EVALUATING THE BENEFITS OF HIGH PRODUCTION MECHANISED TRACK MAINTENANCE MACHINERY IN TERMS OF PROCUREMENT PRINCIPLES ON HIGH TRAFFIC DENSITY LINES

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The Transnet Infrastructure Plan (TIP) 2011 forecasts a growth in the national total freight (all forms of transport) from the current 750 million tons per annum (mtpa) to around 1,800 mtpa in 2040. In the Rail Development Plan section of the TIP, Transnet is preparing for this by putting in place strategies to move those commodities currently transported by road that is more suitable for rail traffic back onto rail. This will result in an increase in traffic beyond the current rail infrastructure traffic limit. The Transnet capital program therefore relies on the optimising of the lines and this regard efficient track maintenance will make a very large contribution. To explain:

An increase in traffic on a railway line requires an exponential increase in the preventative track maintenance intervention frequency (shorter maintenance cycle) to ensure that the line remains reliable, available, maintainable and safe. However, the more trains there are in the system the less time is available for mechanised machinery to occupy the track for maintenance.

To maintain the required maintenance cycle for the increased traffic without uneconomically and impractically increasing the number of machines working on the line, the absolute maximum performance and durability of production is expected of the maintenance machines. High production mechanised maintenance machines will reduce the time required to carry out maintenance, reduce the number of machines required and reduce the total cost of maintenance when all related costs are considered.

This article consists of two parts; the first part examines the necessity of using high production track maintenance machinery to contribute towards line optimisation and reduction in maintenance costs. The second part examines public procurement legislation and the importance and challenges of specifying the required machine adequately to ensure it being contracted considering the procurement scoring system.

Part 1: High Production Machines For High Traffic Density Lines Save Money

The field of mechanised track maintenance is very complex with a wide variety of machines available for nearly every track maintenance activity. Over the years the technology employed on all of these machines have improved vastly to increase its production and durability to keep up with the demands of ever increasing traffic volumes, high speeds and high axle loading. The technology is available and in most cases already in South Africa.

For example, lifting, levelling, lining and tamping of the track is the most frequent of mechanised maintenance activities and it is therefore not surprising that the advancements in this technology has been huge. Thirty years ago the Plasser 09-32 revolutionised mainline tamping with the continuous action principle producing 39 sleepers per minute. Today the Plasser 09-4X produces in excess of 70 sleepers per minute! The fastest
tamping machine in South Africa is the Plasser 09-3X which produces a maximum of 60 sleepers per minute (Figure 1).

These mainline tamping machines can however not tamp turnouts due to the restricted track around the switch blade, diverging rails and frog. Tamping machines were therefore equipped with specialised features to tamp both turnouts and the mainline and became known as universal tamping machines but were of relatively low production when tamping open track of around 15 to 21 sleepers per minute. However, as the demand for maximum production in short maintenance windows grew, universal tamping machines became too slow to keep up with production demands on high capacity lines. The 09-24 Dyna-CAT (Figure 2) bridged the compromise between specialised high production turnout tamping and high production mainline tamping by tamping the heavy and long concrete 1:20 turnout in one pass in less than 30 minutes and can achieve up to 36 sleepers per minute on the open line.

Maximum production is however not the only important criteria for high capacity lines. The durability of the production is also very important since this will determine the tamping cycle. Despite the technology used on Plasser & Theurer machines having been researched and proven to produce the maximum possible durability by independent academics, the durability is today further enhanced with the use of dynamic track stabilising integrated as
part of the tamping machine or working independently directly behind the tamping machine. Research in South Africa by the Track Testing Centre showed that an extension of up to 30% between the tamping cycles is possible if the track is stabilised immediately after tamping. Today dynamic track stabilising is non-negotiable on heavy haul and main lines and has become an integrated part of the tamping process.

Before the benefits of high production machines can be quantified in monetary terms, it is necessary to explain the effect of track maintenance on train operations. Influencing factors would be traffic density, whether it is a single or double line, the number of turnouts, the number and radii of curves, the condition of the track material etc. The variables are therefore vast but the Sishen to Saldanha iron ore line will be used as a good example due to its financial importance for Transnet and its unique characteristics in terms of it being a single line of 861 kilometres, with high traffic density (one train departing from either end at slightly over 2 hour intervals), heavy axle loads (30 ton), 20 crossing loops at approximately 40 kilometres intervals and high value trains of 342 wagons per consist.

With the current targeted 90 million gross tons of traffic on the ore line, the tamping cycle can be calculated at approximately 5 months using empirical formulas. In other words, the 861 km line must be tamped from top to bottom within 5 months before the next cycle must start again. With a 650 mm sleeper spacing, 1,325,000 sleepers must be tamped over this 5 month period.

If for example one tamping machine with a nominal tamping rate of approximately 19 sleepers per minute is used, working for 4 hours per day during a 20 working day month, an average of 91,200 sleepers per month will be tamped. One machine will therefore take 14.5 months to tamp the entire line. At a required 5 month tamping cycle, three of these machines will be required with three occupations along the line of at least 6 hours each to ensure a 4 hour working time.

