Microstructural evolution during high-temperature partitioning of a medium-Mn Q&P steel

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Microstructural evolution during high-temperature partitioning of a medium-Mn Q&P steel

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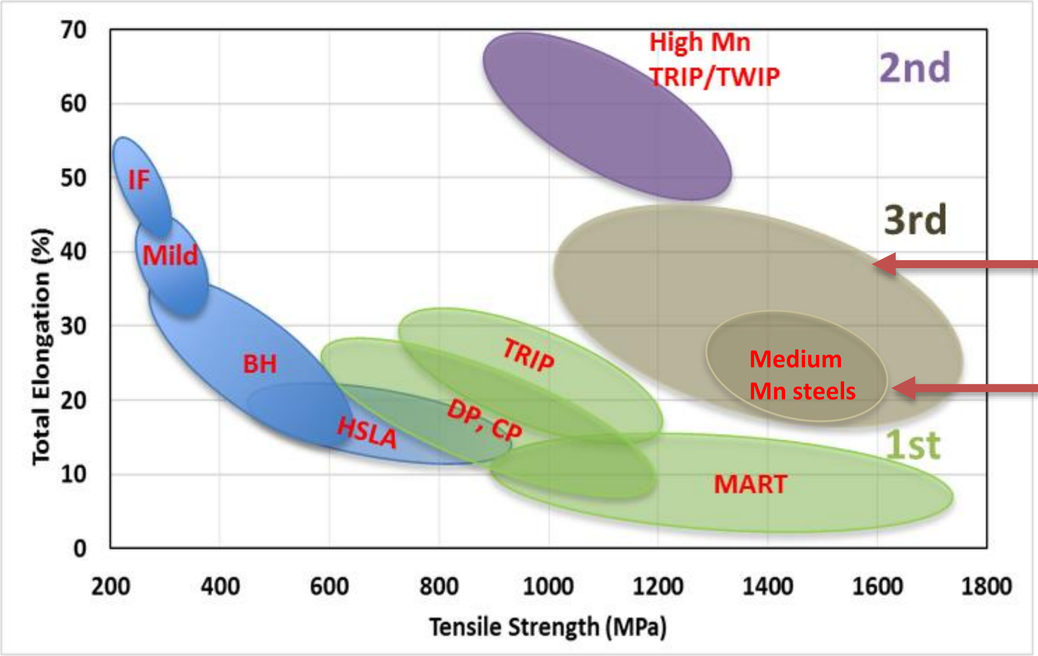
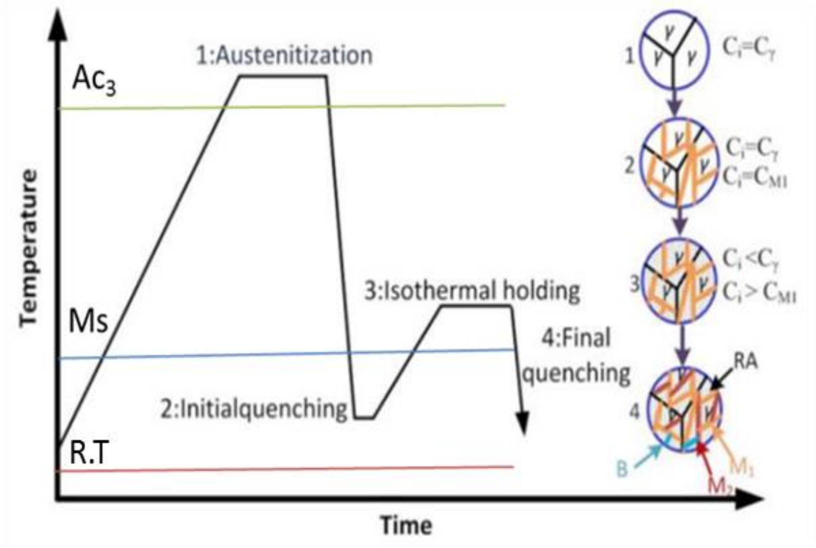
TU Delft

Introduction : 3rd generation AHSS



- Quenching & partitioning (Q&P) process: Combination of high strength and ductility
- Medium Mn steels are considered as potential candidates for 3rd generation AHSS
- Mn – Strong austenite (γ) stabilizer.

Introduction: Quenching & partitioning (Q&P) process



Partitioning of interstitial/substitutional alloying elements from martensite (α^{l}) to austenite (γ)

