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THE REBUILD OF TATA BLAST FURNACE C INCORPORATING THE LATEST IRONMAKING TECHNOLOGY[1]

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Abstract

At the Tata Jamshedpur Steel Works, C blast furnace which is part of the chain of A-F furnaces underwent a reline during 2008-2009. The reline was the first of its kind being carried out completely by the Jamshedpur Ironmaking Engineering team. The new furnace incorporates the world's first Gimbal Top® and has been expanded in terms of production to 0.7million tpa from 0.4million tpa. The up-graded furnace incorporated several new aspects including: the worlds first Gimbal Top®, Taphole drill and Twin mud guns, New Two Stage Davy cone Gas Cleaning plant, new closed circuit Stave cooling system. This paper will discuss the overall project program and furnace design concept. Specific reference will be made to the novel areas of the new design. The construction and commissioning periods will be described and data will be provided from the first few months of operation. This will highlight the benefits of the Gimbal Top®.
Key words: Blast furnace; Rebuid; Top charging system.

REFORMA DO ALTO-FORNO C DA TATA INCORPORANDO AS ÚLTIMAS TECNOLOGIAS DE REDUÇÃO

Resumo

O Alto-Forno C da Tata Jamshedpur Steel Works é parte de uma cadeia de fornos de A-F e passou recentemente por uma reforma em 2008-2009. A reforma foi a primeira conduzida completamente pela equipe de engenheiros da redução de Jamshedpur. No novo forno foi incorporado com o primeiro Gimbal Top® em alto-forno do mundo, além de expandir a capacidade de produção para 0,7 milhões de toneladas por ano comparado com o 0,4 milhões de toneladas por ano anterior. A reforma incorporou vários novos aspectos como: o primeiro Gimbal Top® em alto-forno do mundo, perfuratriz e canhão de lama duplo, novo Davy Cone na planta de limpeza e gás e novo circuito fechado de Staves. Este trabalho irá discutir o programa do projeto como um todo e os conceitos do projeto do forno. Referência específica será dada as áreas com projetos novos. Construção e comissionamento serão descritos e dados dos primeiros meses de operação serão apresentados. Os benefícios do Gimbal Top® serão enfatizados.
Palavra-chave: Alto-forno; Reforma; Sistema de carregamento do topo.

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1 INTRODUCTION

At the Tata Steel Limited (TSL) works in Jamshedpur, India 'C' blast furnace sits in the middle of the string of blast furnaces A to F. A to D are small furnaces and F is slightly bigger; with the Steelworks also having two larger furnaces namely G and H. In 2007 the project for the rebuild of C furnace commenced. The Project Group of Tata Steel executed and implemented the furnace update. The furnace design took on many new aspects that the Tata Steel Project group managed through working with a number of different contractors. Siemens VAI supplied the top charging and gas cleaning technology equipment. SVAI also assisted throughout the construction and commissioning period with supervisory services.

2 'C' BLAST FURNACE REBUILD

The rebuild of the furnace took on many new or novel aspects. The stockhouse automation was updated to incorporate Siemens PCS7 processors and Tata Steel installed the first SIMETAL Gimbal Top® on a blast furnace. Tata Steel stated that the selection of Gimbal charging technology was part of their drive to seek new innovative technologies in blast furnace operation. Prior to installation on the furnace the actual Gimbal unit along with associated charging equipment was put through rigorous trials over a three month period in 2008 to establish that it could achieve its designed throughput and determine key data about the performance for later use in the operation of the furnace itself.

Figure 1 shows the original and new arrangements of the blast furnace. Whilst the skip bridge and stockhouse were retained with refurbishment it is the area of the furnace proper that received the greatest attention at the time of the rebuild.

The blast furnace proper has been designed in consultation with SSIT China. The blast furnace is a free standing design with a four post tower column arrangement. The furnace cooling water system is based on a closed circuit stave arrangement. The staves installed are series cooled with two channels. The closed loop softened water system circuits were designed in house by TSL and Tata Consulting Engineers (TCE). Cast iron staves are used in the hearth, middle stack and upper stack. In the high heat zone of the belly of the furnace cast steel staves were installed. Refer to Figure 2 for additional information on the furnace profile.

