Maintenance of heavy-haul track by rail profiling
Overview of specifications of Rail grinding Machine, infrastructural requirements and cost –benefit analysis

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1.0 Introduction: This overview offer insights into working of Rail grinding Machine used for maintenance of heavy-haul trak by rail profiling. Section 2.0 covers the technical specifications of RGM as formulated by Railway board for Indian railways. In Section 3.0, there is a brief description of salient features of RGI-5&6 supplied to IR. Section 4.0 describes the management of spares and consumables and Section 5.0 brings out the infrastructural requirement for successful operation of RGM along with Section 6.0 which is an account of a cost/benefit analysis.

1.1 Indian railways have entered into an agreement with M/s Loram, USA for supplying of 2 nos of Rail grinding machines (RGMs) costing Rs 90 corore each, which includes basic cost, applicable custom duty & taxes, transportation cost, spare parts for four years and operational maintenance cost for two years by M/s Loram. These are designated as Rail Grinder International (RGI) 5 & 6 allotted for SCR and NCR respectively.

1.2 IR operates with a total route length of about 60000km and is one of the largest networks in the world. Initially the heavy haul routes of NR, NCR, ECR, SCR, SWR, SR, EcoR are planned to be ground and once the areas of concern in these zones are maintained in a preventive grinding mode, the territories of both grinders can be expanded so that additional track is maintainted through grinding. About 3500km for each is being planned to be ground in a year.

2.0 Technical Specifications of RGM

2.1 General

2.1.1 These specifications provide technical requirement for manufacture and supply, testing and commissioning of a self propelled rail grinding machine of 72 stones for use on IR track and training of personnel to operate and maintain this.

2.1.2 This is meant for grinding rails in corrective mode and preventive mode, to improve rail wheel contact point location, to eliminate micro cracks on rail table surface, to remove short and long wave corrugation.

2.2 Dimensional and operating requirements

2.2.1 Axle load shall be less than 20.32 t with min axle spacing of 1.83m and load per meter less than 7.67t

2.2.2 Capable of travelling at 80 kmph in both directions when travelling on its own power and in train formation at 100kmph including wagon and camping coach

2.2.3 Capable of negotiating curves upto 10^0 with 185mm super elevation and upto 3% gradient. The min speed in above conditions shall not be less than 25kmph.

2.2.4 No infringement up to 4.265m track centres

2.2.5 Capable of producing good longitudinal profile of rail head continuously, grinding plain and curved track, track on LC and sharp curves with check rails after removing them, track in tunnels, bridges without removing guard rails and track on platform lines, grinding only one rail as in the case of curves, grinding 60kg/52kg/90R in 72/90/110 UTS strength and HH rails including FPJ, GJ, welded joints on all types of sleepers.

2.2.6 RGM shall be capable of carrying out controlled grinding of corrugation defects, defects of long wave length w/o producing sharp angle bet rail table and gauge face.

2.2.7 Diesel tank capacity shall be sufficient for working continuously for 12 hours.

2.3 Working mechanism

2.3.1 Working mechanism shall be equipped with

- Rail grinding mechanism
- Control system for rail grinding mechanism
- Optical rail profile measurement system and transfer to onboard computer. Shall be equipped with systems to measure rail profile at a speed >10kmph and storage of rail profile data for at least 100km.
- Library of proposed rail profiles for various rail sections and locations.

2.3.2 Electronic rail profile data processing system and software to grind the existing profile to target profile to be provided with following facilities:

- capturing, storing and processing rail profile from other measuring devices
- quantitative assessment of metal removal/m
- Recommending best/ optimum grind pattern , no.of passes and speed at which to grind
- Obtaing comparative picture of target profile and achieved profile after grinding on real time basis with quantitative assessment.

2.3.3 Grinding mechanism should be electric driven keeping in view the likely fire hazard due to spark generations.

2.3.4 All components must be robust and capable of continuous operation up to 8hr in one spell under the field working conditions.

2.3.5 To achieve the target profile with smooth curvature, RGM shall have 72 grinding stones which can be configured in various ways.

2.3.6 Each grinding module shall be controlled by a hydraulic cylinder for up/down movement and to apply required grinding power.

2.3.7 The grinding modules may be grouped together in carriages. Carriage movement shall be controlled hydraulically.

2.3.8 RGM shall stop grinding and lift the stones when operating speed falls below certain speed to avoid metallurgical damage due to heat accumulation.

2.3.9 Each grinding module shall comprise a ring shaped stone and must have the capability of being positioned by the control system independent of any other grinding motor. Tilt accuracy shall be within $\pm 0.25^0$.

2.3.10 The peak load on the grinding motors, under the most demanding condition shall not exceed 85% of continuous load rating.

