

TWB용 고강도 박판 강재의 CO₂ 레이저 용접성 및 성형성 (CO₂ Laser Weldability and Formability of High Strength Steels for Tailored Blanks Applications)

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Abstract: The laser welding and its analysis were carried out using high power 6kW CO₂ laser for high strength steels such as DP, TRIP and conventional high strength steels. Bead on plate welding of thin sheet was examined to investigate the effect of weld variables of laser welding, and to obtain optimum welding condition. In order to investigate the formability of welded high strength steels, LDH test was added on this work. At high welding speed, the partial penetration was obtained by low heat input. Meanwhile, porosity was formed in the bead at low weld speed because of extremely higher heat input. The optimum welding condition of welding was derived from bead width, penetration and hardness property. It was shown that the DP steels had lower porosity level and smooth bead shape, therefore better laser weldability than TRIP steels and conventional high strength steels. In addition, LDH test shows that the welded DP steels have about 90% formability value of base metal, although TRIP steel and conventional high strength steels have about 80% formability value of its base metal.

1. 연구배경

- 자동차 산업에서 생산성 및 품질향상을 위해 레이저 용접에 의한 TWB 부품 적용 확대
- POSCO는 2003년 TWB 2기 가동을 시작으로 지속적 TWB 생산이 이루어지고 있음.
- 고풍력 레이저의 사용에 따른 당사 강종에 대한 레이저 용접특성 파악 시급.
- 차후 TWB 적용이 검토되는 TRIP/DP강에 대한 용접성 평가.

2. 실험 방법

2.1 Specimens

	C	Mn	Si	P	S	Sol Al	Ti	Nb	Mo	Ceq (JIS)
TRIP60	0.107	1.5	1.02	0.080	0.004	0.051	-	-	-	0.40
TRIP80	0.2	1.6	1.63	0.013	0.003	0.033	-	-	-	0.53
DP50	0.066	1.6	0.1	0.019	0.001	0.051			0.05	0.35
DP60	0.107	1.66	0.19	0.014	0.001	0.046	-	-	0.05	0.40
DP80	0.112	1.87	0.21	0.013	0.001	0.044	-	-	0.09	0.45
45R	0.079	0.94	0.03	0.0078	0.007	0.035	0.003	0.002		0.24
60C	0.077	1.49	0.5	0.0020	0.007	0.038	0.048	0		0.33

$$Ceq(JIS) = C + Mn/6 + 24/Si + Ni/40 + Cr/5 + Mo/4 + V/14$$

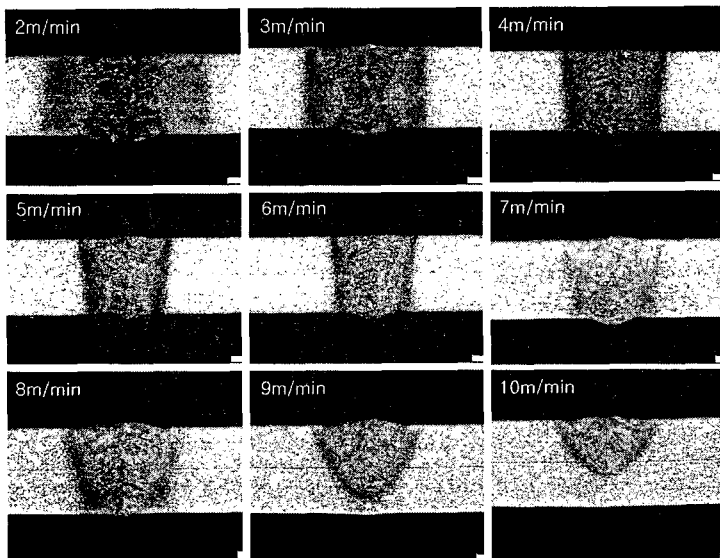
2.2 Experimental

BOP(Bead on plate), 용접부 검사, 경도 시험
 보호가스 특성
 성형 특성 검사(LDH)