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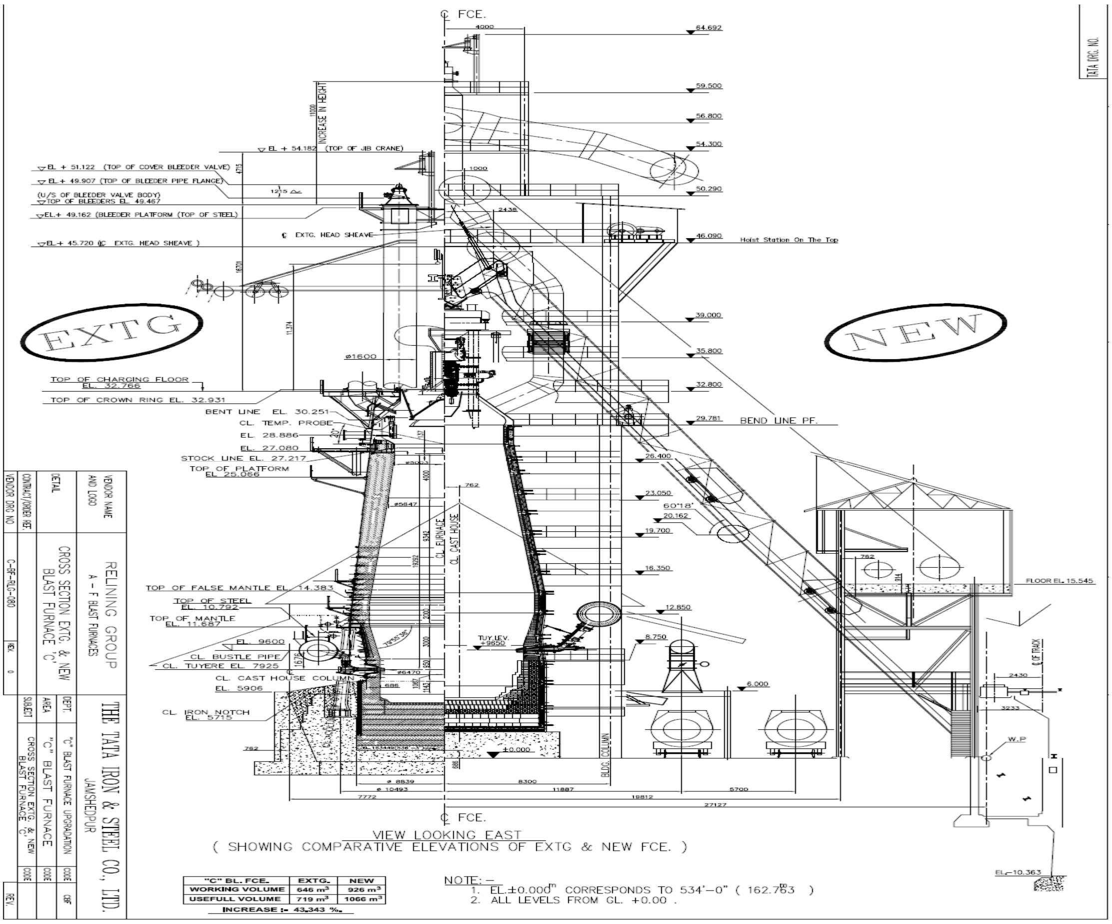
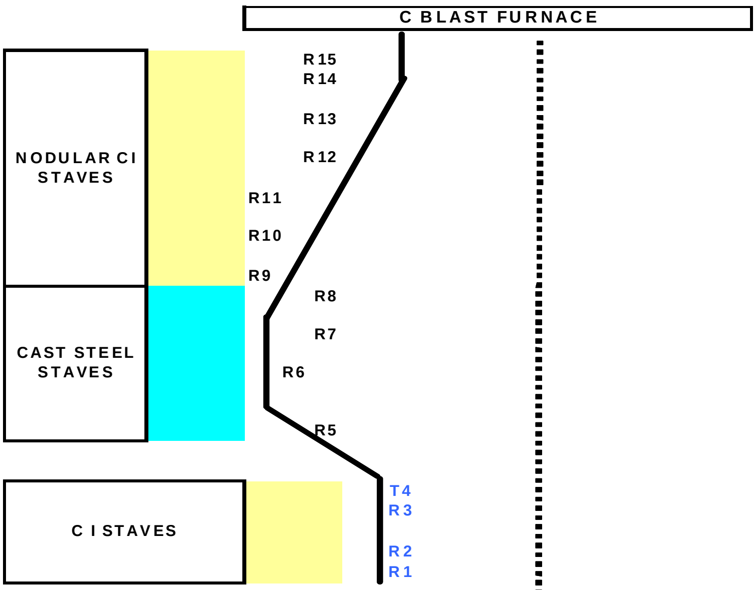