2.3.11 The total grinding power provided on the machine shall not be less than 1330kw/1800hp.

2.3.12 Capable of removing $15mm^2$ from each rail ($40mm^2$ for both rails) per pass of 60kg , 90 UTS rail.

2.3.13 Top surface shall get hardened to 315 to 380 BHN at 10kmph

2.3.14 Test rail profile to be closer to target profile and metal removal shall be uniform over the entire rail surface

2.3.15 Depth of cut for 60 kg 90 UTS rail shall not be less than

- 0.13mm at 15 kmph
- 0.2mm at 10 kmph

2.3.16 Machine operation with lesser modules up to 66 motors/ grinding stones is permitted for limited period and it shall be ensured that there is no excessive stress on grinding motors

2.3.17 While machine is operating at full grinding load at the maximum working speed of 15kmph, the minimum life of each stone shall not be less than 5hr.

2.3.18 Each module shall be provided with stone stop mechanism to prevent accidental contact between rail and motor shaft.

2.3.19 Machine driving controls must be at both ends, each manned by an operator.

2.3.20 Pattern changes and adjustments should be made from an onboard central control panel. The supplier shall furnish a min of 50 patterns.

2.3.21 There shall be computer controlled monitoring of input and output of different electrical/electronic devices with the facility of display of input/output so as to monitor their functioning.

2.3.22 Machine shall be able to grind one rail or both rails in both directions

2.3.23 Grinding carriage shall be capable of lifting and lowering and locked on curves up to 10^0.

2.3.24 Grinding motors must be centered over the grinding spot at all intended angles.

2.3.25 The grinding pattern must be balanced and not changed with curve elevation. The rail grinder must be equipped with a system to maintain constant reference to the gauge face of the rail.

2.3.26 The machine shall record the grinding length vs time on printout to obtain information on output of the machine.

2.3.27 Machine shall be equipped with rail grinding gauge for BG with 4 patterns 1. tangent track 2. high rail in mild curve 3. high rail in sharp curve 4. low rail in mild and sharp curve.

2.3.28 The minimum grinding power per grinding stone shall be 25 hp.

2.3.29 The unit must have following controls and displays

- Stop/start button for individual motors and master stop button
- Current meters for various grinding modules
- Module/carriage up/down control
- Operating speed monitor and control
- Stone condition monitor
- Deviation in motor spindle angles
- Angle setting of different grinding modules
- Any other monitor/control required for proper operation.

2.3.30 Computer controlled system in the cabin shall have facility of system diagnostics which shall do detection of short circuit and open circuit conditions, bad feedback, measurement of amperage in control devices, troubleshooting of various PCBs used up to card/board level fault finding, communication between various subsystems.

2.3.31 The onboard computer shall monitor following and maintain a log

- Grinding motor horse power (Amps)
- Stone usage
- Grinding motor idle amp.
- Stone spark time
- Motor life

2.3.32 RGM shall be equipped with vertical rate of correction feature to restrict grinding in corrugation valleys while smoothening the crests. The unit must be equipped with selective vertical stability control.

2.3.33 The machine shall be equipped with spark arresters to prevent sparks from flying around and these should withstand the heat generated at the work spot and flying metal sparks.

2.3.34 RGM shall be equipped with obstacle sensing device. The distance left un ground shall not exceed 12m while clearing obstacles at 15kmph.

2.3.35 RGM shall have adequate water capacity to prevent and fight fires. 20000 lit storage shall be on machine and 55000 lit storage in separate wagon and these two shall be connected for arresting fires when required.

2.3.36 The machine must be capable of grinding any worn rail profile to shapes within ± 0.3mm of selected target profile.

2.3.37 The metal removal rate must not vary more than 25% between grinding of rail with BHN from 315-380.

2.3.38 The surface finish after grinding shall be that corresponding to RMS value of 12µ roughness.

2.4 Safety mechanism

2.4.1 To be provided with electric horns/hooters at each end that can be operated by push buttons in cab and by remotely 150m from the machine.

2.4.2 There shall be an arrangement that when the fire extinguisher is activated, the engine shall automatically shut down.

2.4.3 There shall be arrangement to prevent dust from grinding process escaping into air. Suitable and efficient dust collection system shall be provided in the machine.

2.4.4 There should be arrangement for water sprays through nozzles at suitable locations.

2.4.5 Grinding carriages shall have non flammable shields to avoid damage due to sparks, grinding dust and flying dust.

2.4.6 Flasher lights shall be provided at both ends.

2.4.7 Safety equipment like jacks, pullers, trifor etc., shall be provided with machine.

2.4.8 Machine shall be provided with emergency backup system to wind up the machine in the event of failure of prime mover/power transmission system.