Retained austenite (RA): Ductility

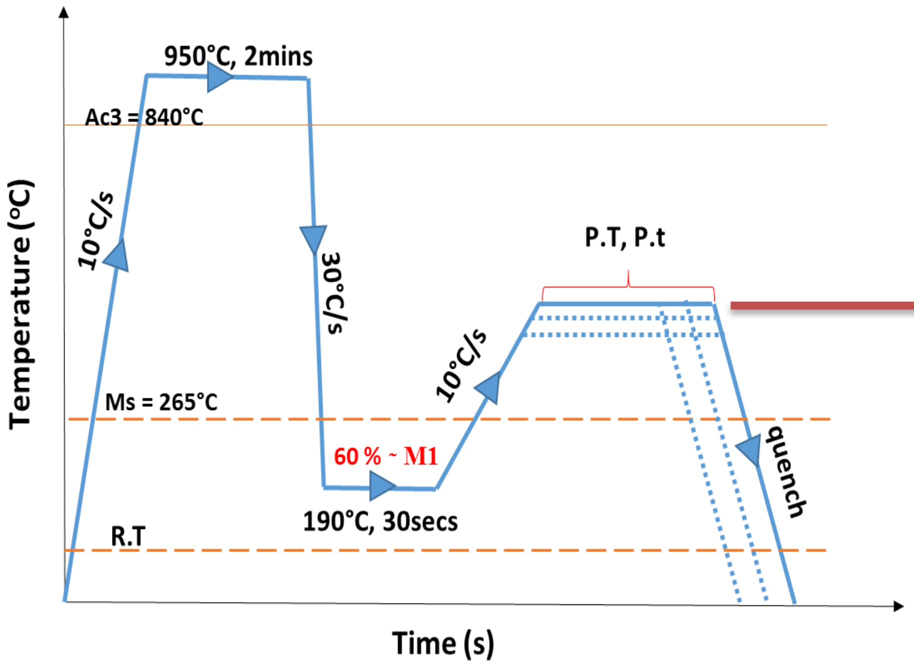
Martensite (primary & fresh): Strength

Ac3 – Austenite finish temperature, Ms - Martensite start temperature, R.T. – Room temperature

In the current research work, we investigated:

The evolution of microstructure at high partitioning temperatures in the medium Mn steels.

Approach: Experiments & characterization techniques



Steel grade: 0.31C-4.58Mn-1.52Si (in wt. %)

Partitioning conditions

- Partitioning temp., : 400, 450, 550 °C
- Partitioning times : 180, 900, 3600 s

Competitive reactions

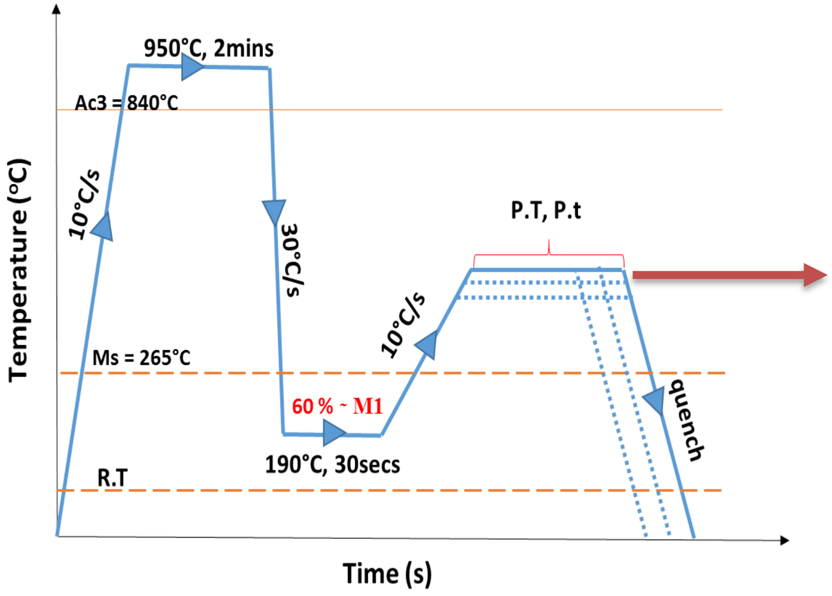
- Carbide precipitation
- Alloying element (C/Mn) partitioning
- Bainite formation
- Pearlite formation

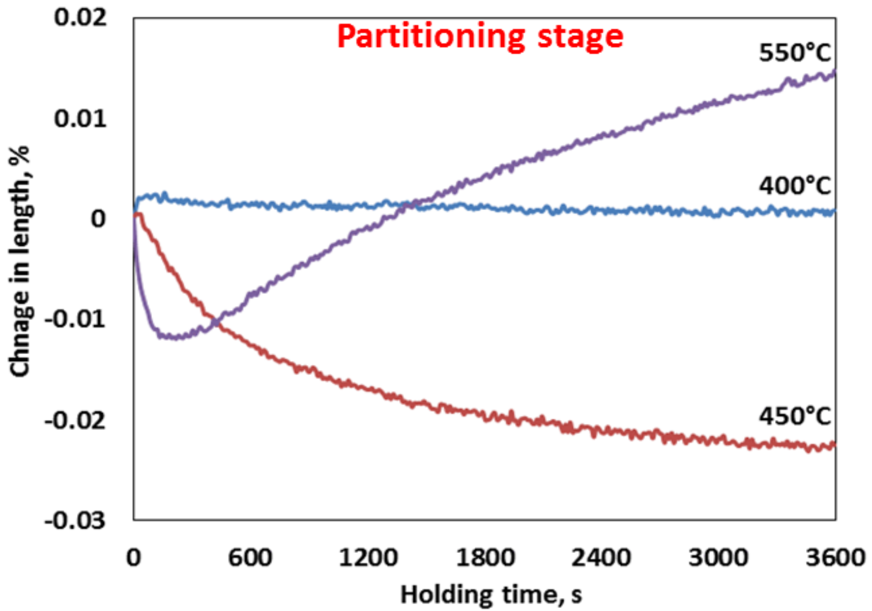
Microstructure characterization techniques