Figure1: Furnace overview showing the furnace before the rebuild and after.



Cooling Ckts	Elements cooled	Water (m3/hr)	Delta T(°C)
Ckt 1	ALL COOLING STAVES	2100	6
Ckt 2	ALL OTHER COOLING MEMBERS	2400	
TOTAL		4500	6

Figure 2: Diagram showing the placement of the staves.

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The furnace has been upgraded from 12 tuyeres to 20 tuyeres; the hearth diameter has been increased to 7.9 m .The furnace inner volume has been increased by 50% to 1072 m^3.

Coal Tar injection is used on the all of furnaces A to F. The design basis for 'C' furnace is 55kg/tHM but this has actually been increased up to a level of 70 kg/tHM

Blast furnace 'C' has one cast house with two tap holes with non–drainable troughs. The cast house has been uniquely designed for C blast furnace with a 30 degree bend in each trough which is the first of its kind in the world. There are common runners for hot metal and slag in case of slag granulation outage. A plan view of the cast house floor can be seen in figure 3. Each tap hole has its own hydraulic clay gun and a common hydraulic/pneumatic tap hole drill machine. The two tap holes are 60^o apart. The cast house leads to the slag granulation system which was designed in-house and TCE.

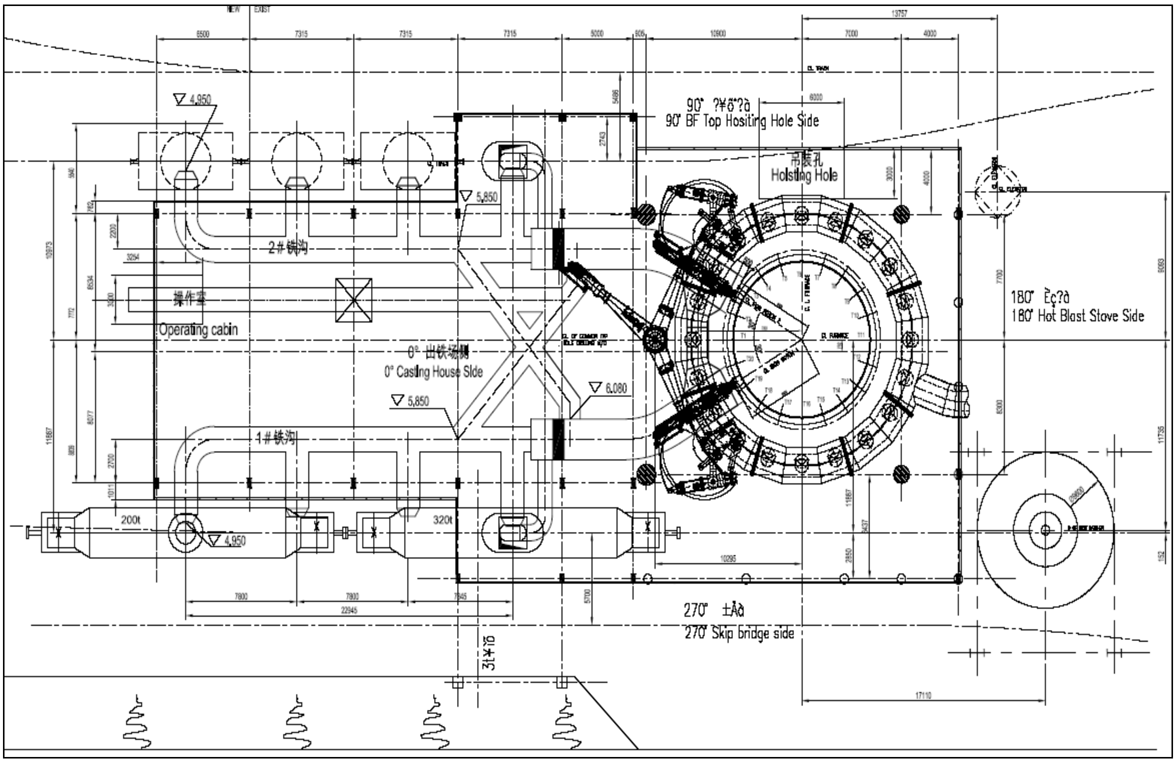

Figure 3: Plan view of the upgraded casthouse floor.

The automation of the hot blast stoves was carried out by Tata Steel with provision of a ceramic burner by elevation of the hot blast main and changing of 40 courses of chequers and the complete change of stove dome refractories and the skin wall of the combustion chamber.

Figure 4: 3-D model of the Davy Cone Gas Cleaning Plant.

The new furnace was designed to operate with a top pressure of 0.5 bar g. The top pressure itself is controlled by an SVAI two stage gas cleaning system incorporating a Davy cone for the final gas cleaning and pressure reduction stage. As the dirty gas leaves the blast furnace the coarse particles are collected in the duct catcher that has been relined. The gas cleaning plant is situated approximately 200 m from the furnace and is managed by the Fuel Management department at Tata Steel. The gas cleaning plants for all of the furnaces are managed by this group and are grouped to suit.