On busy lines such as the Sishen to Saldanha line, worsened by it being a single line, occupations are created by using train free slots to allow maintenance machines to occupy the line. This can be best illustrated using a typical train grid (see Figure 3).

The blue lines represent full trains leaving Sishen at 2 hour intervals (rounded off for the sake of simplicity in this hypothetical example) and arriving in Saldanha 17 hours later. The red lines are the empty trains returning from Saldanha to Sishen, also at 2 hour intervals but takes 21 hours to reach Sishen due to the empty trains entering the loops for the full trains to cross without stopping. At any point on the line a train, full or empty will cross at just over one hour intervals.

To create a train free maintenance window (coloured green in Figure 3) for mechanised track maintenance, some of the slots in both directions must be occupied. Figure 3 shows a typical scenario: to create one maintenance window every day between 8h00 in the morning and 14h00 in the afternoon, slots F1 & F2, F13 & F14 and F25 & F26 in the full direction and slots E9 & E10, E21 & E22 and E33 & E34 in the empty direction must be train free for maintenance.
As a result of the train free slots, default windows appear (coloured lilac in Figure 3), though at night time. This is however only one window per day (and one at night) and if the tamping machine described above is used, at least three of these windows will be required. Tamping is however not the only maintenance activity on the line. Other activities that cannot be done between trains for which occupations would also be required is ballast cleaning, rail replacement, ballast offloading and regulating, rail destressing, overhead track equipment maintenance etc. It is clear that maintenance windows have an adverse effect on train operations and the freight throughput on the line. This also explains why an increase in traffic will exceed the traffic limit for this line if the infrastructure remains the same and or maintenance methods, machinery and strategies are not adapted for the increase.

This over congestion of maintenance windows can be alleviated with the use of high production machines. Similar to the calculation before: one high production tamping machine with a nominal tamping rate of 55 sleepers per minute (as opposed to 19) can tamp 264,000 sleepers per month or a tamping cycle of 5 months for this 861 km line. Therefore only one of these machines would be required as opposed to three slower machines.

However, these high production mainline tamping machines cannot tamp turnouts and neither were the turnouts considered in the above example. In practice however, at least one universal tamping machine would be required to tamp the turnouts. The mix of high production universal tamping machines and high production mainline tamping machines will depend on the characteristics of a particular line.

The contract cost of high production machines would be more expensive than low production machines. However, the contract cost should not be considered in isolation; it’s
the total cost involved in an occupation for mechanised maintenance of which the machine is but one component that must be considered. These costs include, though it will vary between different types of maintenance activities:

- **The cost of Transnet personnel resources:** A permanent way inspector, trackmaster, flagmen, overhead track equipment linesmen, a signalling technician, labour for each of these, vehicles and tools would be required for each occupation.

- **Diesel locomotive, train driver, his assistant and a shunter:** The combined cost of this can be conservatively estimated at R30,000 per day. For some types of maintenance activities more than one locomotive and other rolling stock may also be required.

- **Loss of revenue due to the occupation:** Especially in the future as higher traffic volumes are envisaged, lost train slots will never be caught up again due to the congestion on busy lines. Every slot that is used for maintenance has the opportunity cost to the railway of the income generated by a train. A quick internet search revealed that the commodity value on the international market of each ore train can be R40 million on average ([http://www.indexmundi.com/commodities](http://www.indexmundi.com/commodities)). At a conservative estimate that the income for the Railways is only 10% of the commodity value, each occupation of two slots have an opportunity cost of R8 million! The loss to the South African economy is however R80 million.

To put this into perspective, the contract cost of a typical low production tamping machine package would be approximately R50,000 per day (occupation) and a high production tamping machine package R80,000 per day. Should only the contract values be compared, without considering their production capacity, it is clear which machine will be contracted.

However, if the total cost to the client is considered, the higher cost of the high production tamping machine is completely irrelevant.

Correctly specifying and evaluating the required machine during the procurement process is therefore of paramount importance in terms of the expected outcome of the contract. Contracting a machine that is not capable of the expected production due to failure of the supply chain process during the evaluation of tenders will have financial implications that far exceed the maintenance contract value itself.

The biggest challenge to getting the required machine however is related to the supply chain management process and all the legislation that regulates it.

**Part 2: What is the influence of legislation on contracting the machine that is required?**

Various acts, regulations and guidelines prescribe the manner, format and content for the preparation and administration of procurement documents in organ of state tenders. The most important of these is the Preferential Procurement Policy Framework Act (PPPFA) which simply states that an organ of state must determine its preferential procurement policy and implement it within the framework of a preference point system based on the contract value. The point system is based on either 80 or 90 points allocated to price and either 20 or 10 points allocated to specific goals such as contracting with persons, or categories of persons, historically disadvantaged by unfair discrimination on the basis of
race, gender or disability. The contract must then be awarded to the tenderer who scores the highest points, unless objective criteria justify the award to another tenderer.

The 2011 Preferential Procurement Regulations (the Regulations), published in terms of the PPPFA, provide the criteria for evaluating tenders where the quality or functionality of the product or service, of which production or performance would be one, may have a decisive influence on the outcome of the contract. Clause 4 of the Regulations state that:

“4 (1) An organ of state must indicate in the invitation to submit a tender if that tender will be evaluated on functionality.