- **Dilatometer**
- **SEM**
- **XRD**
- **Vickers Micro-hardness**

P.T – partitioning temperature , P.t – partitioning time, M1 – Initial Martensite, R.T. – Room temperature

Results & discussion

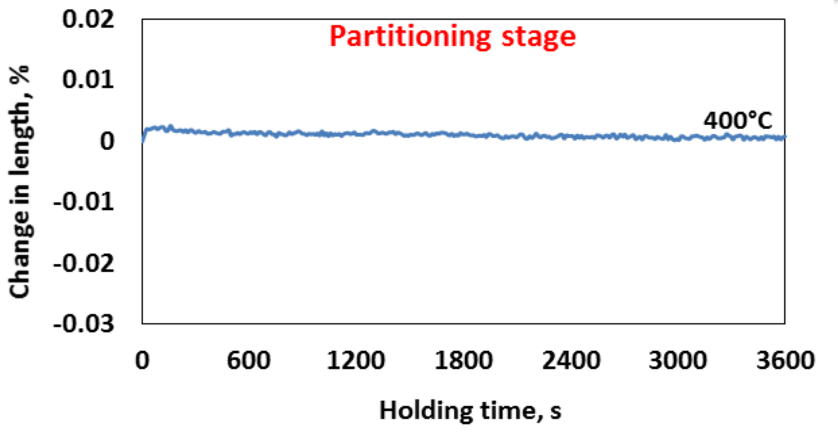


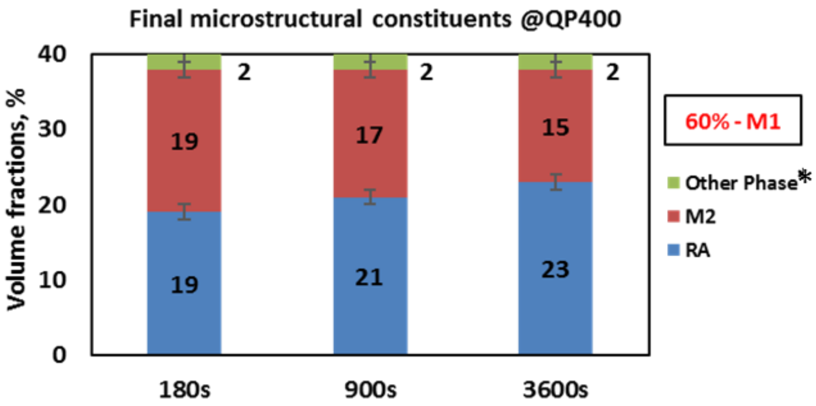


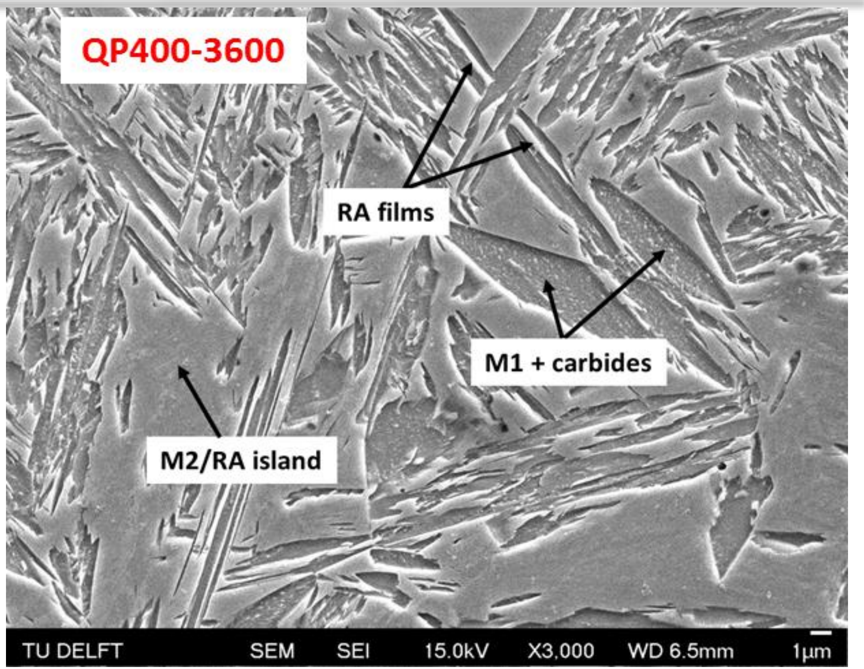
Different dilatometry response during the partitioning stage → Several competitive reactions taking place

P.T – partitioning temperature , P.t – partitioning time, M1 – Initial Martensite