When the gas reaches the first stage of the gas plant it is quenched by water sprays. Once it has passed through the first section the gas is passed over the Davy cone which controls the furnace top pressure and completes the gas cleaning process. Once through the Davy cone the gas is passed through a packed bed to remove excess moisture before it is transported to the common clean gas main.

The SVAI gas cleaning system reduces the dust and mist content in the clean gas to state of the art levels that make the gas a suitable fuel for within the works. Levels of 5 mg/Nm^3 for dust and 5 g/Nm^3 are the design basis for the system.

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Figure 5: 3-D Model of Top Charging System.

The furnace top charging system provided a single top hopper that is 9.0m^3 in volume. The charging system is a central feed pressurised system, with secondary nitrogen equalising. The hopper is pressurised by a primary equalising line that is semi clean gas from the gas cleaning plant. The secondary equalising line is used to keep the pressure in the hopper during discharge. The top hopper is fed by a skip charging system which was upgraded by TSL during the rebuild. The philosophy of the skip charging is single skip charging with a volume of 6.18m^3, with the Gimbal rotating at 8RPM this provides two rings. The operational flow rate that was confirmed during the testing period is 0.42m3/s.

The control of material discharged into the furnace is controlled by a weighing system with vibration monitoring. The furnace charging and stockhouse is controlled using Siemens PCS7 a first at Tata Steel Jamshedpur. The level one and HMI screen for the Gimbal Top® charging was supplied by Siemens VAI. Figure 5 shows the Gimbal Top® charging HMI screen. The screen identifies how much material has been dumped into each ring in the previous charge and how material will be dumped into each ring on the current charge. In addition the operator is also informed of which stage the charging cycle is in, in relation to the Gimbal Top®.

