild curves with proposed profiles of HM & CPC will be lesser.

Contact stresses , L/V ratios etc have been duly taken care off in the profile design analysis.

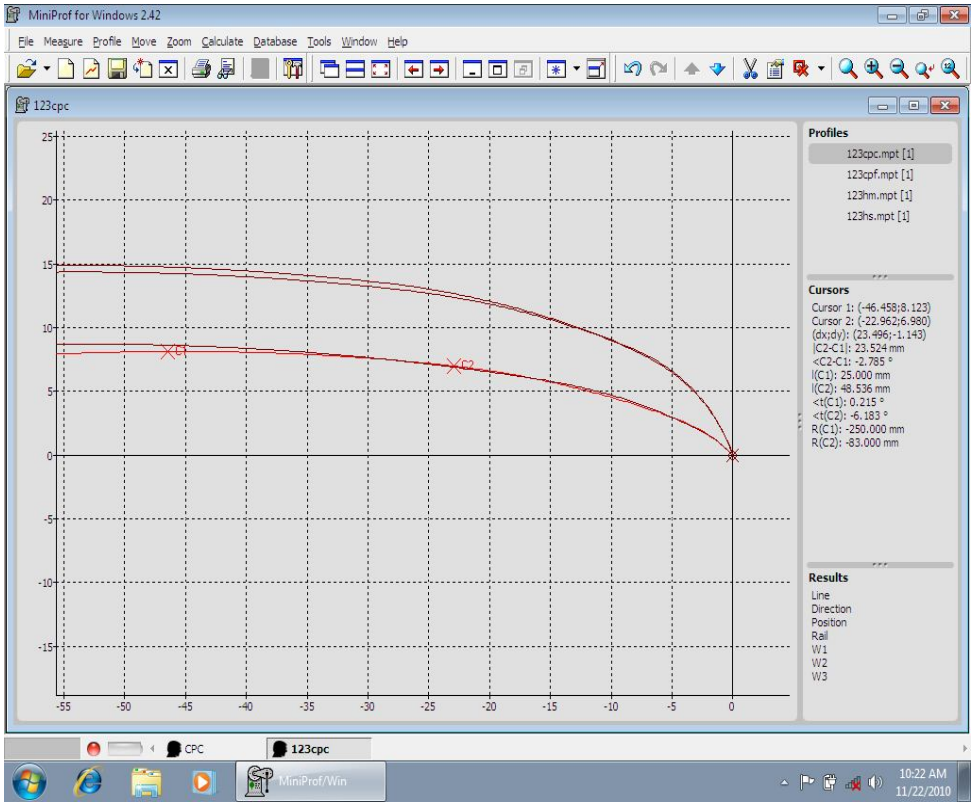
These four profiles compared with one another on a MINIPROF window are seen as under:

HS

HM

CPC

CPF



Fig(i) All target profiles on Miniprof

2. Running of RGM

b. Speed of Grinding

It depends on MR i.e. metal removal and the ability of grinder to remove metal in one single pass of grinding. Having decided the target profiles for different alignment of track and knowing the average rail profiles, the Miniprof software gives the area differences between two rail profiles. Now the cross section area of metal to be removed is a known parameter and depending upon actual calibration of the RGM, speed of Grinding is to be decided in a exact manner. At present the planning as conveyed to Railways is based upon a MR graph (Fig ii) provided by LORAM. Based on this figure and MR requirements, the speeds are proposed as under.

Tangents – 15 kmph single pass grinding

Curves - 18 kmph three pass for both sharp and mild curves grinding.

Fig.(ii) Metal removal graph from LORAM

However once the RGMs are commissioned on SCR & NCR this graph (Fig ii mentioned above) shall be prepared based on actual site measurements in the field using Miniprof instrument. The scheme (fig-iii) suggested by NRC is as under:

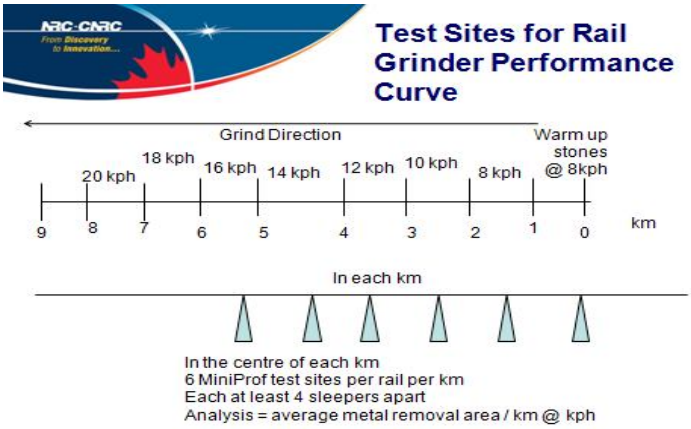


Fig.iii (Scheme to draw relation between metal removal and speed)

c. **Number of passes:**

This depends on speed, MR and type of RGM. When metal removal requirement is more, complete metal can not be removed in one single pass, then more passes are required. Again with PG style of grinding the depth of cut is limited so maximum passes are being restricted to 3 only. As per current planning it is finalized that we shall do single pass on tangents and three passes on curves.

d. **Pattern to be used:**

Pattern refers to disposition of stones on the Rail. Any particular pattern gives a particular type of cut on the Rail. As the operation of RGM is completely computer controlled, any particular pattern can be selected from any point onward and decision mainly depends upon the existing Rail profile and the geometry (alignment) of section. This decision on American Railroads is taken based on Rail Inspection Vehicle (RIV) inspections. As we have no RIV at present, this decision shall be taken either manually depending upon the experience of LORAM operators or the front KLD along with its software and computer hardwares, fitted in front control car of the machine can be detached and fitted into some vehicle to do advance planning ahead of RGM.

