Performance of Flail Hammers

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Performance of Flail Hammers

by Frédéric Guerne [ Digger Foundation ]

Examples from the field show that when carrying out ground preparation work with demining machines, the parameters that influence the user's operational choices can be based on ill-suited criteria. A number of factors need to be considered before employing flails in the field, some of which are described here. This article does not detail a full scientific study, but instead shares some practical experience from the field. The article provides information regarding the strengths and limitations of different flail hammer designs, as well as advice on the best way to use these tools. Our conclusions about flail hammers come from using the Digger D-2 during demining operations in Sudan, and from tests carried out by the Digger Foundation to improve the performance of the D-2 in Sudan.

The article also stresses the point that demonstrations of machines in short runs or lanes cannot be expected to highlight all the key parameters involved, in particular the life span of wearing parts such as hammers. These factors must be analyzed in detail through field tests. Digger's field experience can hopefully provide insight and guidance for others to apply to their own contexts.

Flail Hammers

Two of the most important parameters of flail hammers, their shape and material composition, heavily influence the efficiency, lifespan, and price of hammers. Identifying the best possible hammer, i.e., the design that provides the best results depends on the projected use and leads to the necessity of finding the best balance between these aspects.

Influence of the Hammer Shape on Digging Efficiency

We define efficiency as the ability of a flail hammer to penetrate soil under specific conditions to a given depth using the least possible power. The more efficient a hammer is, the lower the fuel costs. These considerations assume that the desired digging depth is the depth setting of the flail. It is not acceptable to improve efficiency simply by decreasing depth.

To the best of Digger staff knowledge, and from what has been observed by staff in the field, the most widely used hammer shape is the mushroom-shaped hammer. This hammer design provides good digging efficiency—the sharper the cutting edge is, the more efficient the hammer will be. Using the Digger D-2 electronic load-sensing control,1 the efficiencies of different hammer shapes and designs were compared by simply measuring the time spent working as soon as the sharpness reduces, the digging efficiency is lost and the hammer loses its advantage.

Life Span

The Digger Foundation's experience in Sudan has greatly influenced the design of Digger hammers with a 3-mm tungsten coating on the bottom surface. During Digger operations in Sudan at first, the traditional thick, mushroom-shaped hammers were used. In the conditions we met, however, especially of two to three, compared to the non-temporal (150 HB) square-shaped hammers. In North Sudan, a lifetime of around 14–18 hours was finally reached.

Digging Efficiency

The remaining question was how to combine a long life span with a sufficient cutting and digging efficiency. To answer this, we developed a hammer with a new shape—one with a sharper cutting edge than square hammers that could also be used for a long time without needing to be replaced. These new hammers are made of the same standard steel, square-shaped but we used for the square hammers, but arc cut at an angle and have the chain attachment off-center.

The use of the costly tungsten coating (about 12 euro or US$17) for the coating of one hammer when producing a minimum of 200 at one time provided the best compromise between hardness and shock resistance. Though this type of coating increased the lifetime by a factor of four to six compared to the uncoated steel (150 HB), it was still not acceptable (i.e., less than three hours' operating time before being worn out). Six different tungsten coating systems were then tested, from thin (0.1 mm) to thick coatings (2–3 mm). This testing was done using impact tests and flame deposition.

One of the downsides of using a hard tungsten coating was the associated cost. Eventually, the cost/life span ratio was deemed unsatisfactory and Digger then moved to using square-shaped hammers, which have a longer life span. With this hammer type, using 150 HB steel, the advantage is that the hammers can wear more than 70 mm before having to be replaced.

This new solution and design increased the life span by a factor of two in comparison to the expensive, tungsten-coated "mushroom" version. The hammers could now be used for six to seven hours. However, researchers declared a life span of six hours was still not sufficient and sought other solutions to further increase the life span of the hammers.

The steel hammer (150 HB) was replaced by one that can be tempered (about 300 HB). This process had the advantage of being significantly less expensive than tungsten coating. With this improvement, the life span of the hammers was increased by a factor of two to three, compared to the non-temporal (150 HB) square-shaped hammers. In North Sudan, a lifetime of around 14–18 hours was finally reached.