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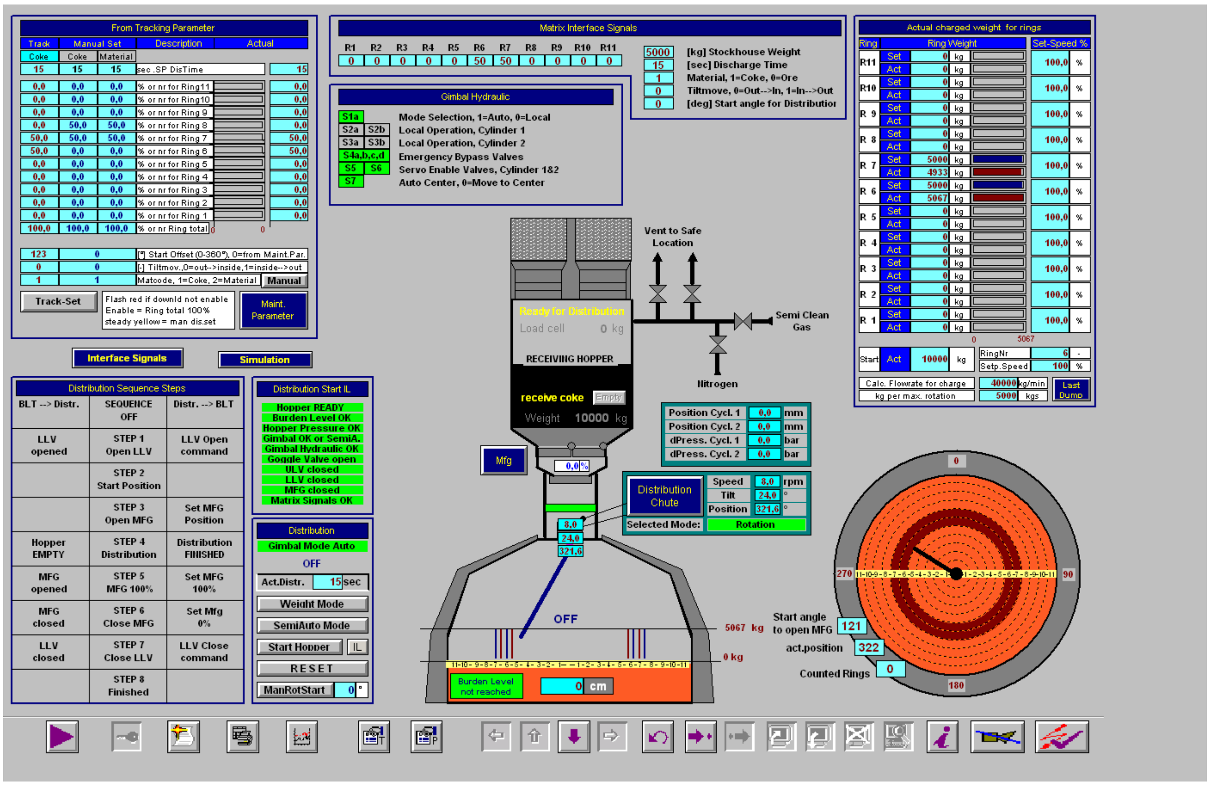

Figure 6: Furnace charging HMI screen.

3 START UP AND INITIAL OPERATION OF BLAST FURNACE C

Blast furnace C was blown in on 22nd September 2009. The furnace inauguration was carried out by the Managing Director of Tata Steel LTD, Mr HM Nerurkar who paid tribute to the good working relationship and dedication of both teams.

“The remodelled C blast furnace complements the technical know-how and dedication of both the Siemens and Tata Steel teams. I am sure that operations at C blast furnace and production as a whole will now greatly be enhanced with the implementation of the Gimbal technology”.

The design output, 2000 tHM per day, of the furnace was reached within 16 days of start up. The furnace is operating with a reduced top pressure of 0.39bar. The new lower top pressure meant that the gas cleaning plant had to adjust its working position of the Davy Cone.

The fuel rates of the furnace have improved from the fuel rates that were seen in C furnace before the re-build. Fuel rates before the rebuild were as high as 650 kg/tHM. Since blow in fuel rates have been as low as 540kg/tHM which is even below the design of 570kg/tHM, despite the potential limitations of the raw materials available.

