

한국소성가공학회 2004년도 춘계학술대회 논문집

자동차 샤시용 고강도 열연강판 개발 동향 (Developing Trends of Hot-rolled High Strength Steel Sheets for Automotive Chassis)

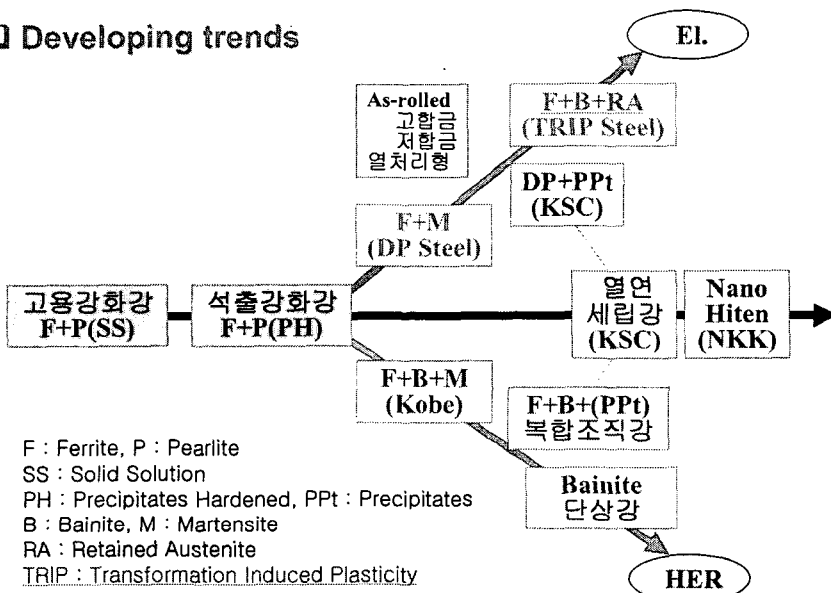
조열래, 김성규

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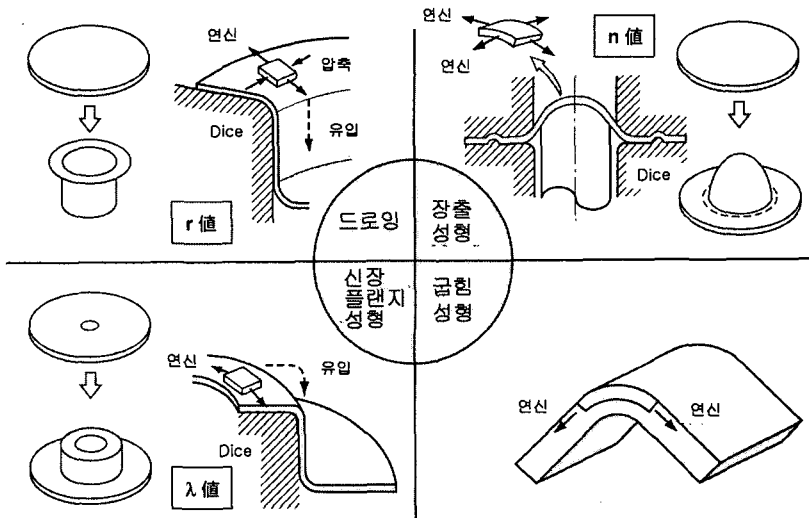
요약: 최근 지구환경을 문제를 해결하기 위한 수단으로 자동차 부품의 경량화 필요성이 더욱 높아지고 있습니다. 자동차 샤시 및 under body 부품, 구조재등에 주로 사용되는 자동차용 열연강판은 자동차 차체 중량의 약 25%를 차지하며, 그 적용 두께는 판발류 강판에 비하여 비교적 두껍고, 인장강도 310-440MPa급 강판이 주로 되고 있으나, 최근 다양한 변태조직을 이용한 가공성이 우수한 590-780MPa급 열연강판들이 개발되고 있어 향후 차체의 경량화에 크게 기여할 것으로 기대되고 있습니다. 본 발표에서는 자동차용 열연강판의 개발 동향과 최근 포스코가 개발한 고강도 열연강판의 적용사례를 소개하고자합니다.

1. Introduction

□ Developing trends



□ Deformation mode



□ Evaluation of mechanical properties

▶ Tensile test

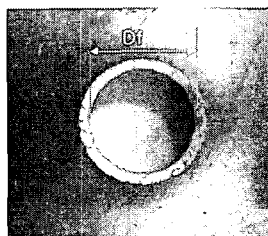
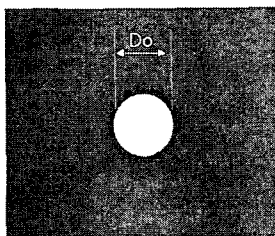
Specimen; JIS No5(GL 50mm, W 25mm), C-direction