Results & discussion



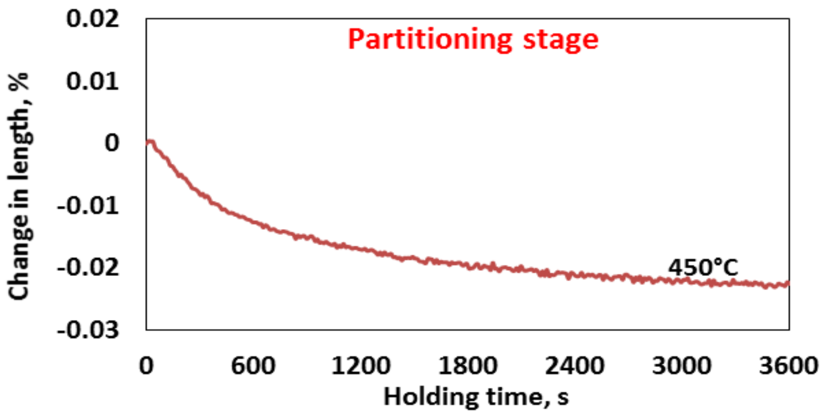


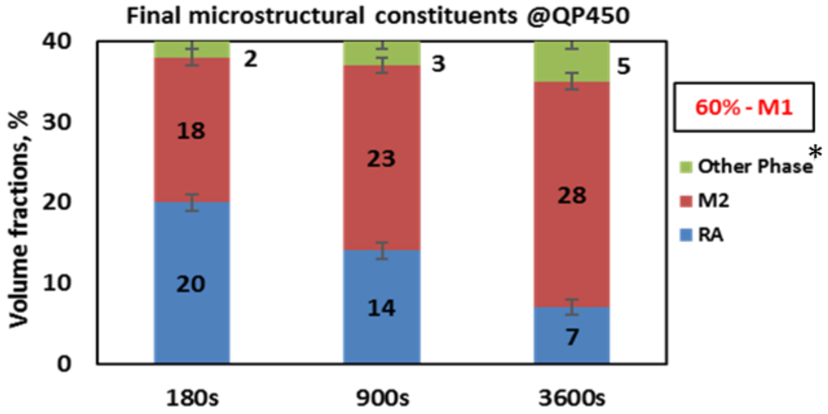


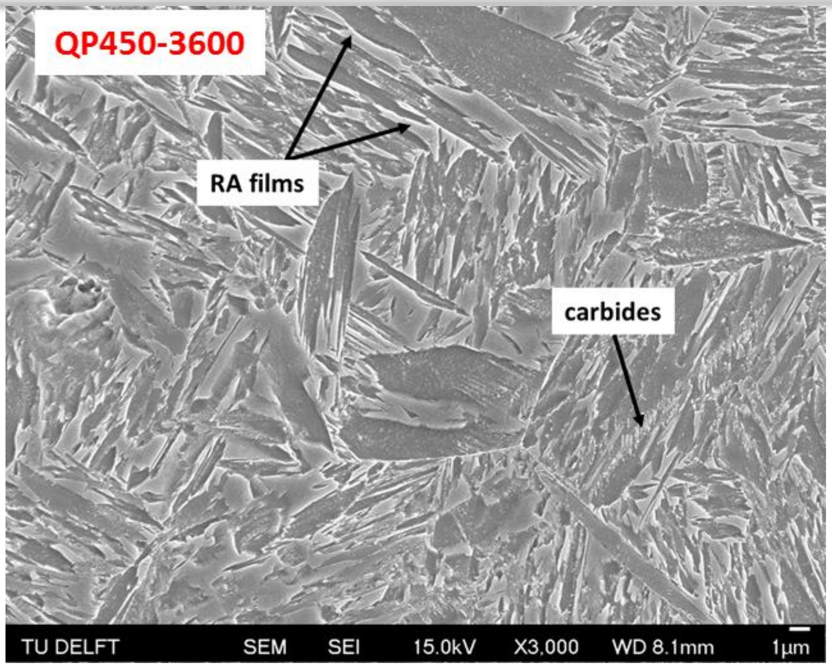
- Precipitation of carbides in M1
- Increase in RA fraction along with holding time.

RA – Retained Austenite, M1 – Initial martensite, M2- Fresh martensite, *Other phase – Carbides or Pearlite

