TALAT Lecture 4204

Design Aspects

7 pages, 5 figures

Basic Level

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Objectives:

– to describe the effects of welding on the materials' strength characteristic

Prerequisites:

– basic knowledge in metallurgy of aluminium

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4204 Design Aspects

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Aluminium Alloys for Welded Constructions

The strength of non-heat-treatable alloys is not affected by the welding heat. However, for cold worked alloys, the strength at the joint is reduced to that of the annealed state. The loss of strength depends on the heat input, which in turn depends on the process. Al-Mg types of alloys are more sensitive in this respect than the Al-Mg-Mn types of alloys. The formation of coarse grains should be avoided, since this cannot be made reversible through heat treatment.

Aluminium Alloys for Welded Constructions

Non-heat-treatable alloys	Heat-treatable alloys
pure Al	AlCu
AlMg	AlCuMg
AlMn	AlMgSi
	AlMgSiCu
	AlZnMg
	AlZnMgCu
	AlLiCu
	AlMgLi

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The heat-treatable alloys also lose their strength at the weld zone. However, the behaviours of Al-Mg-Si alloys and Al-Zn-Mg alloys should be differentiated. The former alloys can be reversed to their original hardness only by repeating the solution treatment, quenching and ageing steps. This can, however, be seldom applied in practice due to the size of the constructions and the expected distortion (**Figure 4204.01.01**).

Al-Zn-Mg alloys, on the other hand, require lower solution treatment temperatures and lower quenching rates for repeating the heat treatment. This behaviour is utilised for regaining the strength loss in the heat-affected zone. The welding heat itself is sufficient for solution treatment and the cooling that follows is sufficiently rapid for the quenching step. The fast cooling is a result of the heat being conducted rapidly away from the heat-affected zone due to the good thermal conductivity of aluminium. The joint can then be aged at room temperature (natural ageing) or at elevated temperatures of up to 160 °C (artificial ageing).

Heat-Affected Zone in Welded Aluminium Joints

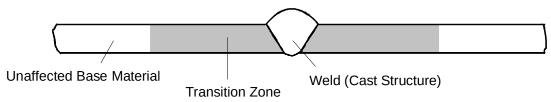
The type of the material to be welded, i.e., whether or not it is a heat-treatable alloy, is decisive for the strength attained after welding (**Figure 4204.01.02**).

Non-heat-treatable cold-worked alloys cannot be reverted to the original cold-worked state (e.g. hard) after welding. The joint strength always corresponds to that of the annealed state.

A different situation exists for the heat-treatable alloys. In principle, the weld zone which is in the annealed state after welding, can be reverted to the original aged condition by repeating the ageing steps of solution treatment, quenching and ageing. The major problem is the usually large size of the welded constructions making it necessary to have large heat treatment furnaces. Another problem is the distortion which accompanies the quenching.

The welding heat produces the self-ageing effect in the Al-Zn-Mg types of alloys. The welding heat suffices for the solution treatment and the fast cooling is equivalent to a quenching. The joint then ages at room temperature.

Heat-Affected Zone in Welded Aluminium Joints



	Material	Starting State	HAZ Strength	Possibility of Increasing HAZ Strength
Non-Heat-Treatable	Al 99,5 AlMn AlMgMn AlMg 3 AlMg 4,5 Mn	Annealed (Recrystallised Structure)	No Change	None
		Half Hard, Hard (Cold-Worked Structure)	Softening Due to Recrystallisation	None
Heat-Treatable	AlMgSi	Cold-Worked, Artificially Aged (Aged Structure)	Softening Due to Coarsening of Precipitates	Repeating Solution Treat-ment and Aging
	AlZnMg	Naturally Aged, Artificially Aged (Aged Structure)	Softening Due to the Repeated Solution Treatment	a) Natural Aging, 90 Days b) Artificial Aging

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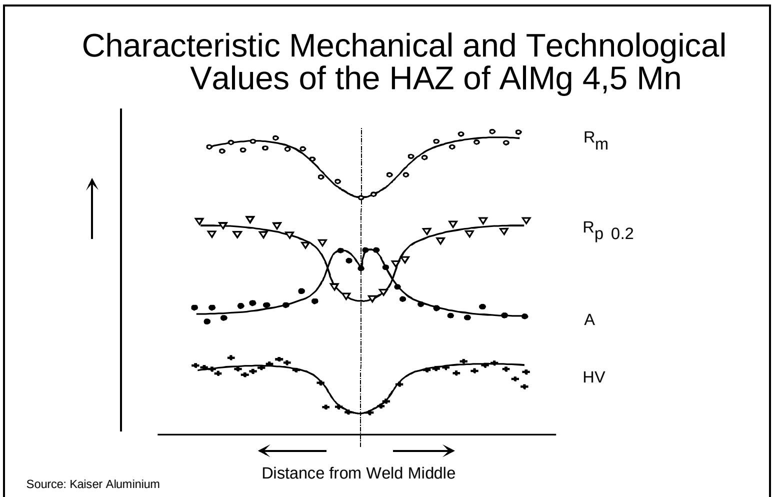
Characteristic Mechanical and Technological Values of the HAZ of AlMg4,5Mn

The loss in strength and hardness in the weld region is typical for aluminium and its alloys. The elongation values increase at first but then fall slightly at the weld middle, this fall being caused by precipitations (**Figure 4204.01.03)**.