3. 실험 결과

3.1 BOP test

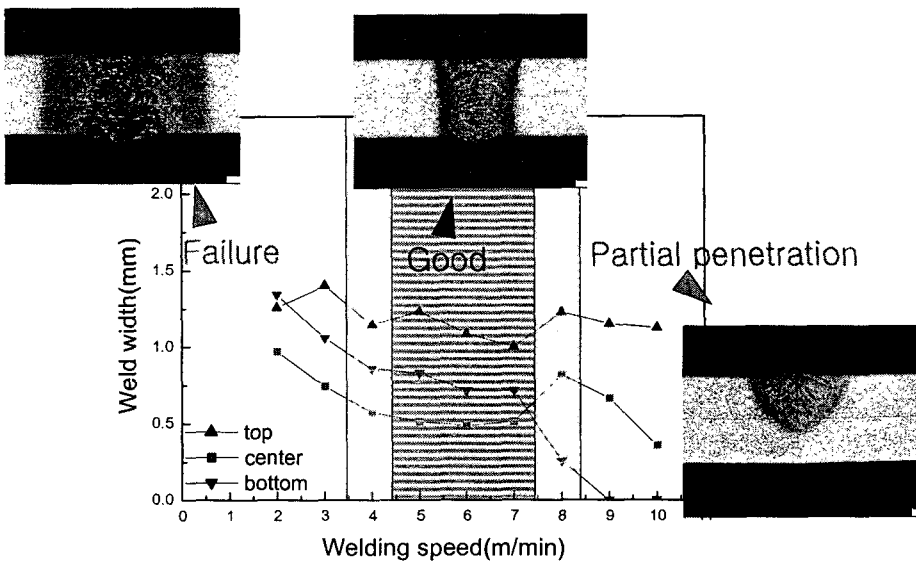
□ BOP(Bead on plate) laser welding on DP50 steels (6kW, He shielding)



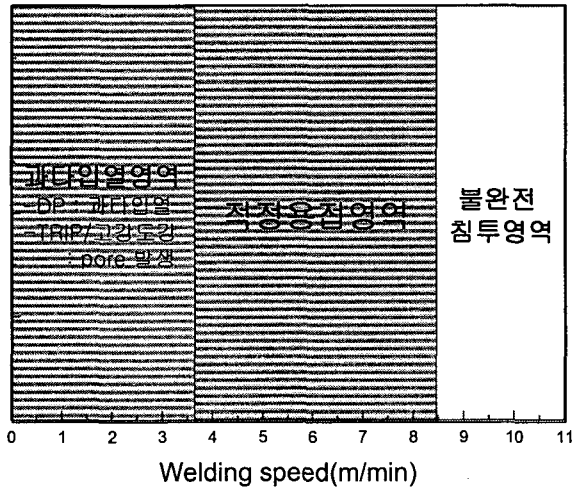
□ BOP(Bead on plate) laser welding on TRIP60 steels(6kW, He shielding-20l/min)

	단면	표면	후면
2m/min			
6m/min			
9m/min			

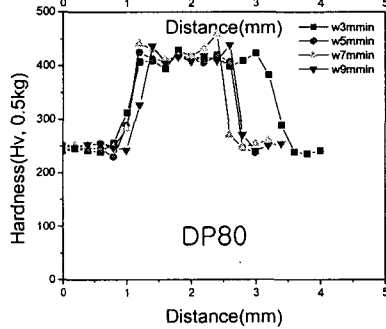
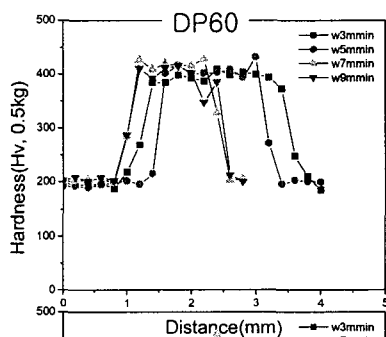
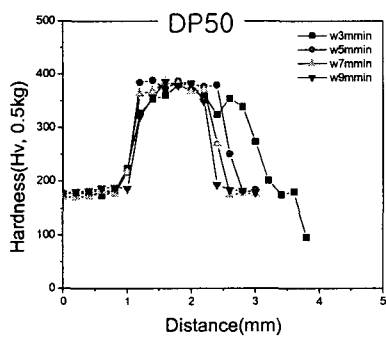
□ Weld width & welding speed on DP50 Steels(1.2t)