Results & discussion



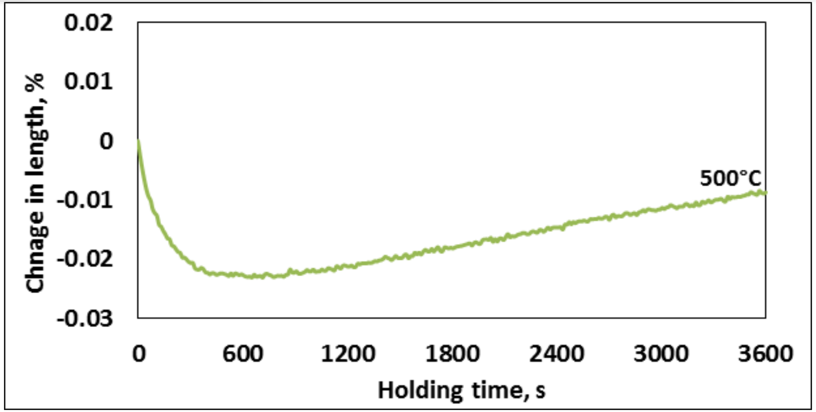


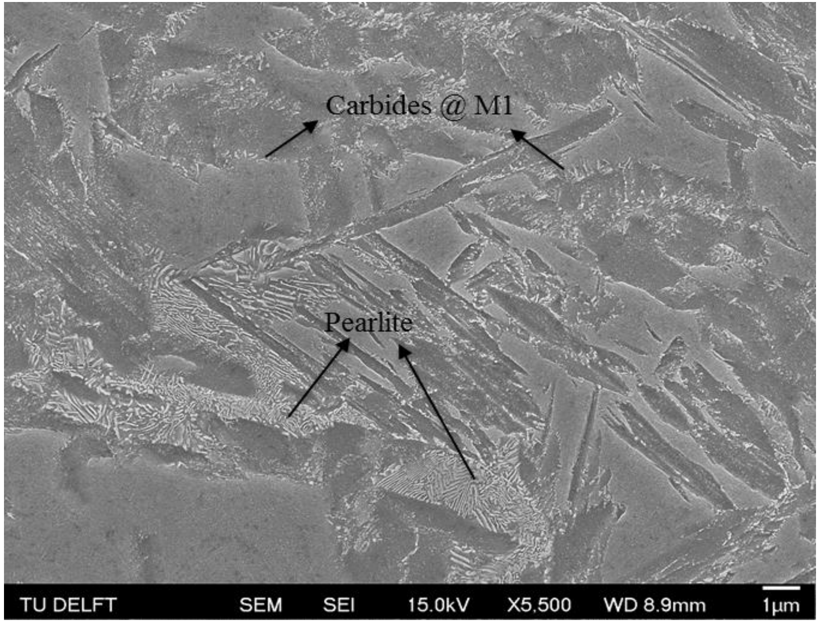


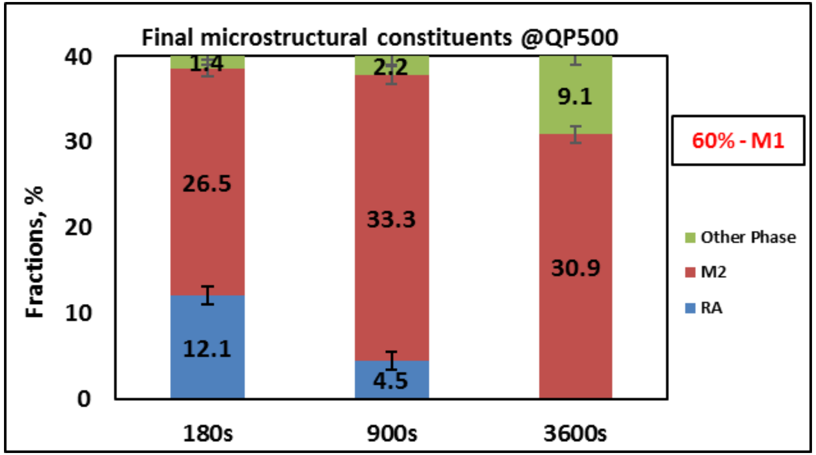
- Strong precipitation of carbides in the γ grains.
- Decrease in RA fraction along with holding time.

RA – Retained Austenite, M1 – Initial martensite, M2- Fresh martensite, *Other phase – Carbides, Pearlite