Cross head speed; 10mm/min

▶ Hole expanding test

$$HER(\text{Hole Expanding Ratio}) = (D_f - D_o) / D_o \times 100(\%)$$

Do: initial punched hole dia.(=10mm), Df: inner hole dia. after fracture



2. Types of Hot Rolled HSS for Automotive

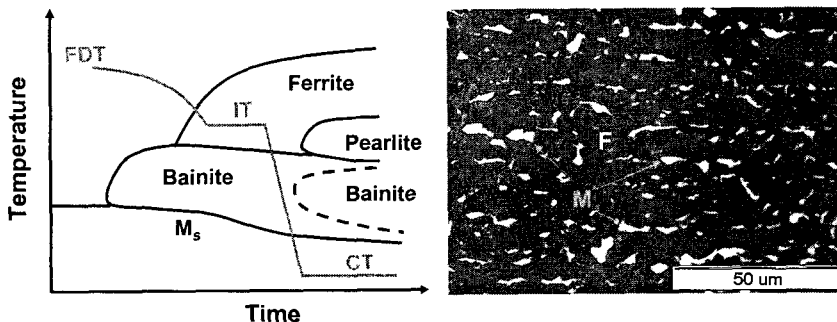
TYPE	Tensile strength(MPa)							Notes
	540	590	690	780	980	1180	1370	
General use	●	●	●	●				PH
High Burring		●	●	○				FB
Low yield Ratio		●		○				DP
High elongation				●	△			TRIP
Multiphase(CP)					○	△		PH+CP
Autobeam							(●)	(after QT)

● commercial ○ under development △ plan

	Characteristic	Application
PH	- Precipitation Hardened Ferrite(Nb,Ti,Mo)	wheel rim, frame, boom
FB	- Precipitation hardened Ferrite + Bainite - High stretch flange formability	wheel disc, lower arm suspension
DP	- Lower YR and good fatigue property	tubular beam, subframe
TRIP	- Excellent stretch formability	(sub frame)

❖ Manufacturing Strategy

- ✓ Finish rolling in austenitic region
- ✓ Controlled cooling with holding at intermediate temperature(IT) in ferritic region → Carbon enrichment → Stabilization of austenite → Shift of bainitic transformation nose
- ✓ Rapid cooling below martensite start temperature(M_s)



TS 590MPa DP Steel

❖ Characteristic

- Continuous yielding behaviour and lower yield ratio
- Good bake hardening and fatigue properties

❖ Chemical composition

Grade	Chemical composition(wt%)							Ceq. ¹⁾
	C Max.	Si Max.	Mn Max.	P Max.	S Max.	Al	N Max.	
590DP	0.10	add	1.50	add	0.005	0.020 ~ 0.050	0.006	██████

1) Ceq. = wt% C + wt%(Mn+Si)/6

❖ Guaranteed mechanical properties(transversal)

- YS 370 ~ 470 MPa
- TS 590 ~ 670 MPa
- Yield Ratio < 0.70
- Tota Elongation Min. 24 %

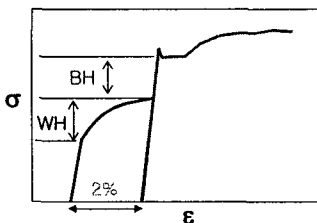
TS 690MPa DP Steel

❖ Mechanical properties(2.6mmt)

Steels	Microstructure	YS(MPa)	TS(MPa)	T-EI(%)	YR	HER(%)
590DP	F + M	380	600	30	0.65	65~85
590PH	F(+ppt) + P	529	608	27	0.87	75
590FB	F(+ppt) + B	510	600	23	0.85	92

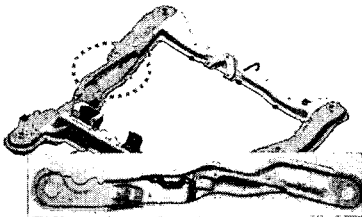
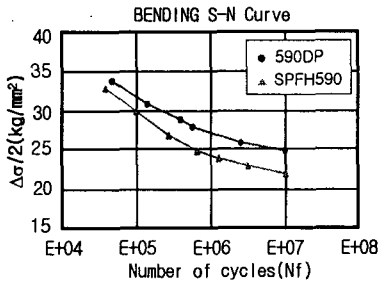
❖ Bake hardening property; about 80MPa

- 2% prestrain, 20min. holding at 170°C



Temp (°C)	Pre- strain	YS(Mpa)		BH (Mpa)
		WH	BH	
170	0%	378	438	60
	2%	472	549	77
180	2%	472	559	87

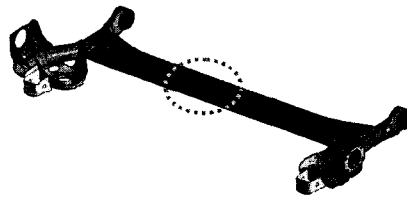
❖ **Fatigue property**



❖ **Application: Tubular beam Subframe**

Fatigue endurance test

- Tubular beam(φ89.1mm)
- Torsional cond.; ±40mm
- Requirement; > 200,000 cycles
- Result; more than 430,000 cycle

