Operational, network and infrastructure selection criteria for tamping machines

INTRODUCTION

There are many different tamping machine models available, each designed for a specific purpose. Applying the wrong machine could mean either under-utilising the machine at an increased cost per sleeper, or the machine being incapable of completing the tamping cycle in the allotted time at an even greater cost in terms of track deterioration. In addition, when choosing a tamping machine for a railway or track section, various operational, network and infrastructure considerations, such as the length of the line, the traffic density, the number of turnouts on the line, etc, must be considered.

SELECTING THE APPROPRIATE TAMPING MACHINE

The following are some of the considerations to be taken into account when deciding on the appropriate tamping machine for a particular line or section:

Calculating the tamping cycle based on traffic throughput

Condition-based maintenance is regarded as the most efficient maintenance strategy for track infrastructure. However, a railway must budget for the maintenance requirements in advance in order to ensure that the necessary machinery is available when required. The tamping cycle must therefore be determined and is especially important when there is a change in traffic or tonnage throughput, axle loading, etc, which will change the status quo. The following is an empirical formula that is often used to determine the expected tamping cycle on freight lines in South Africa:

Tamping cycle in months = 48 ÷ √(annual throughput in MGT)

If the annual throughput on a particular line is expected to be, for example, 5 million gross tons (MGT, i.e. the total tonnage including the weight of the rolling stock), the tamping cycle will be approximately 21 months if the above formula is used. In other words, the same spot on the line must be tamped again 21 months after the previous tamping cycle. However, one should consider that at lower traffic volumes other external factors may influence the tamping cycle. If the expected traffic is 50 million gross tons, for example, the expected cycle will be approximately 6.8 months.

Calculating the tamping cycle based on axle loading

The above empirical formula for calculating the tamping cycle is based on freight trains with an axle loading of approximately 22 to 26 tons. Dynamic track stabilisation is recommended after any ballast maintenance including tamping. Using the formula with stabilisation may increase the track durability by up to 30%, providing a tamping cycle which will ensure a line of high quality.

For higher axle loadings of 26 to 30 tons the formula may prove to become increasingly conservative, and dynamic stabilisation becomes a necessity. Other external factors, such as climatic conditions and general track conditions, should then also be considered to ensure that the tamping cycle is not too low, causing secondary damage to the track.

For axle loadings in excess of 30 tons, the formula will be inadequate to maintain the line without secondary track damage caused to the rest of the track structure due to poor geometry. We do not have the experience in South Africa of such high axle loadings, but it is certain that the empirical formula would have to be adjusted for an exponential increase in the tamping cycle.

On light axle load lines, such as for commuter trains, the formula may at first seem to be too liberal, but here the train speed needs to be considered. Even small track geometrical defects will have an effect on passenger discomfort. As the speed increases

Figure 1: 08-16 Universal tamping machine with split-head technology

Figure 2: 09-Dyna-Cat Universal tamping machine with integrated stabilisation

Figure 3: 09-3X Continuous action three-sleeper high-production tamping machine with tow-behind dynamic stabilisation

to the level of rapid rail links such as the Gautrain, the dynamic effects of small geometric defects increase. As a rule of thumb, the same formula should therefore apply to light axle load commuter lines, with stabilisation becoming a necessity as the train speed increases.

Calculating the tamping cycle based on the length of the line

In practice, various lines sometimes share resources such as tamping machines, in which case the tamping cycle of all the lines that share a machine or machines have to be considered. Double lines also have the advantage that traffic can pass on the adjacent line. To illustrate the influence of the length of line on the type and number of machines required, single lines of 500 km and 1 000 km respectively can be used as examples, together with the above throughput figures of 5 MGT and 50 MGT.

Maintenance planners should always aim to have as few machines on the line as possible, because of their disruptive effect on traffic, especially on single lines where substantial planning and resources are required for each machine, and for each additional machine. Where higher production is warranted, higher-production machines have a lower resultant unit cost of maintenance than lower-production machines. However, the choice will always be between one or more universal tamping machines which can tamp both turnouts and plain track, or two or more tamping machines which can be combined to perform these tamping functions.