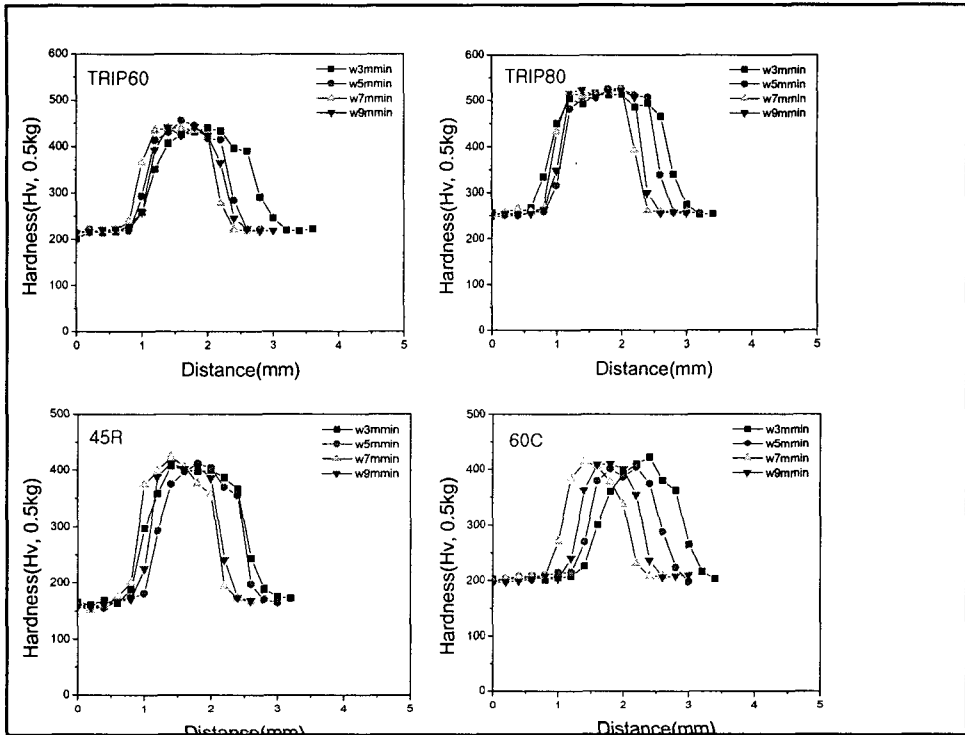


□ The effect of welding speed on Laser weldability of high strength steels(DP, TRIP, 45R, 60C)