Results: Dilatometer, SEM (500°C - 3600s) & final fractions

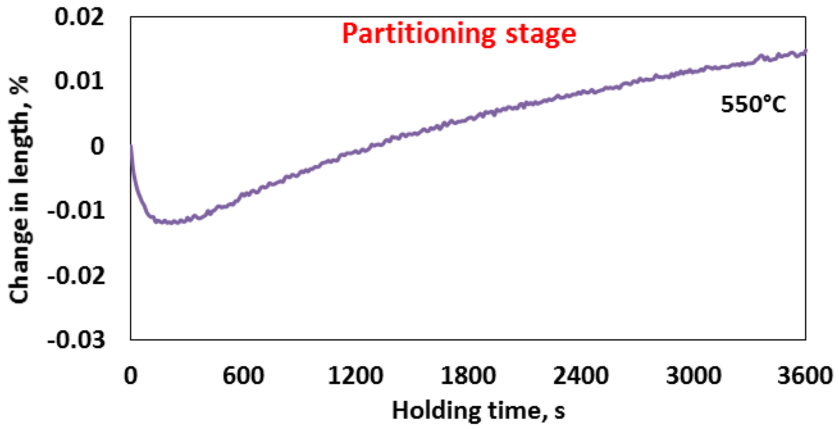


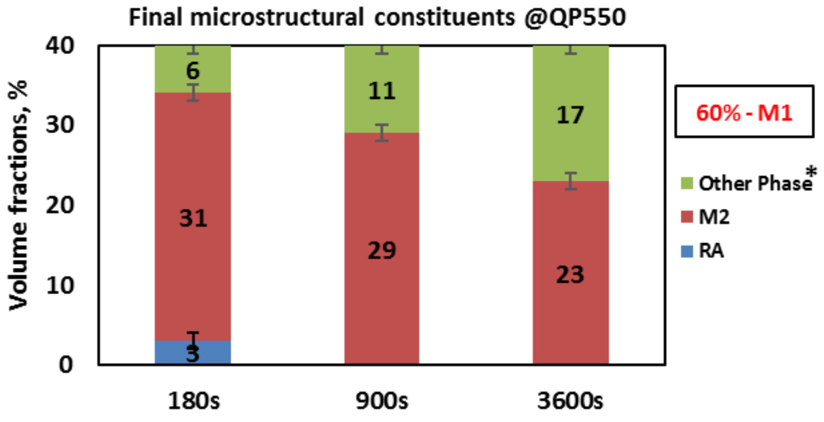


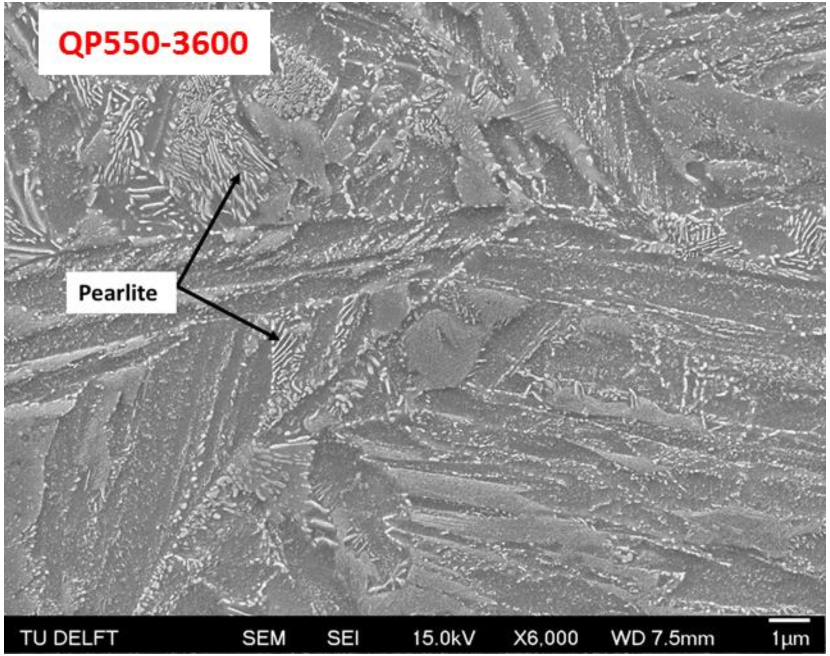


RA – Retained Austenite, M1 – Initial martensite, M2- Fresh martensite, *Other phase – Carbides, Pearlite

