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SETTING OF ADHESIVE BONDED SURFACE OPTIMUM ROUGHNESS VALUE

STANOVENÍ OPTIMÁLNÍ HODNOTY DRSNOSTI LEPENÉHO POVRCHU

Abstract

Bonded joint is a very exacting system. Its quality and failure rate depends on many factors. Basic failures of bonded joints divide in adhesive and cohesive ones. When the breakaway between adhesive lay and bonded material occurs, it is adhesive failure. The presence of oxides and of not quite suitable wetted surface geometry is the reason. By a suitable mechanical pretreatment of a bonded surface the adhesive failure can be hindered. For tests two groups of materials were chosen, namely steel and aluminum alloys. The aim of tests was the evaluation of roughness parameters change of steel, aluminum and duralumin surfaces using different grit of the abrasive cloth. Thanks to different material structure it was possible to determine the different effect of the same abrasives on the integrity of the grinded surface. Comparing the reached strength values the hypothesis was confirmed that the bonded surface mechanical pretreatment is one of key influences on the bonded joint primary strength. The analysis of reached data makes possible the formulation of optimum roughness parameters values with contemporary defining the abrasive cloth type.

Abstrakt

Lepený spoj je velmi náročný systém a jeho kvalita či poruchovost závisí na mnoha faktorech. Základní poruchy lepených spojů se dělí na adhezní a kohezní. Dojde-li k odtržení spoje mezi vrstvou lepidla a lepeným materiálem, jedná se o adhezní poruchu. Důvodem je přítomnost vrstvy oxidů a rovněž ne zcela vhodná geometrie smáčeného povrchu. Vhodnou mechanickou úpravou lepeného povrchu bývá zabráněno vzniku adhezívního porušení. V testu byly využity dvě skupiny materiálů, ocel a hliníkové slitiny. V článku je hodnocena závislost parametrů drsnosti ocelového, duralového a hliníkového povrchu na změně brusného plátna. Analyzování získaných dat nám umožní formulaci optimálních hodnot parametrů drsnosti při současném určení typu brusného plátna.

1 INTRODUCTION

Bonded joint is a very exacting system. Its quality and failure rate depends on many factors. Basic failures of bonded joints divide in adhesive and cohesive ones. When the breakaway between adhesive lay and bonded material occurs, it is adhesive failure. The presence of oxides and of not quite suitable wetted surface geometry is the reason. By a suitable mechanical pretreatment of a bonded surface the adhesive failure can be hindered. Thanks to mechanical pretreatment the effectual surface, that is the really wetted surface, increases. The strength increase owing to the material roughing is the result. For the bonding technology application the optimal roughing determination of

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bonded surfaces is important. The surface roughness measurement is one of basic ways of the surface evaluation. The surface roughness is characterized by standardized terms. Thanks to single materials physical and mechanical properties it is not sufficient to quantify only the type and method of the bonded surface mechanical pretreatment. Abrasiveness of single materials is different and therefore the surface integrity evaluation is necessary. Without the optimal parameters determination of surface integrity and of methods how to reach it the successful application of bonding technology is impossible in practice.

2 MATERIALS AND METHODS

For tests two groups of materials were chosen, namely steel and aluminum alloys. The aim of tests was the evaluation of roughness parameters change of steel, aluminum and duralumin surfaces using different grit of the abrasive cloth. Thanks to different material structure it was possible to determine the different effect of the same abrasives on the integrity of the grinded surface. At the same time the influence of bonded joints strength properties is compared. Microstructures of steel, duralumin and aluminum specimens are presented in Figs. 1, 2 and 3. Tab. 1 presents the chemical composition of bonded specimens.

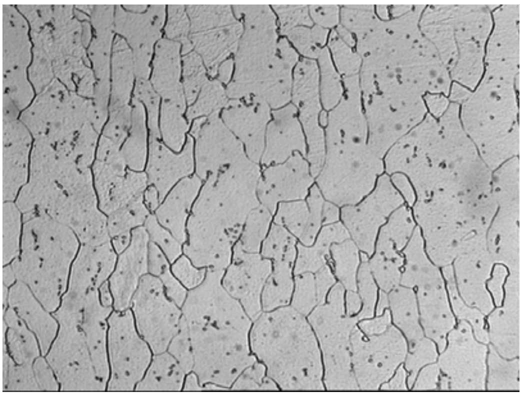

Fig. 1 Microstructure of the steel specimen: ferrite, sporadically tertiary cementite (Nital, 500x magnified)

Tab. 1 Chemical composition of bonded specimens

Specimen	C	Mn	Cr	Ni	Al	Cu	Nb	Ti	Fe	Si	Mg	Zn
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
Steel	0.047	0.24	0.076	0.017	0.065	0.039	0.007	0.016	99.5	-	-	-
Duralumin	-	0.51	0.003	0.003	93.197	5.012	-	0.013	0.304	0.35	0.571	0.014
Aluminium	-	0.006	0.003	0.002	99.612	0.018	-	0.016	0.203	0.12	0.007	0.01

The surface of standardized test specimens was pretreated using abrasive cloth of different grits, namely 100, 150, 240, 320, 400 and 500. Grinding by use of abrasive cloth was carried out normal to the loading force. The loading force was from about 7 up to 9 N. Ahead of measuring and bonding the specimens were cleaned in perchlorethylene.