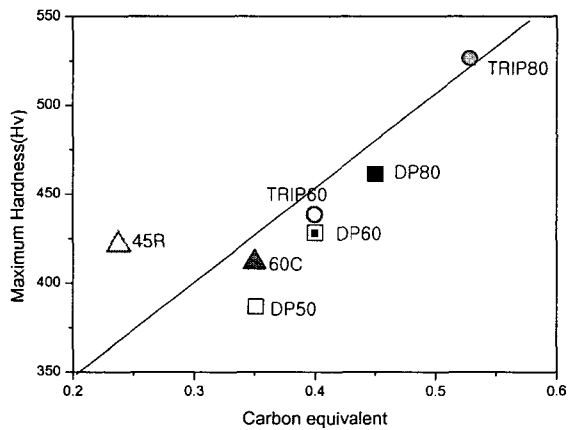


3.2 Hardness distribution

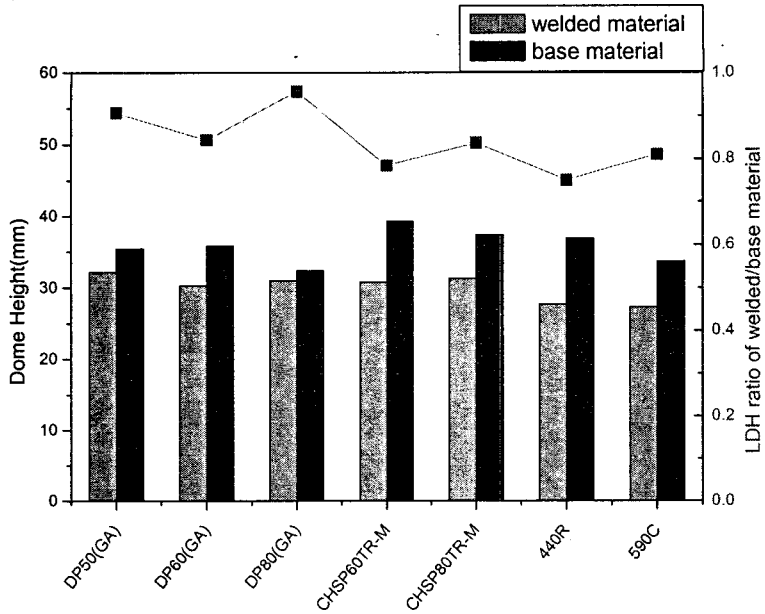




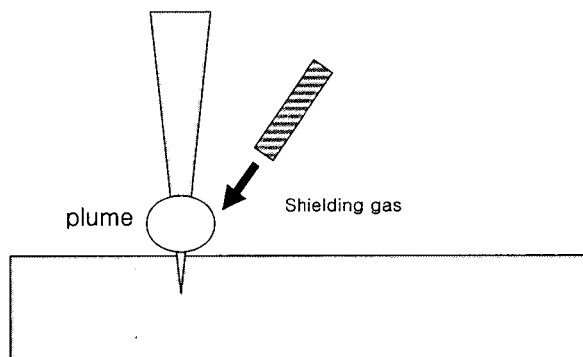
□ Relationship between Maximum hardness and chemical composition