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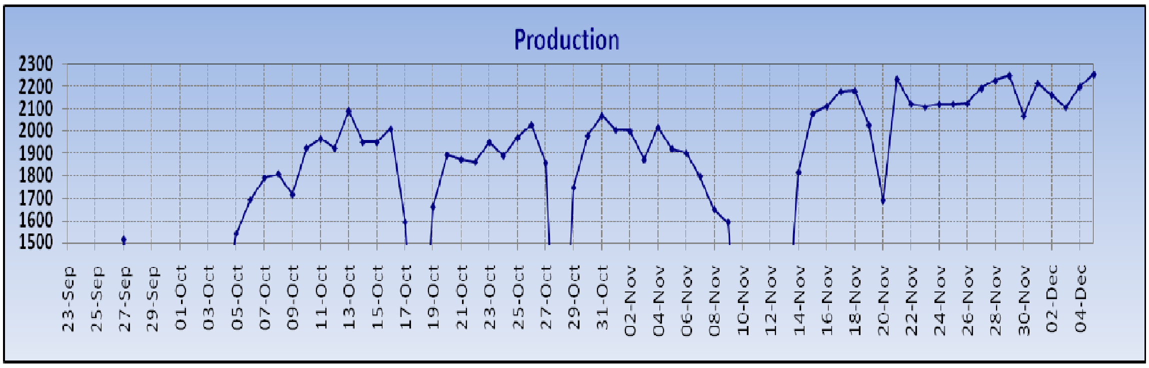

Figure 7: Chart showing the production from blow in until reaching in excess of the design target of 2000tpd.

4 CONCLUSION

4.1 Benefits of Centre Charing

During the first two months of operation it was identified that gas was tracking up the walls of the furnace which creates a non ideal temperature profile. To rectify the temperature profile coke was charged at true centre. This increased the gas flow through the centre of the furnace and created the wanted profile. Figure 7 below shows the above burden temperature profile while charging at notch one, a tilting angle of 4^{o} and the improved temperature profile once true centre charging had been carried out.

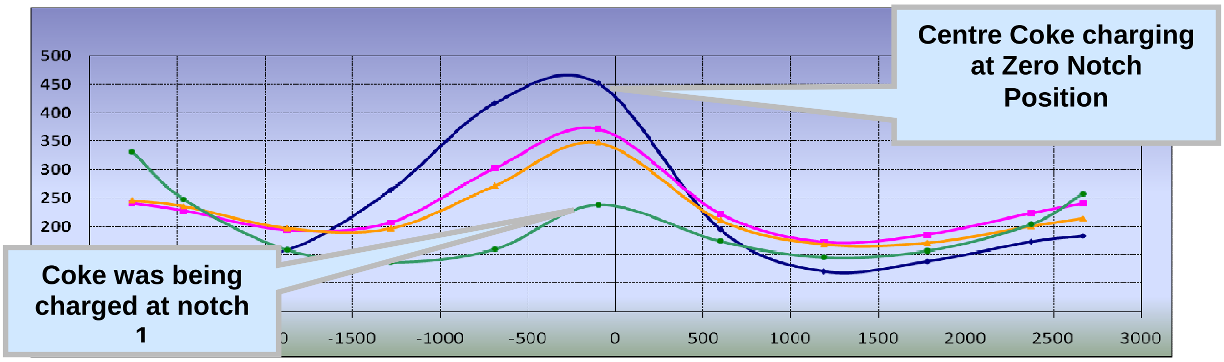

Figure 8: Above Burden Temperature profile identifying the benefits of centre charging.

4.2 Benefits of Sector Charging

During routine data analysis it was noticed by the operations team that the stave body temperatures were falling. A drop in temperature indicates that there is a build up of un-reacted material in the area. Five tonnes of coke were charged in a sector pattern to rectify the temperature. Referring to figure 8 is can be seen that within two days the temperature had normalised and the rise could be seen in lower stack area.