Scenario 1: 5 MGT throughput on 500 km line

For the 5 million gross ton (MGT) throughput example, it means that a machine, or a combination of machines, must tamp a total of 500 km in a 21 month period before it theoretically starts at the beginning again. One would expect that a relatively low-production machine would be adequate for such low throughput. A tamping machine with a nominal tamping rate of 16 to 18 sleepers per minute will tamp a minimum of 960 sleepers in one hour. One can expect a maximum of about four working hours per day in a 240 working-day year. The machine will therefore tamp 3 840 sleepers per day. At a sleeper spacing of say 700 mm, it equates to 2.7 km tamped per day, or 54 km per month consisting of 20 working days. The effect of shorter sleeper spacing on heavy haul lines must be considered.

This tamping machine would therefore complete one cycle of 500 km in 9.3 months, which is much less than the required 21 months. Only one machine would therefore be required and a universal tamping machine would provide flexibility in that only one machine would be required for tamping the main line and the turnouts. As turnouts take longer to tamp than main-line, the number of turnouts should be considered. A line of such low throughput is more likely to share resources. Higher-production machines shared with other lines should therefore be considered, which would provide for lower unit costs of tamping.

Scenario 2: 50 MGT throughput on 500 km line

On a line with 50 MGT throughput the 9.3 month cycle will be too long since the required tamping cycle is 6.8 months. A faster machine, or more machines, would therefore be required. Staying with the concept of using one machine, a high-production continuous-action two-sleeper universal tamping machine, such as the 09-Dyna-Cat, may produce up to 32 sleepers tamped per minute (nominal) with integrated stabilisation. The machine will produce 7 680 sleepers tamped and stabilised per day (5.4 km/day or 108 km/month). This machine will therefore have a tamping cycle of 4.6 months, which is less than the required 6.8 months and leaves enough spare capacity for emergencies, turnouts, yards, etc. These are excellent circumstances to ring-fence tamping, as ideal unit costs are possible.

Scenario 3: 1 000 km line and/or high throughput

For a 1 000 km line with the same throughput as above (50 MGT) and using the same universal tamping machine, the tamping cycle will still be 6.8 months, but a much longer line must now be tamped over this period. Even two machines will not have adequate spare capacity to maintain the tamping cycle of such a long line. A high-production plain-track tamping machine, such as the 09-3X continuous action tamping machine, combined with a lower-production universal tamping machine, such as the 08-16 mentioned before to tamp the turnouts and yards, will have to be considered as one of various scenarios.

Calculating the tamping cycle based on the number of turnouts and curves on the line

With the length of the line there are also other network considerations. Curves and turnouts may require a more frequent tamping cycle than plain (straight) track. The more curves and turnouts there are on the line, the more the machine will have to be moving up and down the line to satisfy the tamping cycles of turnouts, curved and plain track. As the line gets longer, one machine may be impractical, even if it is capable of keeping to the required tamping cycle. If emergencies and other sections that require more frequent tamping are also considered, such as those on weak or failing formations, the time the machine will be travelling between working areas may diminish the machine's production. More machines of lower-production capabilities, spread along the line, may therefore be required.

Calculating the tamping cycle based on the traffic and maintenance windows

The above scenarios did not consider the number of trains required to increase the throughput from 5 MGT to 50 MGT. Even if longer trains are used to transport the freight, more frequent trains would still be required. The higher the traffic density, the less time will be available for maintenance and the shorter the maintenance windows will become.

Tamping machines will be required to tamp more sleepers in the shorter windows to keep to the required tamping cycle. Therefore, high-production machines would be required. On a single line more tamping machines cannot always be accommodated, since train slots must be occupied to create a maintenance window, and creating more than one maintenance window will have a severely negative effect on income-producing traffic.

Calculating the tamping cycle based on the number of crossing loops and whether it is a double or single line

Double lines are more flexible due to the fact that traffic can pass on the adjacent line. Single lines require more careful consideration of maintenance in general, due to the effect it has on traffic.

On high-traffic-density single lines tamping is often required to take place in-between trains, which means that the machine must vacate the line for oncoming traffic. This requires crossing loops where the train can cross the machine. If these crossing areas are too far apart, the machine may not be able to work for very long before it needs to start vacating the line. Once again, higher-production machines may be required and the travelling speed of these machines will also become important.

CONCLUSION

There are many considerations when choosing the appropriate tamping machine for a specific line or section. Unless all the selection criteria are considered, the most cost-effective machine or combination of machines will not be contracted, which may result in excessive costs and track infrastructure damage.

Source:
http://www.saice.org.za/downloads/monthly_publications/2013/2013-Civil-Engineering-May/#/0