Summary

The entire terminal of Tata Steel has the capacity to produce 7,5 million tons of steel annually, while they expect to produce 7,2 million tons of steel in 2011. In order to produce the previously mentioned 7,2 million tons of steel, they need over 10,8 million tons of iron ore, as well as high volumes of pellets and coal. Since all of their raw materials are shipped to them in bulk vessels, it comes as no surprise that Tata Steel is situated adjacent to the North Sea.

On the terminal three 40 tons bulk cranes are responsible for unloading all the necessary bulk material. In order to ensure the cranes operate within their designed limits, they are fitted with an overload protection system. This system intervenes when the crane is subjected to a load which exceeds a pre-defined threshold, seizing all activity. These interruptions negatively affect the cranes' productivity (tons/hour) as well as being a hindrance for the crane operators.

Tata Steel noticed a relation between the moisture content of the iron ore, and the number of maximum load occurrences during the unloading process. Whenever they unload an iron ore with a relatively high moisture content, the amount of maximum load occurrences increases significantly when compared to 'dry' iron ores. How the additional moisture content affects the interaction between the material and the grab, giving rise to the increased amount of maximum load occurrences, was initially unknown.

One force which could possibly explain the increased amount of maximum load occurrences, was film cohesion, which would create suction between the material and the surface of the grab.
An experiment was devised in order to determine whether or not film cohesion occurs during the unloading process, and to possibly quantify that force.
Based on the results of the experiment, film cohesion appears to not influence the force on the grab significantly.
Reviewing the load on the crane during ML occurrences revealed that the payload in all those cases was simply too high, with the highest payload recorded being 52 tons.. Any payload over ~45 tons will cause the overload protection system to intervene, once the additional forces of acceleration come into play.

Since there are only two factors which influence the nominal weight of a filled grab, namely the bulk density of the material and the capacity of the grab, both were examined.
Experiments indicated that the bulk density for Carajas fines maintained by Tata Steel; 2,5 tons/m^3 should be higher, based on the experiments it should be ~2,7 tons/m^3.
Even with the increased bulk density a nominal weight of 52 tons still could not be explained, the capacity of the grab was also examined.

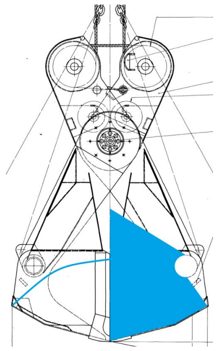

Figure 0.1 Designed capacity (left) and realized capacity (right)

During previous experiments a fill rate of the grab was observed, which went beyond the designed 9,6m^3. This increased capacity was realised through the formation of an additional pile of material between the two main tubes in the grab (see Figure 0.1). The formation of this pile was made possible because of the additional moisture content, which increased the angle of internal friction of the material, allowing the pile to be formed. This increased the capacity of the grab from the designed 9,6m^3, up to 13-14m^3.

With the higher capacity and the increased bulk density, the previously mentioned 52 tons can be explained. These very high nominal weights caused the increase of maximum load occurrences during the unloading of iron ore with a high moisture content.

Possible measures which could reduce the problems caused by maximum load occurrences include:

- Adjusting where the overload protection system is allowed to intervene. It currently can intervene during trolley travel, which results in the grab swaying causing possible dangerous situations. The overload protection system shouldn't intervene during trolley travel.
- In order to reduce the impact on the crane, loads which will trigger the overload protection system should be stopped much faster than they currently are. One way of determining maximum load cases faster is through using the speed of the closing and hoisting sheave. Once a certain speed is reached, the load on the crane is checked, if the load exceeds a certain pre-defined threshold, the grab should be halted. With such a system a majority of the ML cases should be stopped much faster than after the current three seconds.
- A dedicated grab for problematic iron ores with a lower capacity (~8m^3) should lower the amount of maximum load occurrences considerably.

Tata Steel is already taking measures in order to reduce the hindrance caused by maximum load occurrences. They have ordered new grabs with a capacity of 9,0m^3, which will be made out of lighter high tensile strength steel.

Another measure which Tata Steel has undertaken is to diminish the amount of Carajas (one of the worst problematic iron ores) in their ore portfolio. Over the course of roughly two years Carajas should be fully replaced by Tonkolili, a new iron ore from Sierra Leone.

Tonkolili should have minimal maximum load occurrences, due to its very low bulk density of 2,06 tons/m^3.