POSTECH

Graduate Institute of Ferrous Technology
GIFT

# δ - TRIP Steel

**H. L. YI[1,a], S. K. Ghosh[1], H. K. D. H. Bhadeshia[1,b], K. Y. Lee[2]**

[1]*Graduate Institute of Ferrous Technology (GIFT), Pohang University of Science and Technology (POSTECH), Pohang 790-784, Republic of Korea*

[2]*POSCO Research Laboratories, Gwangyang, Republic of Korea*

•***E-mail:*** hityihl@postech.ac.kr[a], hkdb@postech.ac.kr[b]

## *Introduction*

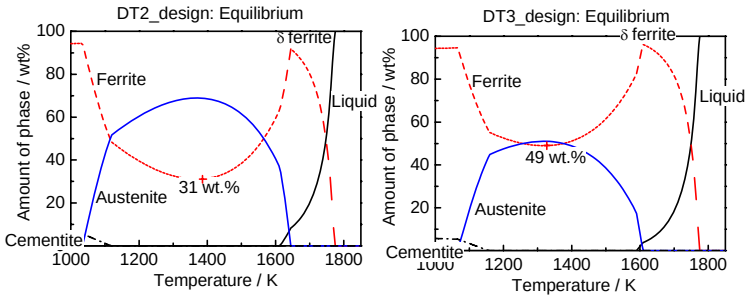
An attempt has recently been made to produce TRIP-assisted steel which contains a large fraction of δ-ferrite dendrites locked into the microstructure from the solidification process. This δ-ferrite persists in the microstructure during subsequent heat treatment, such that the steel can never become fully austenitic at any temperature. The steel is then heated into the two phase δ + γ phase field and the resulting austenite then transformed isothermally into a mixture of bainite and carbon-enriched retained austenite. This retained austenite gives the steel its improved properties thorough transformation-induced plasticity. This concept contrasts with normal TRIP-assisted steels in which the steel can be fully austenitised. It has been discovered in further experiments that the alloy design procedure which ensures the presence of stable δ-ferrite in the microstructure must take into account that the solid–state transformation that takes place in cooling from the solidus temperature does not occur with the equilibrium partitioning of solutes. As a consequence, the amount of δ-ferrite obtained can be far less than expected from equilibrium calculations.

## *Alloy design*

Two alloys were designed based on the phase diagram calculated by MTDATA with TCFE v1.21 database.

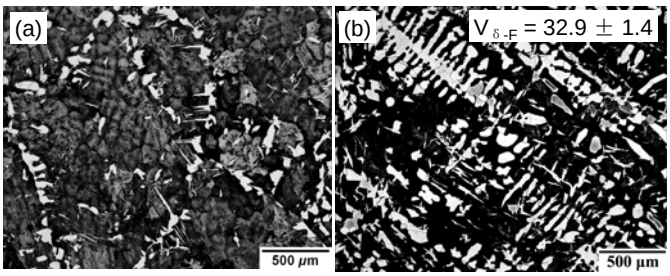
Chemical compositions of two designed alloys

| | C | Si | Mn | Al | Cu | P |
|---|---|---|---|---|---|---|
| DT2_design | 0.4 | 0.25 | 2.0 | 2.1 | 0.5 | 0.02 |
| DT3_design | 0.4 | 0.25 | 2.0 | 2.5 | 0.5 | 0.02 |




