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RESEARCH IN JOINING TECHNOLOGIES IN AUSTRIA

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Within the Austrian network of excellence COMET K-project JOIN4+ companies and research institutes cooperate in funded research projects. JOIN4+ exhibits a total budget of 6.6 Mio. Euros, which is covered by all research partners, the Austrian government as well as the involved provinces. Currently eight different projects in two areas are treated. In this contribution the funding situation as well as selected results are presented. 11 Ref., 7 Figures.

K e y w o r d s : *research funding, welding, friction welding, FSSW, modelling, AHSS*

1. Introduction

Innovative and competitive products require sound basic research with according budgets. As one positive example the Austrian Network of Excellence for Joining Technologies JOIN4+ is presented in this contribution. International partners from industry and academia in the field of welding technology cover relevant tasks enabling the company partners to introduce innovative products on the global market.

2. Funding concept

The Austrian Research Promotion Agency (FFG) offers different concepts for co-financing of application-oriented research. The current COMET-program (Competence Centres for Excellent Technologies) contains three different routes (K2, K1 and K-projects) which covers different aims, budgets and contract periods. [1].

K-projects are focused on the application, which is very attractive for companies. Nevertheless compared to K1 and K2, K-projects show the smallest overall budget.

2.1. Basic guidlines

Within K-projects company partner have to finance 50% of the project volume by means of in-kind or cash contribution.

5% of the overall budget has to be covered by the research partners by means of inkind contributions. Two third of the residual is funded by the as fore mentioned FFG and one third is covered by the involved provinces of Austria. The maximum possible funding is limited for each K-project.

2.2. Projects and partners

Within the K-project JOIN4+ 15 company partners are actively involved in eight different projects. Two partners are from Germany, one is from Switzerland, the remaining are from Austria:

<u>Company partners</u>:

- ✧ Air Liquid Austria GmbH
- ✧ Audi AG
- ✧ Berndorf Band GmbH
- ✧ Bombardier Transportation Austria GmbH
- ✧ Benteler SGL Composite Technology GmbH
- ✧ Fronius International GmbH
- ✧ InfraTec GmbH
- ✧ Jansen AG
- ✧ MCE – Maschinen und Apparatebau GmbH & Co
- ✧ pewag austria GmbH
- ✧ PLASMO Industrietechnik GmbH
- ✧ Wilhelm Schmidt KG
- ✧ voestalpine Draht GmbH
- ✧ voestalpine Stahl GmbH
- ✧ Welser Profile AG

Five scientific partners from Austria and one from Germany are completing the project team:

<u>Research partners:</u>

- ✧ Johannes Kepler University Linz, Institute for Communications Engineering and RF-Systems
- ✧ Fraunhofer Institute for Mechanics of Materials
- ✧ Graz University of Technology, Institute for Materials Science and Welding
- ✧ Vienna University of Technology, Institute of Materials Science and Technology
- ✧ Light Metals Technologies Ranshofen
- ✧ Schweiβtechnische Zentralanstalt Wien

In each subproject at minimum two companies and one research partner have to be involved. One requirement of this research funding approach is the strong link between different subprojects leading to a significant added value compared to single projects.

As shown in Figure 1: Coupling of different sub-projects covering different topics1 different sub-projects within JOIN4+ are coupled to each other. Additionally to informal information exchange, seminars and other activities are organised by the JOIN4+ management.

Due to different focus of the diverse projects tow clusters were formed. These areas are called *Advanced Materials Joining* focusing on the behaviour of the material to be joined and *Advanced Joining Processes & in-situ Process Control* concentrating on advanced joining processes. Additionally, modelling and simu-