2.5 Acceptance test

2.5.1 Acceptance tests shall include dimensional test, Negotiability of 10^0 curve and 1 in 8.5 turnout, train running speed test (light run) on IR mainline track, construction and Engineering of machine and output performance tests on high carbon 90/110 UTS H.H rail with 60/52 kg UIC section and on standard carbon 72/90 UTS with 52/60 kg section. The test locations shall be so chosen that the profile of the rail shall not be abnormally deformed. Output tests include the depth of metal removal capability and total metal removal at 5 locations each having a grind length of about 500m.

2.5.2 Av. Depth of Metal removal per pass for a site at specified speed at each of 5 sites for 60 kg 90 uts shall not be less than

- 0.13mm at 15kmph
- 0.2mm at 10kmph

2.5.3 Av. Metal removal per pass at specified speed at each of 5 sites for 60 kg 90 uts shall not be less than

- $15mm^2$ from each rail (40 mm^2 for both rails) per pass with top surface hardened to 315 to 380 BHN at 10kmph

2.5.4 Difference of target profile and achieved profile shall not differ by more than ± 1% in terms of x-sectional area of rail head

2.5.5 The min. life of grinding stones shall be 5 hours in continuous grinding 15kmph grinding speed

2.6 Warranty and post warranty maintenance contract

2.6.1 In addition to warranty and spare part obligation, tenderer shall comply post warranty maintenance contract which will be operated by zonal rly for 2 yrs after expiry of warranty. During this period, machine will be operated by IR and supplier has to ensure availability of trained engineer, availability of spares/consumables and shall ensure min. of 25 days/month machine available time.

3.0 Salient features of RGI-5 &6

3.1 Each RGI consist of 1 control car, 3 grind cars, 1 water wagon and 1 camp coach. Control cab and grind cars are imported where as water wagon and camp coach are manufactured in India. The bogies of grind car were manufactured in India and taken to M/s Loram work shop at Hamel, USA and assembled there and then these units were shipped as bogie mounted.

3.2 Control car consists of

3.2.1 Pressurized AC Cab having travel and grind controls and computer displays with HMI (Human Machine Interface)

3.2.2 Air compressors of 30 cft capacity

3.2.3 Silicone control rectifier (SCR) for converting 480V AC into 0-600V DC for supplying to driving trucks

3.2.4 Frequency converter for converting 480V, 60hz, 3 ph AC to 220V, 50hz single phase AC.

3.2.5 Water system having one 10000L upper tank and 10000L belly tank with interconnection.

3.2.6 Two Drive trucks, one in front and one in rear

3.2.7 ORPMS (Optical rail profile measurement system) manufactured by KLD labs and installed on the rear side of rear truck for obtaining the rail profile before grinding

3.2.8 RCA (Rail corrugation analyser) developed by Stuart grassie and installed on the front side of rear drive truck to obtain the rail corrugations before grinding duly connected with computer systems.

3.2.9 Two sequencing/travelling video cameras in the front of the machine for sequencing the grinding operations and for travelling in reverse.

3.2.10 Obstacle detection system mounted on the front side of front drive truck

3.2.11 Two water cannons behind control cab for firefighting purpose

3.3 Each grind car consists of

3.3.1 Pressurized AC work room for keeping tools and plants and having the PLCs pertaining to that car

3.3.2 1600A breaker box for disconnecting the engine from car and car from the machine for troubleshooting

3.3.3 Hydraulic power unit

3.3.4 One main fuel tank of 4560L capacity and another storage tank of 3040L capacity without interconnection

3.3.5 One 1350 Bhp Cummins QST30 Engine

3.3.6 One 900kw generator for generating 480V AC 3 phase

3.3.7 Dust collection system with 50hp blower and with 27 filters

3.3.8 2 nos of grind carriages supported on buggies and each containing 6 grinding motors/rail

3.3.9 First and third grind car have water system, each consisting of 2 ditch sprays (one far and one near) on each side and 6 tie sprays in the sleeper area to wet the grinding area before and after grinding to contain the fire hazards.

3.4 Water wagon of

3.4.1 55000L capacity mounted with 30hp pump for transferring of water to grind cars and camping coaches

3.4.2 Provided with ORPMS mounted on rear side of rear axle for taking the rail profile after grinding

3.5 AC Camp coach

3.5.1 Suitable for accommodating 14 persons with living, dining area with kitchen, bath and toilets etc.,

3.5.2 Having observation room in the rear with driving and braking controls used when machine is being moved in reverse direction

3.5.3 Two sequencing/travelling video cameras in the front of the machine for sequencing the grinding operations and for travelling in reverse.

3.5.4 Water system for camp coach along with 2 water cannons in the rear for firefighting purpose

3.5.5 Obstacle detection system used when grinding in reverse direction.

4.0 Management of spares and consumables

4.1 For arranging the spares and consumables the following procedure to be followed:

4.1.1 Fortnightly meeting of Dy.CE/TM of controlling Rly & Dy.CE/TM of RGM working Rly to review inventory and in case RGM works for more than 3 months, Dy.CE/TM of RGM working Rly has to maintain temporary inventory.