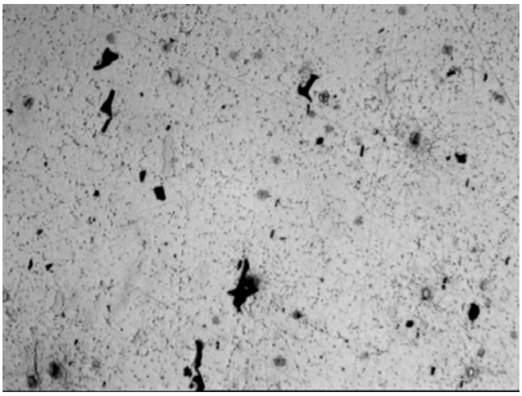

Fig. 2 Microstructure of the duralumin specimen: solid solution α with consolidating phase CuAl2 and sulfur-content inclusions – annealed (HF, 500 x magnified)

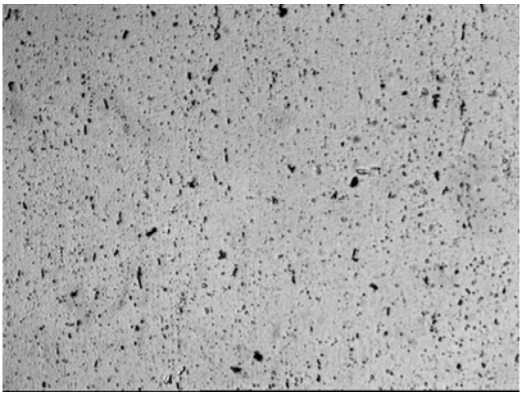

Fig. 3 Microstructure of the aluminum specimen: Al + FeAl3 + needles of Si (Keller, 500 x magnified)

Surface roughness parameters were measured using profilometer. Modern profilometers make the easy adjusting and measuring possible. Surface roughness parameters were measured using the profilometer Surftest 301. For the surface roughness measuring the use of the correct cut-off value is important. The value of 0.8 was used as the value used most often for heterogeneous materials. The surface roughness was measured in 5 points of each specimen. Following parameters were determined: Ra – the arithmetic mean of the departures of the profile from the mean line and Rz – the average of the maximum peak-to-valley length of five consecutive sampling lengths. Measuring was carried out according to CSN EN ISO 4287.

After the evaluation of bonded surfaces mechanical pretreatment the specimens from steel, duralumin and aluminum were bonded according to the standard CSN EN 1465. Tested assemblies were made by bonding of two test specimens of dimensions 100 x 25 x 1.5 mm at 12.5 mm lapping (standard). For bonding three two-component adhesives were used: Bison, Ceys and Uhu.

3 TEST RESULTS

Single bonded joints were destructively tested and evaluated. Laboratory tests evaluation is presented in Figs. 4, 5 and 6. From Fig. 4 the grinding using the abrasive cloth of grit 100 was evaluated as the bonded surfaces optimal mechanical pretreatment. Using duralumin the highest strength was reached at grit 400 for all adhesives. Only using the adhesive Bison almost the same strength was reached by grinding using the abrasive cloth of grit 320. In this case the difference of the average strength was 0.1 MPa. Bonding aluminum the optimal mechanical pretreatment was carried out using the abrasive cloth of grit 400 – 500. Using these grits the difference of reached strength values was about 3 % (Uhu and Ceys). Only using the adhesive Bison this difference was 12 %.