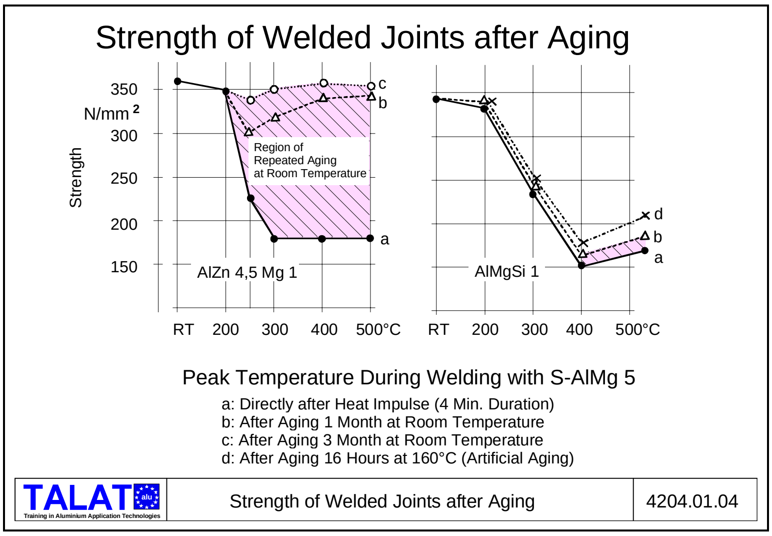
Characteristic Mechanical and Technological Values of the HAZ of AlMg4,5 Mn 4204.01.03

This loss of strength must be considered in designing the welded construction. Calculations should then be based on the reduced allowable stress.

Strength of Welded Joints after Ageing

The weldable, self-hardening Al-Zn-Mg alloys have to be handled differently than the other heat-treatable alloys. The reason for this is the relatively large solution treatment range (350 - 500 °C) and the slow ageing effect at room temperature (natural ageing). The solution treatment and quenching occur at much lower levels than for the other heat-treatable alloys. The full strength is regained after a room temperature ageing time of 90 days.

This effect cannot be attained without additional heat input and quenching for Al-Mg-Si types of alloys. A slight increase of strength can be attained by artificial ageing.



With respect to cracking, the Al-Mg-Si types of alloys are better than the Al-Zn-Mg types of alloys, being less crack sensitive (**Figure 4204.01.04**).

4204.02 Productivity of Arc Welding Processes

- Cost Comparison for Welding with Various Shielding Gases

Cost Comparison for Welding with Various Shielding Gases

The gas costs are decisive for the determining the production costs. However, considering the gas costs isolated by themselves alone can lead to misinterpretations. One tends to forget that larger wire feed rates can be used while welding with the hotter helium arc. The higher gas cost is more than compensated for by lower wire and personnel costs. The lower wire costs are calculated on the basis of the melted wire per meter length of weld.

Cost Comparision for Welding with Various Shielding Gases

AlMg3; 8mm Thick; Square Butt Joint, ∅ 1.6mm; MIG Pulsed Welding

		100% Ar	75% Ar +25% He	50% Ar +50% He
Welding Time	min/m	2.50	2.08	1.60
Weld Weight	g/m	119	108	86
Gas flow	l/min	20	20	29
Gas Cost	DM/m	0.75	1.08	1.21
Wire Costs	DM/m	3.45	3.13	2.49
Labour Costs + overheads	DM/m	2.29	1.91	1.47
Total Costs	DM/m	6.49	6.12	5.17

Assumption for Costs Evaluation:
100% Ar 15DM/m³
75%Ar + 25%He 26DM/m³
50%Ar + 50%He 26DM/m³

Wire Electrode ∅1.6mm: 29DM/kg
Labour Costs + Overheads: 55DM/kg

TALAT	Cost Comparision for Welding with Various Shielding Gases	4204.02.01

This effect is can be observed clearly when using helium contents of more than 50 %. (**Figure 4204.02.01**).

4204.03 Literature/References

- Aluminium-Taschenbuch, 14. Auflage, 1984, Aluminium-Verlag, Düsseldorf

-Welding Kaiser Aluminium, Kaiser Aluminium & Chemical Sales Inc., Kaiser Center, Oakland, California, 1978

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