Results & discussion



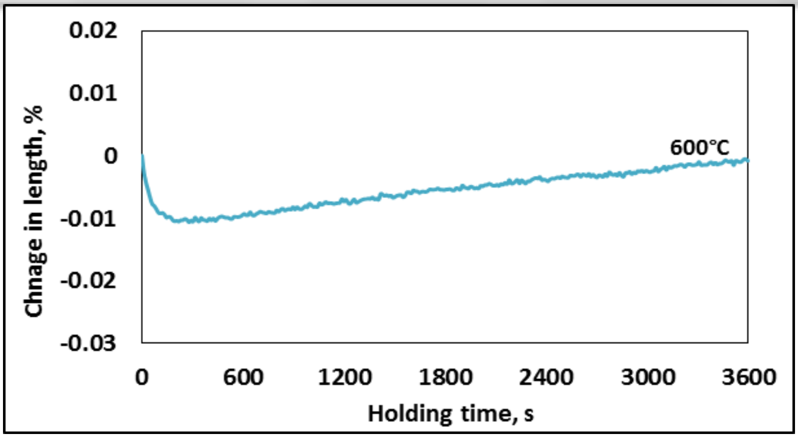


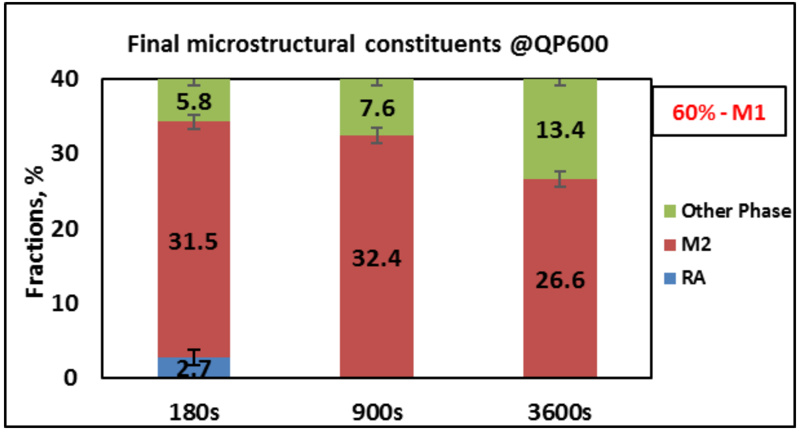


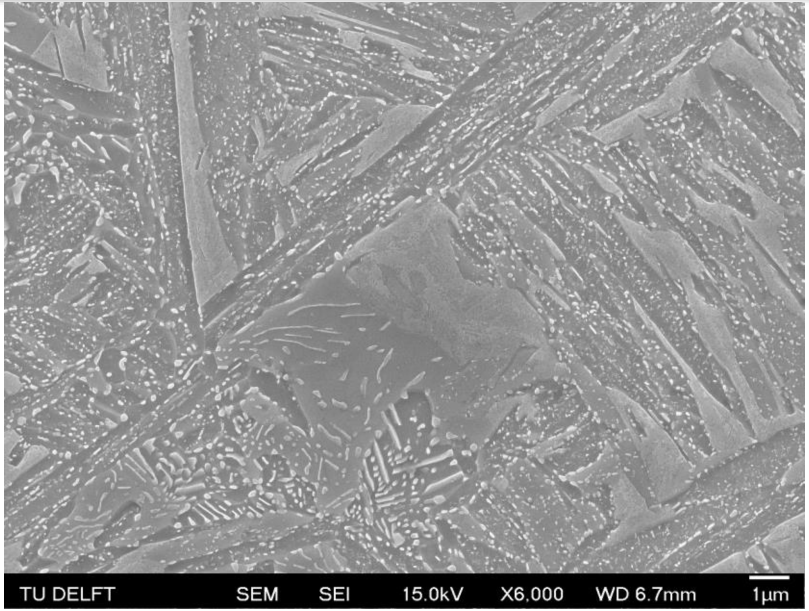
- Strong carbide pptn at short holding times, ΔL ↓.
- Pearlite formation at longer holding times, ΔL ↑.
- No RA was detected.

RA – Retained Austenite, M1 – Initial martensite, M2- Fresh martensite, *Other phase – Carbides, Pearlite

Results: Dilatometer, SEM (600°C - 3600s) & final fractions







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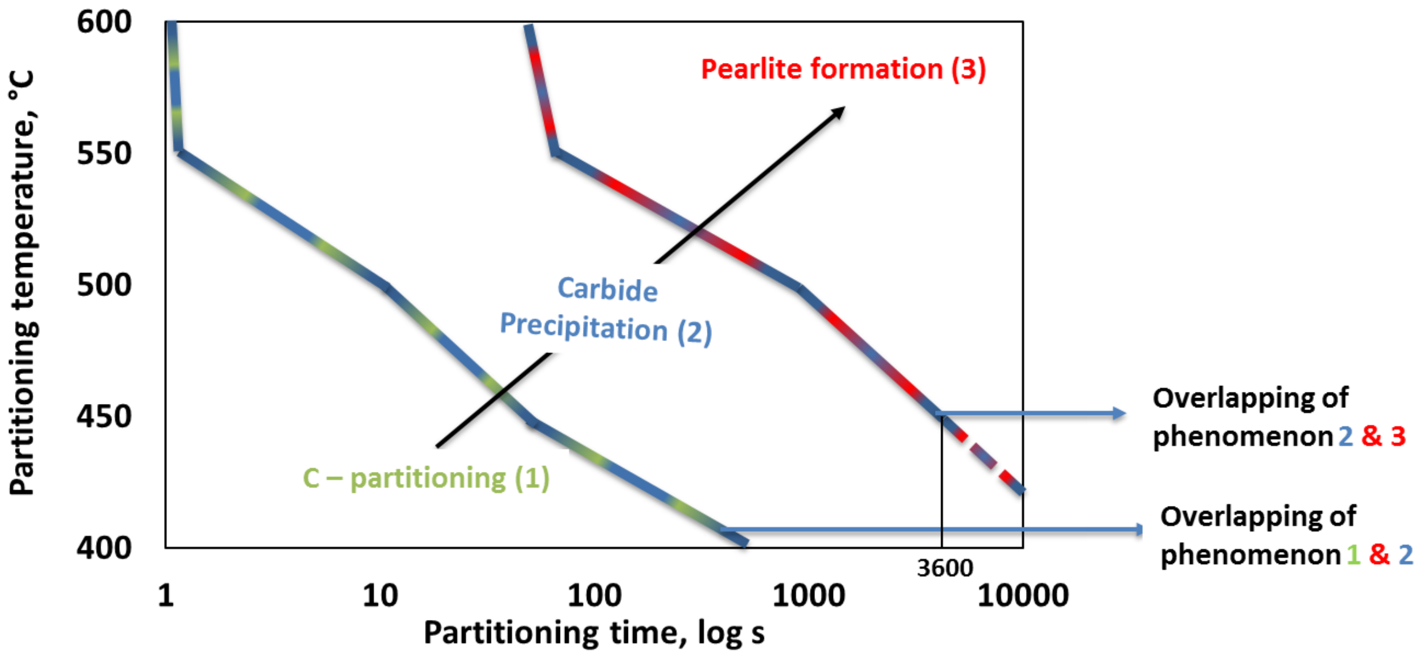
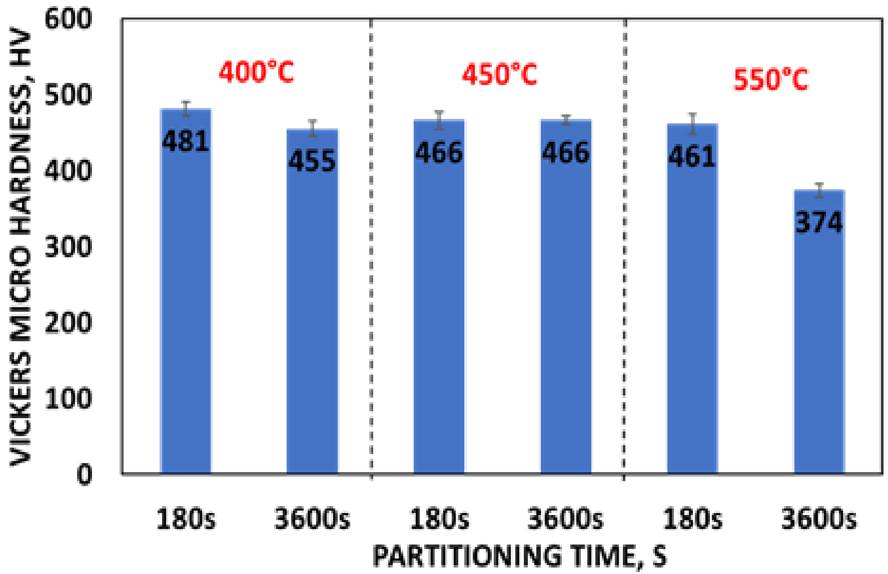
Results & discussion