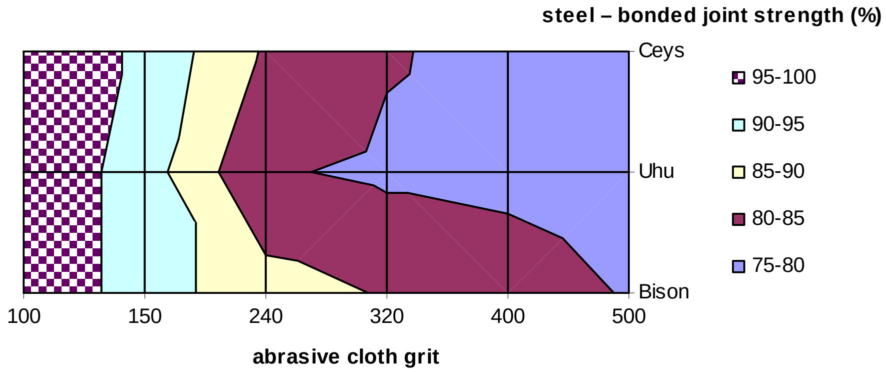

Fig. 4 Influence of bonded surface mechanical pretreatment on the bonded joint strength – steel

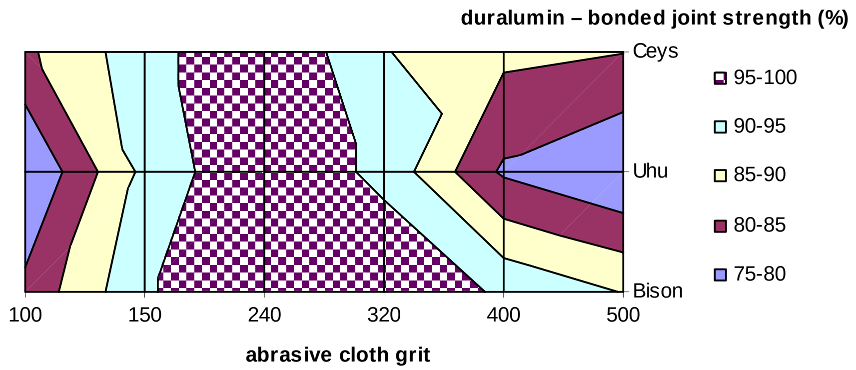

Fig. 5 Influence of bonded surface mechanical pretreatment on the bonded joint strength – duralumin

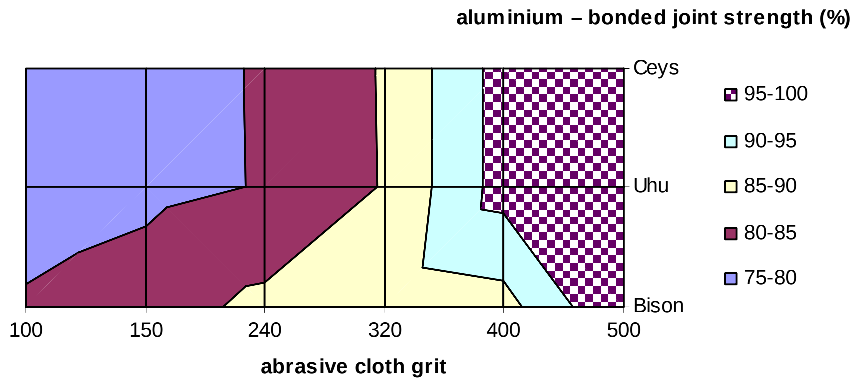

Fig. 6 Influence of bonded surface mechanical pretreatment on the bonded joint strength – aluminum

Evaluating the surface roughness parameters the premise of steel and aluminum alloys different chemical composition influence on the abrasion rate showed itself. Between single materials the different roughness parameters at the same grinding conditions were determined. Comparing results from Figs. 7 and 8 the influence on the Ra and Rz values is perceptible. It was determined that the highest strength was reached at almost the same values of Ra and Rz. Therefore it is evident that the optimal roughness values presented in Tab. 2 are optimal although they were reached using different abrasive clothes.