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The center of gravity of the hammer head will automatically be positioned in line with the chains by the centrifugal force of the turning flail, ensuring that the hammer position is at the desired angle when hitting the ground and that its cutting edge is optimally placed. This wear of the hammers, due to their position, is minimal while allowing...
for maximum cutting. These hammers are also tempered to provide the same advantages we had with the square-shaped ones.

Cost Aspects
As indicated above, in order to reach a good efficiency/life span ratio, technological solutions (steel quality, tempering process, etc.) have to be engaged, which can increase the price of the hammers. According to Digger’s experience, it is more effective to have high-quality hammers with an appropriate design than to use low-cost hammers that will be worn out in a few hours. Another requisite operator to receive the machine frequently to replace damaged hammers. Having to change hammers also represents a logistical problem in terms of transportation and storage of spare parts. Such delays, in turn, further increase the overall running cost. Trying to save money with low-quality hammers can turn out to be quite costly.

Flail Rotating Speed
Another important point to regard with the hammer design is the rotating speed of the flail. The faster a flail rotates, the greater the wear of the hammers. Decreasing the rotating speed of the flail, however, can lead to very dangerous results concerning the digging efficiency of the flail to try to reduce the wear. This will undoubtedly reduce the quality of the work, and it is not recommended.

Conclusion
Flail hammer choice represents a critical aspect of mechanical-demining operations with flails. The design and quality of the hammers need to be considered carefully since these factors will have cost and operational implications for the project as a whole in the long run. Regarding the comparison between life span and digging efficiency, Table 2 (above) summarizes the characteristics of the standard hammers Digger developed and corresponding lifetimes based on Digger’s operational experience in Sudan.

Some flail manufacturers offer low-cost hammers with parts such as hammers to reduce the total running cost of the machine advertised on commercial documents. It is important to consider that the hammer materials and not just their initial cost, to gauge all costs associated with machine operation. This aspect must be thoroughly analyzed according to the factors described above when considering where and under which conditions the flail will be used. See Endnotes, Page 125.

Summary Comparison Between Life Span and Digging Efficiency

<table>
<thead>
<tr>
<th>Hammer Type</th>
<th>Lifetime under extreme wear conditions (North Sudan) (failing hours)</th>
<th>Average lifetime under normal wear conditions (South Sudan) (failing hours)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square shape, tempered hammers (380 HB) (hard)</td>
<td>14–18</td>
<td>60–80</td>
<td></td>
</tr>
<tr>
<td>Square shape, untempered hammers (150 HB) (soft)</td>
<td>6–7</td>
<td>30–40</td>
<td></td>
</tr>
<tr>
<td>Square special shape hammer, tempered hammers (380 HB)</td>
<td>14–18</td>
<td>60–80</td>
<td></td>
</tr>
</tbody>
</table>

Square-shaped hammer:

1. Use the hammer. While in the area, the hammer (or a variation thereof) was the only tool available to the person who discovered the landmine.
2. Total running cost of the machine advertised.
3. Some flail manufacturers offer low-cost hammers with parts such as the hammer materials to reduce the total running cost of the machine advertised on commercial documents. It is important to consider that the hammer materials and not just their initial cost, to gauge all costs associated with machine operation. This aspect must be thoroughly analyzed according to the factors described above when considering where and under which conditions the flail will be used.

Frederico Guerre worked for 10 years in Europe in industry as a development engineer. Since 1996, he has worked as a technical consultant and public relations staff for the Digger Foundation (Digger Foundation, 1996), the non-profit organization of the Digger Foundation, which manufactures demolition-assisting machines.

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Latin Victims are Invisible, India and Sri Lanka [on page 12]
3. For a copy of the article, available at: http://mediaquatro.sites.uol.com.br/minas-folha.html. This article was also reprinted in "Beyond Borders: Towards a Total Ban on Anti-personnel Mines and for Cooperation in Mine Action." Comprehensive Action Against AP Mines, Case [from page 16]
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