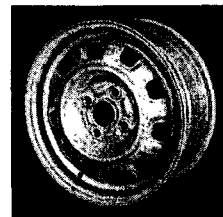
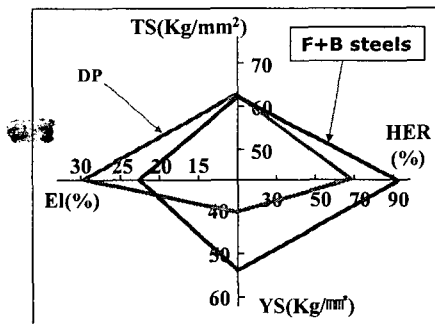


Tubular beam(2.6t)

❖ **Characteristic;**

High stretch flange formability due to lower hardness difference between precipitates hardened ferrite matrix and bainite phase

❖ **Mechanical properties(3.0mmt)**

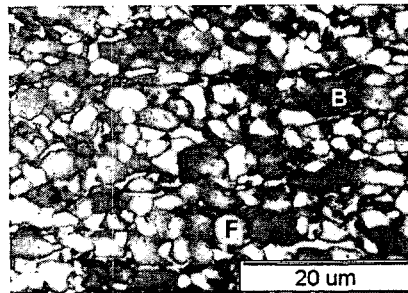
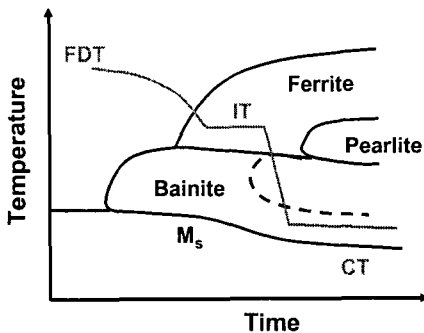


❖ **Application; Wheel disc, Lower arm**

3. New HR HSS(3) - 780MPa TRIP Steel

❖ Manufacturing Strategy

- ✓ Finish rolling in austenitic region
- ✓ Controlled cooling with holding at intermediate temperature(IT) in ferritic region → Carbon enrichment → Stabilization of austenite → Shift of bainitic transformation nose
- ✓ Rapid cooling below bainitic start temperature(Bs)



Retained austenite: white yellow

780MPa TRIP Steel

❖ Characteristic

- Excellent TS-EI combination using TRIP effects
- Crash energy absorbing and fatigue properties

❖ Chemical composition

Grade	Chemical composition(wt%)								Ceq. ¹⁾
	C Max.	Si Max.	Mn Max.	P Max.	S Max.	Al	N Max.	Nb Max.	
780TR	0.20	0.005	1.70	0.020	0.005	0.020 ~ 0.050	0.006	add	0.005

1) Ceq. = wt% C + wt%(Mn+Si)/6

❖ Guaranteed mechanical properties(transversal)

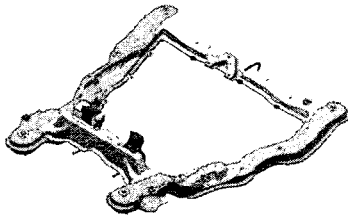
- YS 580 ~ 680 MPa
- TS 780 ~ 870 MPa
- Yield Ratio < 0.85
- Total Elongation Min. 26 %

780MPa TRIP Steel

❖ Mechanical properties(2.6mmt)

Steels	Microstructure	YS (MPa)	TS (MPa)	T-EI (%)	U-EI (%)	YR	N 5 to 15%
780TR	F + B + γ_R	645	812	33	26	0.79	0.22
780PH	F(+ppt) + P	740	810	20	12	0.92	0.13

❖ Application; subframe(under trials)



Front subframe(2.6t)



3. New HR HSS(4) - 780MPa PH Steel

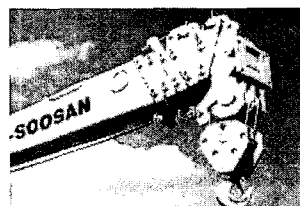
❖ Characteristic

High strength, good bendability and weldability obtained by the optimized precipitation control of Ti, Nb and Mo carbides during hot rolling and cooling process

❖ Mechanical properties(7.0mmt)

Steels	Microstructure	THK (mm)	YS (MPa)	TS (MPa)	T-EI (%)	YR
780PH	F(+ppt) + P	7.0	740	810	20	0.92
590PH	F(+ppt) + P	3.0	529	608	27	0.87

❖ Application ; Crane booms Frame(trailor) Tower crane



4. Summary

- ✓ Recently developed HSS of POSCO and commercializing activities were introduced.
590DP, 590FB, 780PH and 780TRIP
- ✓ In this year, another three type of hot rolled AHSS will be developed and try to commercialize with auto makers.
780FB, 780DP and 980CP
- ✓ We have future plan to develop ultra high strength steels
980TR, 1170CP