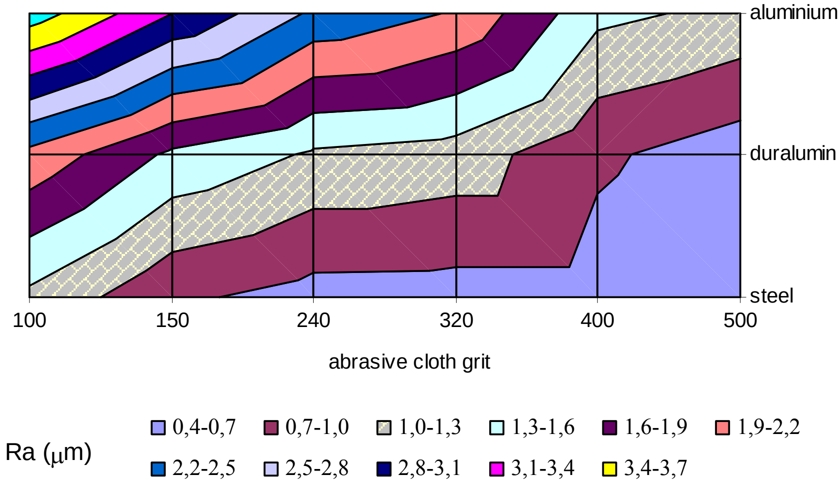

Fig. 7 Influence of material and abrasive cloth on the Ra values

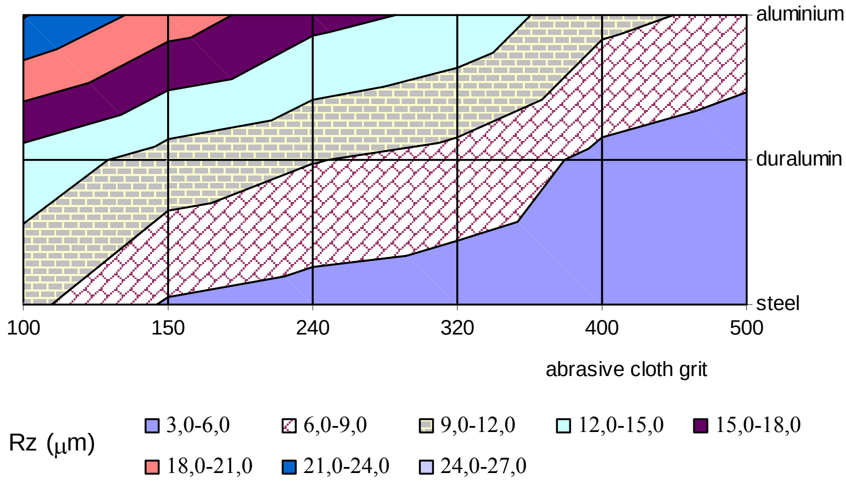

Fig. 8 Influence of material and abrasive cloth on the Rz values

Tab. 2 Optimal values

Roughness parameters	Steel – abrasive cloth of grit **100**	Duralumin – abrasive cloth of grit **240**	Aluminum – abrasive cloth of grit **400 – 500**
Ra (μm)	1.24	1.26	1.22
Rz (μm)	9.83	9.12	8.23

The difference between the optimum and unsuitable adhesive bond surface treatment can be seen in the fig. 9.

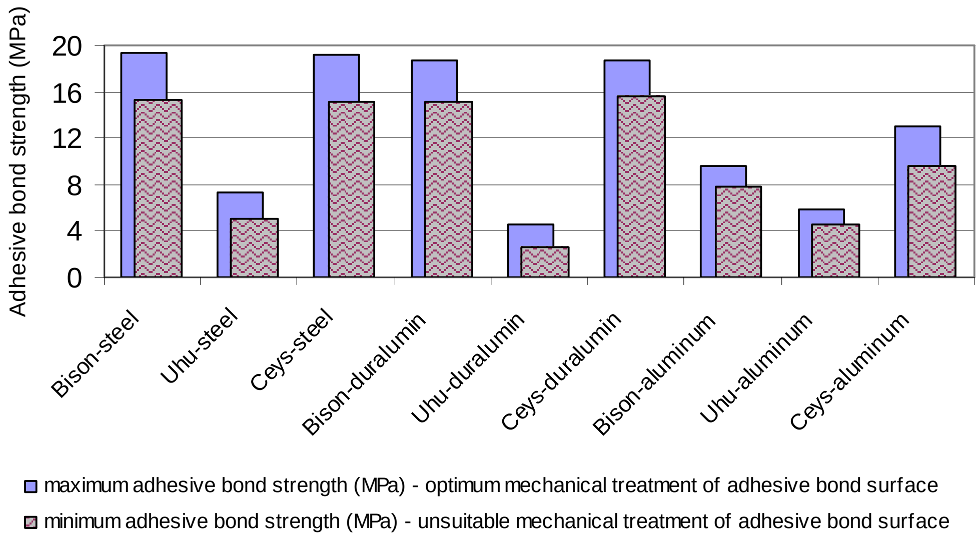

Fig. 9 Comparing of optimum and unsuitable mechanical treatment of adhesive bond surface

4 CONCLUSIONS

The analysis of obtained data made possible the formulation of roughness parameters optimal values (presented in Tab. 2) and at the same time the determination of the abrasive cloth grit. Suitable abrasive cloth is for steel of grit 100, for duralumin of grit 240 and for aluminum of grits 400 and 500.

Comparing the reached strength values the hypothesis was confirmed that the bonded surface mechanical pretreatment is one of key influences on the bonded joint primary strength. From the test results it stands to reason than not only the mechanical pretreatment is necessary but that this pretreatment must be specified, too. At the use of an accidental abrasive cloth the reaching of bonded joint optimal strength is not guaranteed. The tests showed that at the use of unsuitable grit the strength decrease compared with optimum can be up to 43 %.

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