- Figure showing various phenomenon taking place at different partitioning temperatures and times, that are determined from the current work.

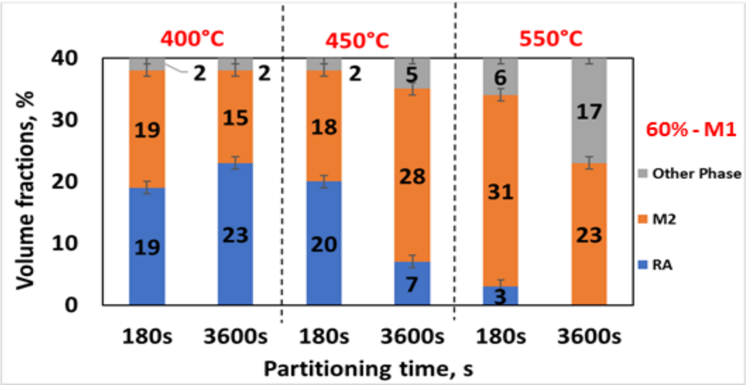
Results & discussion

Vickers Micro Hardness, HV



P.T (°C)	Long holding times (3600s)
400	Tempering of M1, lower fraction of M2
450	Tempering of M1, higher fraction of M2 and carbide precipitation
550	Tempering of M1, , M2 is C depleted due to pearlite formation

Final microstructural constituents



M1 – Initial martensite, M2 - Fresh martensite, P.T., - Partitioning temperature

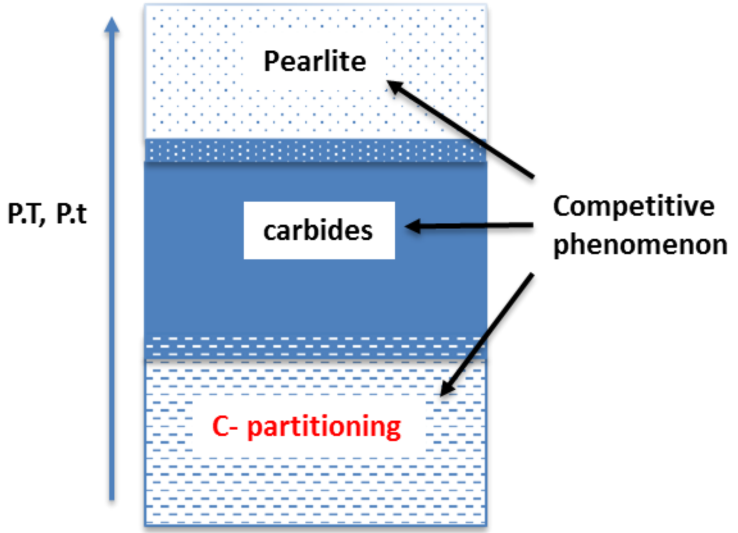
Conclusions

- **In this research work, the evolution of microstructure at high partitioning temperatures, during partitioning times up to 1 hour, in the medium Mn steels was investigated**

1) Overlapping phenomenon (carbide precipitation and pearlite formation) are activated at high partitioning temperatures. This counteracts the stabilizing effect of C and Mn partitioning.

2) At higher partitioning temperatures, carbon partitioning stimulates pearlite formation.

3) The control of other competitive reactions during the partitioning stage plays a key role in the stabilisation of the austenite in medium-Mn steels.



C- carbon, Mn - Manganese, P.T – partitioning temperature , P.t – partitioning time

Conclusions

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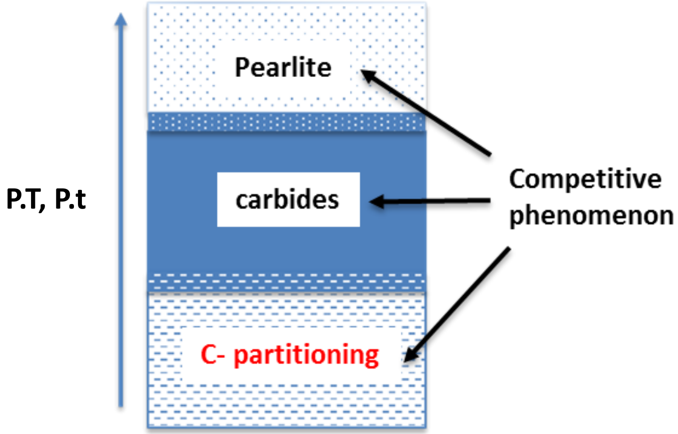

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