In nutshell It is important to consider that RGM is a costly machine and its planning must be done in detail much before taking the traffic block. The detailed planning invariably includes the exact chainages of sections to be ground, start of the curve ,end of curve, whether the curve is left or right,

,its degree of curvature, target profile to be used, pattern to be used, speed of grinding & passes required. Along with GDMS all these data are prefed in the RGM computer system.

3.0 Pre and Post Grind Inspections

(A) Test sections

The most important is to establish and take observations on test sections. Most of grinding related decisions can be taken using these observations. Effectiveness of grinding in terms of correct pattern, speed, number of passes etc are to be decided based on close observations. In a typical test section following main observations are recorded.

- visual inspections & Surface photographs using a good digital camera.
- Dye penetration test (DPT) for surface defects and length of GCC
- Miniprof measurements
- Type of contact on Rail using spray paint or chalk on Rails

In this regard a detailed proforma has been developed by RDSO and field officials have been circulated the proforma through their headquarters and also during IRICEN trainings. All officers and supervisors of the RGM routes were explained in detail, the importance of the items of profarma and they were also explained how to take the required measurements. RDSO officials are visiting the Railways to collect data from these test sections. So far 91 test sections have been established on NCR, SCR & ECoR. However certain more test sections need to be established on SWR, NR, ECR and on GTL division of SCR.

RDSO proforma on RGM monitoring has been developed in two parts. One part is related with measurements on test sections, while the other part deals with route specific information. The route specific data include USFD results, Rail fracture statistics, defect generation rates (DGR) on the routes. Using these route specific information pre and post grind; we can derive quantitative judgements and arrive at calculated decisions on benefits of RGM in the long run. The real economics of working of RGM can be established then.

(B) Regarding post grind inspections followings Equipments & terms are important :

- Grind quality Index (GQI)- This indicates how close is the achieved (ground) profile of rail compared to the target profile. The measurement shall be taken with the KLD camera systems and Image processing software installed in RGM itself. Higher GQI indicates more closeness to the target. The important point to note that , as we are following PGG strategy of grinding the GQI will in increase in due course of time (after 7

to 9 cycles of grinding) and expecting high GQI just after 1st round will be foolish.

- Facet widths- Just after grinding there will be lateral cut facets on the rail top – as per international norms these should not wider than 3-4 mm in gauge region, upto 7 mm in shoulder, to 8-10 mm in the crown region. These facets are rounded of just after few passes of trains.
- Surface roughness - As per Our specifications this value is limited to 12µ RMS value. Special surface roughness measuring instrument are being procured by SCR & NCR.
- Surface hardness- SCR & NCR have to procure 1 instrument for surface hardness measurement. IR currently uses 260 BHN rails but with passage of loads the top 6-7 mm surface gets hardened upto 320-340 BHN. Though the top 0,1 to 0.2 mm is removed during grinding there should not be any significant loss of hardness.
- Rail crown (top table) radius using Star gauge- Star gauges are provided on the RGM. Using five facets of this star gauge, an approx measurement of rail crown radius is done. With passage of loads the rail crown gets flattened and one of the aims of grinding is to restore it back.
- Bar gauge measurements- The bar gauge fitted with desired templates are used by experienced grinding supervisors for both pregrind & postgrind inspections. Pregrind these will help in grind planning and post grind along with a tapergauge it will help us in deciding, the variation of the achieved profile (ground profile) with respect to the target. Such bar gauge measurements in pregrind inspections are important as these give insight as to which pattern will suit the best.
- RCA- One rail corrugation analyser fitted in rear bogie of the front control car of RGM is based on inertial system of Rail corrugations measurement and is designed by Stuart Grassie. Proper use of RCA data will be helpful in corrugation studies.
- Inspect the rails for surface defects caused by imperfect grinding i.e. bluing of rails; donuts etc. should not be present.

Conclusion :

We are just beginning Rail grinding exercise on our system and the routes for initial cycles have been decided based on inputs from NRC, LORAM and IR zones. Sufficient training to officers and staff has been imparted. Now the onus lies on us to carefully use this wonderful machine to obtain its best potential. So the following are a must to succeed :

1. Planning carefully and exhaustively.
2. Having planned, adhering strictly to the plan during execution.

3. Watch closely- observe pregrind & postgrind the rails & wheels to improve upon the plan . Close monitoring of the .test sites is a must.
4. Being truthful in data reporting- honesty in taking and reporting data- our success or failure shall depend upon a course of action- and that depends on a careful analysis of stored data.

Having done these, the Rail grinding programme is bound to succeed and reap bountiful benefits and savings for IR.

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