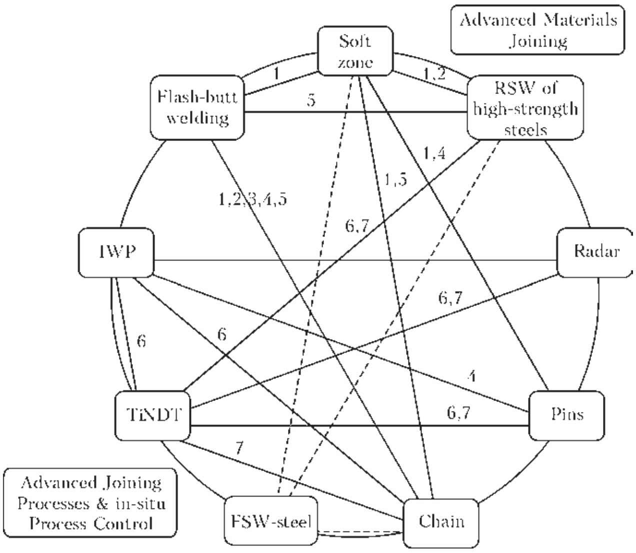

Figure 1. Coupling of different sub-projects covering different topics

lation is applied to all projects and a strategic project is run within JOIN4+.

2.3. Organisation

The Institute for Materials Science and Welding at Graz University of Technology in Austria is the responsible consortium manager. Different persons in charge cover scientific, financial and operative tasks. To consider and protect different interests of scientific and company partners, the core partners are joined in the legal consortium *ARGE JOIN4+,* supporting the consortium management.

2.4. Boundary conditions

Additionally to the funding contract each individual sub-project is defined by a project contract determining tasks, responsibilities and intellectual property rights between the partners. Funding is paid annually based on the given cost report.

For documentation, annual reports have to be forwarded to the funding organisation. These reports also include success stories. Additionally the K-project is evaluated after two years and after the end of the funding period. As a result of these evaluations changes and advancements can be requested by the funding organisation.

Depending on the requirements of the involved provinces additional efforts are necessary such as the formulation of a marketing concept or the setup of a homepage.

3. Selected results

3.1. Soft zone

The soft zone due to welding of advanced high strength steels often is a limiting factor in the application of these materials (Figure 2: Soft zone due to welding of high-strength steel. [2]2).

In this sub-project it is systematically investigated, which welding parameters are essential in the development of this weak zone and how they change the local material properties. Furthermore it is explored,

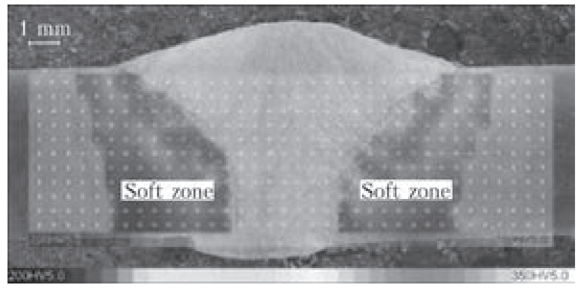

Figure 2. Soft zone due to welding of high-strength steel [2]

which variables, describing the soft zone, significantly influence the strength of a real joint. Basically the static strength is investigated but also the fatigue strength is considered.

Therefore extensive experimental thermo-mechanical investigations are performed to evaluate the numerical finite element simulation using Abaqus solver. [3] The systematic variation of different variables describing the soft zone shows that especially the quotient of width of the soft zone and sheet thickness as well as the level of the soft zone compared to the strength of the base materials are the most influencing factors. However preparation of the seam, especially of the bevel angel, was found to be less important.

Additionally microstructure development due to welding is modelled by means of SYSWELD. In house developed routines are implemented to consider effects like grain growth. [4] Variables necessary in these routines are based on microstructural characterisation of different treated microstructures by means of metallography. The results are then verified and extrapolated by use of MatCalc simulations. With this coupling of different methods it is possible to calculate the grain size and therefore to estimate material's strength due to an applied welding process.

3.2. Chain

In a predecessor project a prototype for a totally new approach in chain production was designed. Two half links are welded by means of linear friction welding. [5] In the current sub-project the influence of different welding parameters such as amplitude, frequency, friction force and forging force on the quality of the joint is investigated systematically. It is found that the geometry of the flash is a reasonable indicator for the quality. This correlation enables very fast inline quality estimation during the start-up phase of the process. Furthermore it is found that with decreasing welding cycle time the quality of the joint improves. Based on this it is concluded could that this new production process is highly economic (Figure 3: With decreasing friction time the joint quality improves. Quality is estimated by means of flash geometry from not acceptable (A) to very good (D).3).