Equilibrium phase diagrams for the two designed steels

## *Results and Discussions*

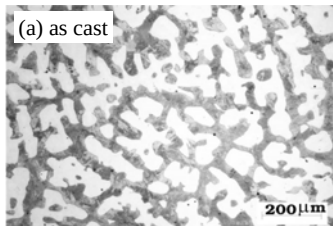



Optical micrograph of (a) DT2_P and (b) DT3_P in as-cast condition

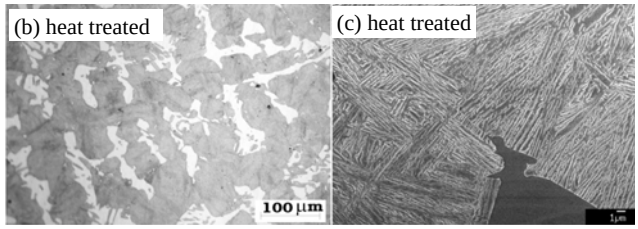
## *Conclusions*

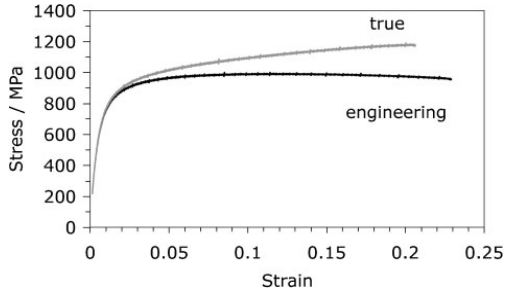
Alumimiun is the most significant element to increase the fraction of δ-ferrite in the as cast steel. It containing 2.5 wt.% of Al fulfiled 32.9±1.4 vol.% of δ-ferrite at the as cast condition at the approximate industrial continuous cooling rate 20°C/s. The mechanism that he volume fraction of δ-ferrite is between the equilibrium and para-equilibrium phase diagrams will be discussed in the other paper.

***Acknowledgement*** This project is supported financially by POSCO




Optical micrograph (a), (b) and FEGSEM image (c), of δ - TRIP steel



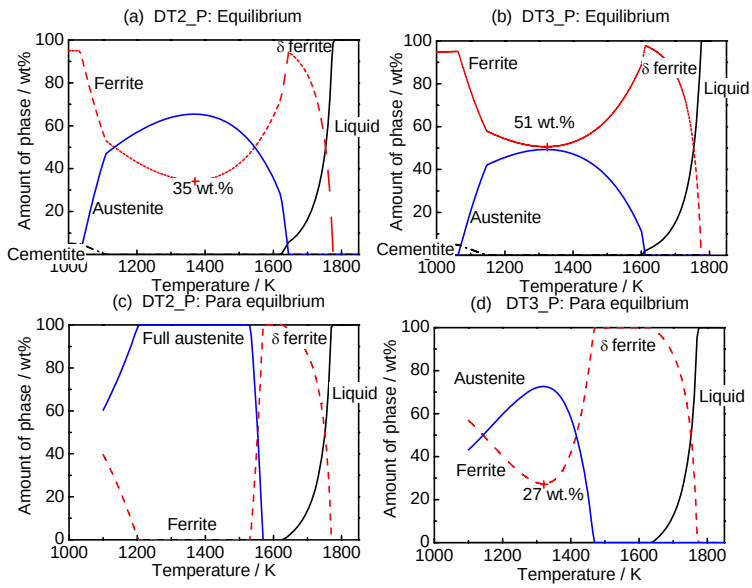

Stress–strain curve of heat treated δ - TRIP steel at room temperature(S. Chatterjee and H. K. D. H. Bhadeshia, 2007)

## *Experimental*

Two 34kg ingots were obtained from POSCO using a steel mold in an electric vacuum furnace with a approximate cooling rate 20°C/s, whose dimensions were 170mm in length, 100mm width and 230 mm in height, whose chemical compositions are shown the following table.

Chemical compositions of two alloys produced in POSCO

| | C | Si | Mn | Al | Cu | P |
|---|---|---|---|---|---|---|
| DT2_P | 0.361 | 0.255 | 2.02 | 2.13 | 0.485 | 0.02 |
| DT3_P | 0.368 | 0.233 | 1.985 | 2.493 | 0.491 | 0.02 |




Equilibrium (a), (b) and para-equilibrium (c), (d) phase diagrams for the two steels received from POSCO