4.1.2 Dy.CE/TM of RGM working Rly shall monitor the consumption of spares and Dy.CE/TM of controlling Rly shall be nodal authority for over all working & spares consumption

4.2 The yearly requirement of consumables for RGM are as follows:

4.2.1 Water Glycol hydraulic fluid- 625 litre/year (only for leaks , spoils or contamination)

4.2.2 Multi purpose grease- 2100 litre/year

4.2.3 Grease Synthetic high temp.-100 kgs/year

4.2.4 Journal oil- 150 litre/year

4.2.5 Synthetic gear oil-11.35 litre/year

4.2.6 Air compressor oil (Pallube 32)- 23 litre/ 8000 hrs

4.2.7 Coolant- 45.4 litre/year

4.2.8 Lube oil 15w40- 2500 litre/year

5.0 Infrastructural requirements

5.1 Stabling station logistics:

5.1.1 Stabling siding should be planned and developed at a distance of about 50 km on the section where RGM will be deployed with CSR of 300m and yard connectivity at both ends. Alternatively there can be Two spurs with minimum length of 150 m (CSR) each. In case the same is not available a new siding should be laid or existing spurs may be extended for stabling the RGM train.

5.1.2 The stabling siding shall have the following facilities:

- Drinking water
- Electric supply for lighting
- Approach road
- Resting facilities
- Toilets & bath rooms
- A ramp/elevated (working) platform
- Decanting arrangements for HSD oil

5.2 Existing fuelling points (RCD) of IR can be tapped as an alternative source of supply of HSD oil. Instructions issued by board vide Lr.No RS(POL/05/0501/2/2008/RGM dt.20.05.09 duly approved by Mech, stores , finance, TM Directorates of Rly Bd.

5.3 To arrange fuel as per requirement (2100 lt HSD/4 hrs. working) or 50 litre/km

5.4 To arrange for watering to maintain 75000L (includes working & fire fighting requirements. Around 30000 litres/ 4 hrs working) or 750 litre/km

5.5 Operating Department shall ensure expeditious movement of RGM train to RCD points and back to the base station in order to avoid the loss of working days.

5.6 Track features to be taken and track to be attended.

5.7 As an emergency back up arrangement, zonal railway shall sanction recoupable imprest of 5 lakhs for HSD oils, lubricants,consumables, safety gear and equipment and to cater for unforeseen situations.

5.8 Extra funds to a tune of Rs 12 crores/year for each machine to be provided (fuel – 2.5 Cr, grinding stones – 4.0 Cr, spares – 5.5 Cr)

6.0 Cost benefit analysis

6.1 The total cost of the machine is Rs 90.0 Cr and Idling cost of the machine per day is Rs.12 Lakhs. The cost of staff as being planned for creation is Rs. 1.85 Crores per annum i.e. Rs 51,000 / Day.

6.2 Considering average progress as 25km/day, (2hr 45min eff. Block/ for 4 hr block), the operational cost is as follows:

6.2.1 Operational cost:

- Capital cost: 90 Cr
- Depreciation/year = 6 Cr
- Interest: 9.0 Cr
- Approx. annualized cost: 15 Cr

6.2.2 Cost of fuel per year:

- average consumption : 500 lts/hr.
- Total consumption 4 hours/day for 300 days per year : 500X4X300 = 6,00,000 lts
- Cost of HSD @ Rs. 36 per lt = 2.16 Cr

6.2.3 Cost of man power for one year : 1.85 Cr

6.2.4 Cost of spares (other than grinding stones) @ 6% of the total cost: 5.5Cr

6.2.5 Cost of grinding stones: 4 Cr

6.2.6 Total operating cost including capital cost: 28.51 Cr.

6.3 Expected progress of rail grinding per year:

6.3.1 Considering progress @ 25 Km/day and for 300 days in a year and 70% efficiency, the total length will be 5250 Km.

6.4 Hence, the grinding cost per pass Km= 28.51 Cr/5250Km = Rs. 54,304 per track pass Km.

6.5 Considering a 50 GMT route , Rail life will be 12-15 years. If the rails are ground, the approximate rail life will be 20% more i.e. 15-18 years.

6.6 Considering a 5250km route which can be ground by one RGM, the track renewal required without grinding will be 375km and with grinding it will be reduced to 310km. Hence, there will be a saving of 65km trackr renewal per year by resorting to rail grinding program.

6.7 Considering the cost of track renewal at 0.77Cr/km, there will be saving of about Rs 50 crore/year due to reduction in track renewals due to rail grinding as against the operational cost of Rs 28.51 Cr and the ROR works out to 75%. Hence the rail grinding is advantageious as well as economical. Apart from this direct benefit, there will be other benefits like less wear of wheels, less fuel consumption, lesser noise and reduction in rail fracture due to rail grinding.