Additionally to comprehensive experimental investigations of the friction welding process of chains, a simulation program of the process is de-

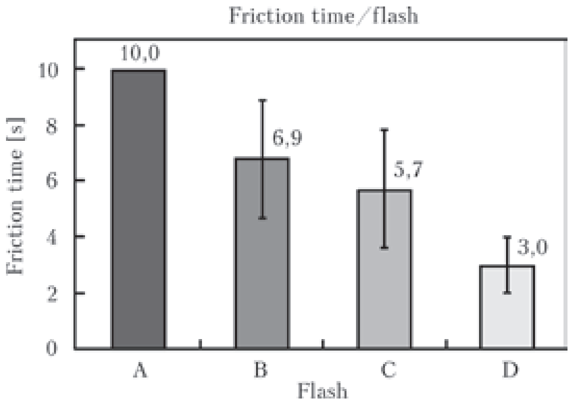

Figure 3. With decreasing friction time the joint quality improves. Quality is estimated by means of flash geometry from not acceptable (A) to very good (D)

veloped. A sever difficulty is the proper description of the heat input, which is based on friction and significantly changes during the process. By means of an inverse approach both heat input and temperature dependant friction coefficient is estimated. Therefore the local temperature of the chain, as an input parameter for this calculation, has to be measured as a function of time.

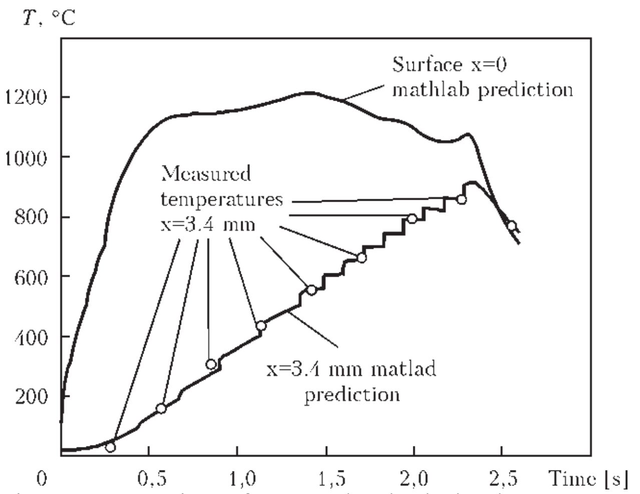

Figure 4. Comparison of measured and calculated temperature during friction welding

With the estimated heat input as a boundary condition the transient temperature field and subsequently deformation as well as flash formation can be calculated by means of an FE code, see Figure 4: Comparison of measured and calculated temperature during friction welding.4. [6]

3.3. Pin structures

Applying the CMT process (Cold Metal Transfer) developed by Fronius it is possible to produce different geometries of so called pins, as shown in Figure 5.

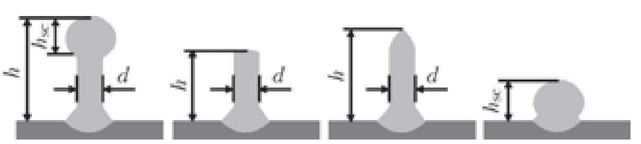

Figure 5. Different geometries of pins with characteristic dimensions

By proper application of voltage and mechanical movement of the filler wire the height and shape of the pin can be determined.

Using such pins enables to strengthen the joints between dissimilar materials such as steel and aluminium or even metal and fibre reinforced polymers by form-fit. [7]

In this project two different goals are defined. In a first step the production process of the pin itself is modelled. Especially heat input distribution during welding and shaping of the pin is modelled in a coupled FE calculation for different materials such as steel, titanium aluminides, etc. Secondly, the properties of the pins in combination with the materials to be joined are estimated. These properties depend on a high degree on the process of welding and shaping which is performed prior to the mechanical loading.

Aluminium pins face a special challenge for a successful application. Based on the thermo-physical properties they cannot be produced shorter than approximately 2 mm. Since one possible application is automotive industry where thin sheets are of interest, even 2 mm pins seem to be too long. Therefore one current focus in research is to produce much shorter pins for aluminium.