3.3 Formability of high strength steels (6kW, 6m/min, 15l/min)

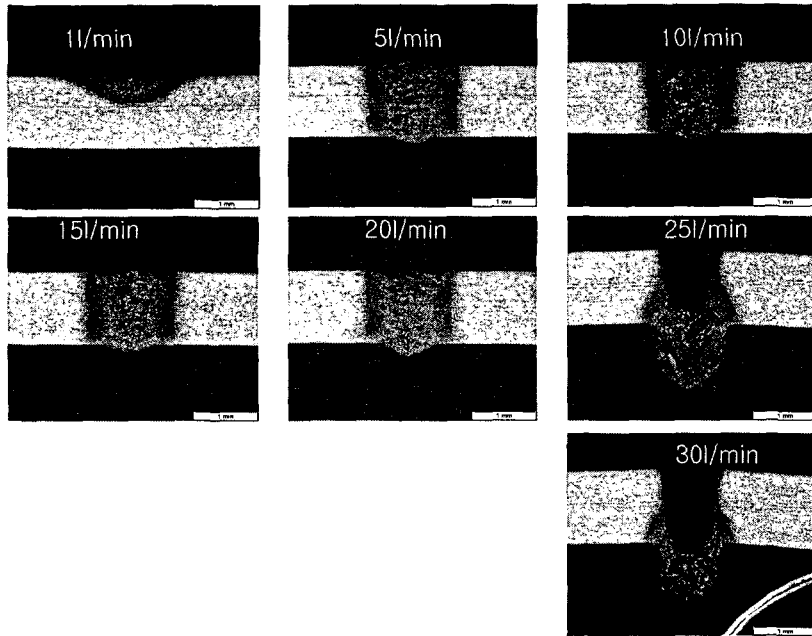


3.4 고강도강 용접성과 보호가스 효과

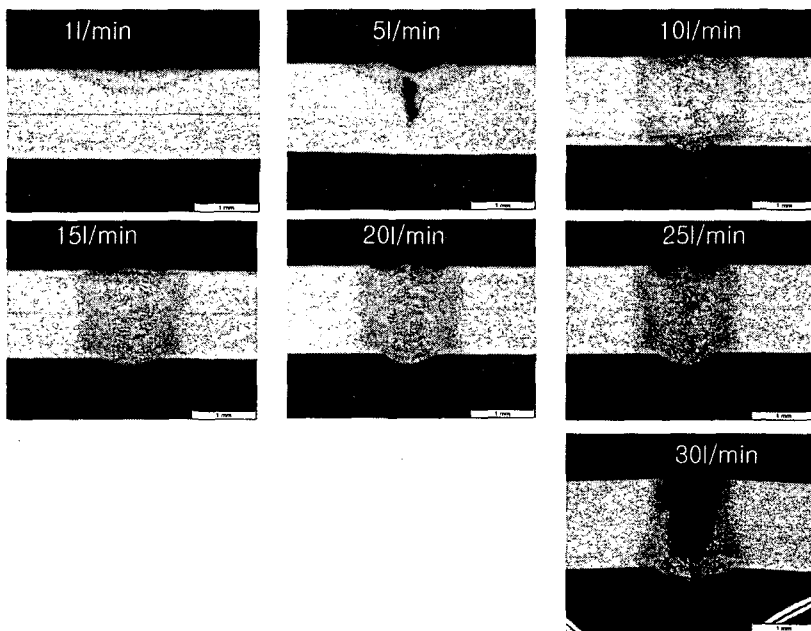


properties	Shielding gas						
	He	Ar	CO ₂	N ₂	Ar+N ₂	Fe	Zn
Ionization potential(eV)	24.5	15.76	13.79	14.54	15.15	7.83	0.793
Dissociation potential(eV)	-	-	5.5	10	-	-	-
Thermal conductivity(W/mK)	0.1381	0.0159	0.0138	0.0234	0.0197	-	-
Atomic weight(g/mol)	4	39.95	44	28	67.95	55.85	65.37

□ The effect of flow rate of He shielding gas on laser weldability of DP50 steels



□ The effect of flow rate of Ar shielding gas on laser weldability of DP50 steels



4. Summary

- 1) 고강도강의 BOP 시험 결과 강종에 차이 없이 용접속도에 따라 유사한 비드 형상을 가지는 것으로 나타났다. 한편 1.2t 시험편의 적정 용접속도는 4~8m/min으로 나타났다.
- 2) 용접속도가 빠를수록 비드폭은 작아지며, 경도값은 높게 나타났다. 그리고, 최고 경도값은 강의 성분(Ceq)에 비례하는 것으로 나타났으며, 그 결과 TRIP80(Ceq=0.53)의 경우 최고 520HV이상의 경도값을 가지고 있었다.
- 3) LDH test 결과 DP강의 모재대비 용접부의 성형성이 약 90% 정도로 나타났으며, TRIP 및 일반 고강도강은 약 80%의 성형성을 갖는 것으로 확인되었다.
- 4) He을 보호가스로 사용시 기공의 형성은 크게 억제되었다. 그리고 Ar 사용시에는 기공 형성이 He에 비해 많이 형성되는 것으로 나타나 사용시 주의가 필요한 것으로 보인다. 기공 형성은 TRIP > 60C/45R > DP 순서로 나타나 DP강이 가장 좋은 레이저 용접성을 가지고 있었다.