(2) The evaluation criteria for measuring functionality must be objective.

(3) When evaluation tenders on functionality, the-
(a) evaluation criteria for measuring functionality;
(b) weight of each criterion;
(c) applicable values; and
(d) minimum qualifying score for functionality,
must be clearly specified in the invitation to submit a tender.

(4) No tender must be regarded as an acceptable tender if it fails to achieve the minimum qualifying score for functionality as indicated in the tender invitation.

(5) Tenders that have achieved the minimum score for functionality must be evaluated further in terms of the preference point systems prescribed in regulations 5 and 6 [the 90/10 or 80/20 point system].”

Quality or functionality can therefore be introduced in the procurement documentation as eligibility criteria (pre-qualification criteria) as a means of ‘gate keeping’ to ensure that only those tenderers who are likely to deliver the required quality or functionality continue to compete for the award of the contract.

The scoring of functionality is therefore merely to establish that the tenderer is capable of providing the service and to reject the tender submissions of those who fail to attain the threshold score. Thereafter the tender offers can be evaluated on the basis of price and preference alone. The points scored for functionality will therefore not contribute towards establishing the successful tenderer in terms of price and preference evaluation.

The result is that a cheaper lower production and/or substandard machine can make it through the eligibility process (‘gate’) and score the highest points due to its lower price, unless the technology and speed is specified as non-negotiable. The tender board will then have to contract this machine according to the PPPFA without any discretion (performance or production can by law not be used again as objective criteria to award the tender to bidder who did not score the highest points). Referring back to Part 1 above, the higher production machine may be more expensive in terms of the contract value, but if the overall cost of maintenance is considered, the lower production machine’s ‘saving’ will be negligible due it requiring longer or more train slots to achieve the same output as the high production machine. This can be illustrated at the hand of the following hypothetical example:

The Railways advertises an invitation to tender for a tamping machine to tamp an 800 km single line at a 6 month tamping cycle. The tamping machine must therefore be capable of tamping 1,600 km (2,461,000 sleepers) in a 230 working day year. Train slots are 2 hours apart and provision is made for 2 slots per day for tamping, providing an effective 4 hour
working day (refer again to Figure 3). It is an ore line and the income to the railway is approximately R4 million per train. Calculations by the Railways showed that a tamping machine with a minimum tamping production of 45 sleepers per minute would be required (45slp/min x 60min x 4hrs/day = 10,800slp/day x 230days = 2,484,000slp/year > 2,461,000slp/year required). The tender documentation is advertised as such and two tenders were received:

<table>
<thead>
<tr>
<th>Tenderer A</th>
<th>Tenderer B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Production Offered</td>
<td>45 sleepers/min</td>
</tr>
<tr>
<td>Contract Price (per annum)</td>
<td>R14,900,000</td>
</tr>
</tbody>
</table>

Table 1

In terms of the PPPFA, even if Tenderer B received the full 10 points for preference (equity) and Tenderer A doesn’t, the contract must still be awarded to Tenderer A if the price component is purely based on the contract value since Tenderer A will achieve the highest points.

However, as explained in Part 1 above, the lower production machine would require more occupations than a higher production machine at the expense of the opportunity costs of income generating trains as illustrated by Table 2.

<table>
<thead>
<tr>
<th>Tenderer A</th>
<th>Tenderer B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required production per year</td>
<td>2,461,000 sleepers</td>
</tr>
<tr>
<td>Production in 4 hours per day</td>
<td>10,800 sleepers</td>
</tr>
<tr>
<td>Production in 230 days per year</td>
<td>2,484,000 sleepers</td>
</tr>
<tr>
<td>No. of days/occupations required¹</td>
<td>227 occupation</td>
</tr>
<tr>
<td>Opportunity cost of maintenance²</td>
<td>R1,816 million</td>
</tr>
</tbody>
</table>

Table 2

¹ No of days/occupations required = Required production per year ÷ production capability in a 4 hour day
² Opportunity cost of maintenance = No of occupations required x R4 mil/train x 2 trains per 4hour occupation

Therefore, despite Tenderer B’s contract price being R3,5 million more expensive per annum, this is insignificant compared with the saving of R448 million per annum brought about by the fewer occupations required by Tenderer B’s higher production machine and the resulting more trains that can be run. This does not even include other occupations costs as discussed in Part 1.

High speed technology is only cost effective if the benefits that it provides are factored into the evaluation. This article therefore calls on the Railways to consider a different approach to calculating the price component of tenders while still remaining within the framework of the PPPFA. This would require the price component to be calculated considering the overall cost to the Railway per occupation and the production achieved as opposed to a contract value alone. This article will not at this stage propose a formula for such a calculation since the variables are vast but to find the best value for money and optimising line availability, this concept requires further investigation.
This article recognises that not all lines have a traffic density where production would make such a large difference in terms of opportunity costs but the other costs mentioned in Part1 such as personnel costs and locomotive requirements should still be considered.