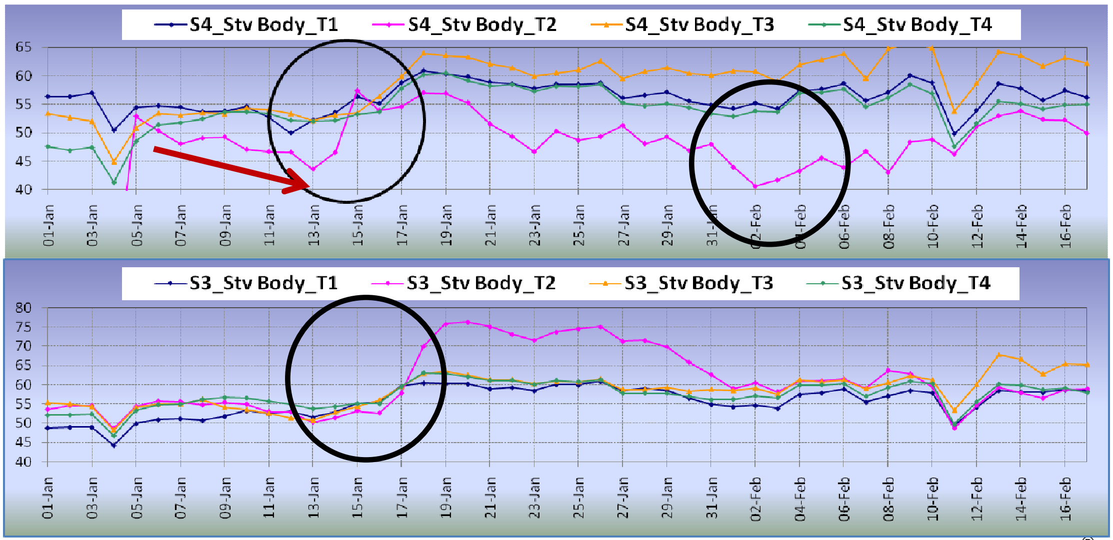

Figure 9: Stave temperature profile showing the benefits of the flexibility of the Gimbal Top®.

In addition to the two cases mentioned above the operations team at Tata Steel have used the spot and sector charging function of the Gimbal Top® to rectify sluggish material movement in the furnace. During the blast furnace operation some sluggish burden movement was observed at tuyere numbers 5 and 6. The proper burden descent could be restored by spot charging a skip of extra coke.

To gain a better and more precise understanding of sector and spot charging a model has been developed to facilitate this. Figure 9 shows the model with two examples.

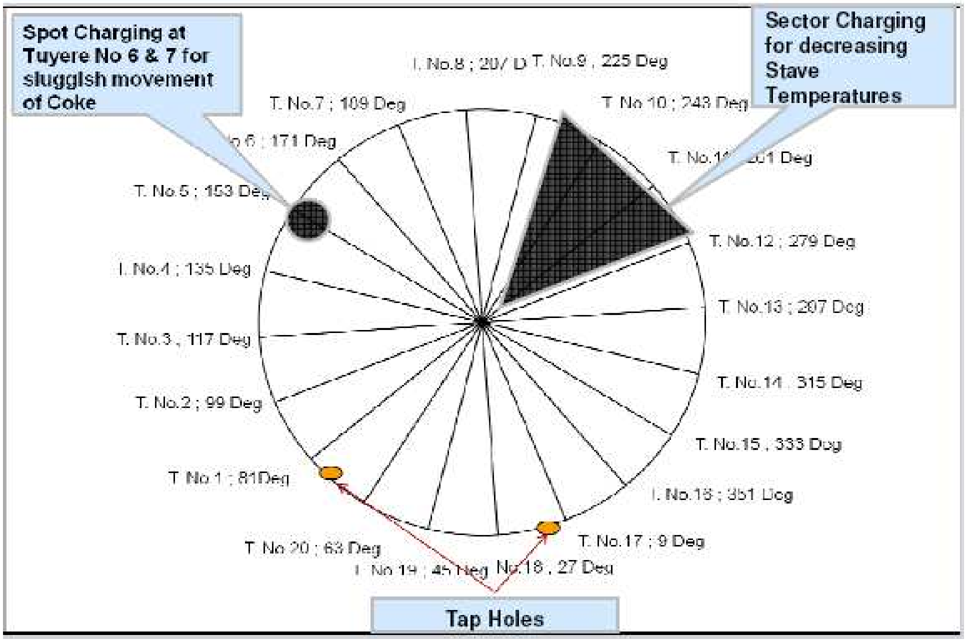

Figure 10: A map of the furnace tuyeres identifying the tuyere position to allow accurate sector and spot charging when required in a certain area.

The execution of the project by Tata Steel was carried out successfully and C furnace was started in September 2009. Since blow in the furnace has worked at design capacity. The updated technology installed has allowed for more efficient running of the furnace. The flexibility of the Gimbal Top® has allowed the operations team at Tata Steel to react to and solve operational issues quickly.