Based on the Surfisculpt® process, which was developed by TWI for steel, electron beam process is applied to structure the surface of aluminium thin sheets

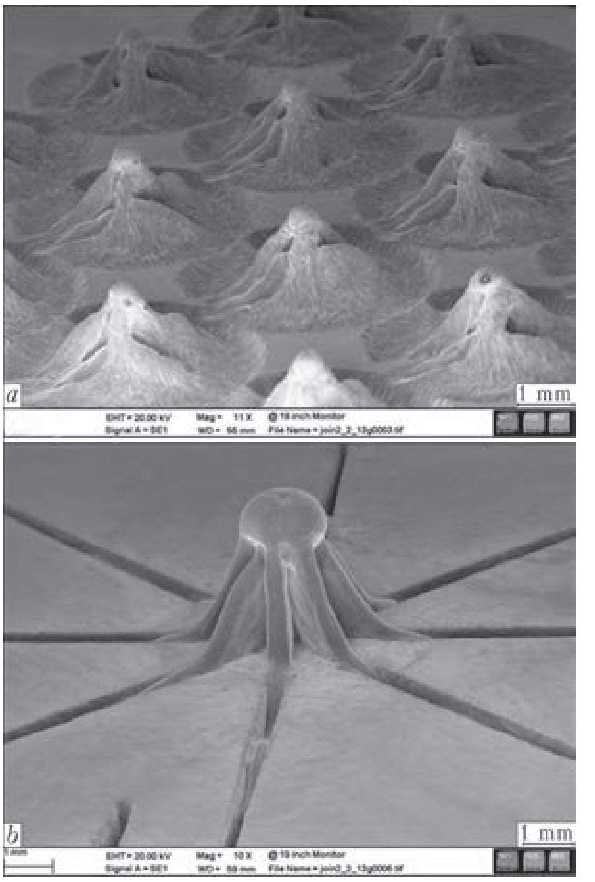

Figure 6. Surface structuring by pins (a) is produced from base material by electron beam introduced material flow (b)

Figure 7. Comparison of experimentally and numerically determined thermo mechanical affected zone after FSSW of AA6082-T6 [11]

(Figure 6: Surface structuring by pins (a) is produced from base material by electron beam introduced material flow (b).6). This approach has not been reported for aluminium alloys so far.

Friction stir spot welding (FSSW) of AA6082-T6

Additionally to the sub-projects that have been submitted, proved and funded by the COMET program, there is a further possibility to finance basic research projects in the so-called non-k area, where the company partners directly finance strategic projects. One topic under consideration deals with the modelling of microstructure evolution of aluminium alloys during the friction stir spot welding process.

Based on previous projects [9,10] a physically based model developed to describe the microstructural evolution due to FSSW [11]. To generate proper material input parameters for the simulation, Gleeble experiments are conducted with a torsion unit. The grain size representing the thermo mechanical heat affected zone is measured from specially defined welding experiments. These results are then used to evaluate the simulated thermo mechanical heat affected zone by means of the calculated grain size distribution, see Figure 7: Comparison of experimentally and numerically determined thermo mechanical affected zone after FSSW of AA6082-T6. [11]7.

4. Summary

The Austrian K-project JOIN4+ is a very successful cooperation between companies and academia. In two working areas eight different projects with significant interconnections are treated. Following key issues can be summarized:

- ✧ Basic mechanisms of friction welding
- ✧ Prediction of properties of welded joints in advanced high strength steels
- ✧ Improved reliability for detection and characterisation of weld defects
- ✧ Improved process reliability by control of significant welding parameters
- ✧ Development of modern sensors for welding processes
- ✧ Joining of dissimilar materials

Sound communication between the project partners stimulates to find surprising solutions leading to innovative and advanced results. A further advantage of this approach is the possible starting point of a long-term cooperation between acting partners.

5. Acknowledgement

The K-project Network of Excellence for Joining Technologies JOIN4+ is funded in the frame of COMET — Competence Centers for Excellent Technologies by BMVIT, BMWFJ, FFG, Land Oberösterreich, Land Steiermark, SFG and ZIT. The program COMET is managed by the Austrian Research Promotion Agency in Vienna. http://www.ffg.at/comet.

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