

DECLARATION OF JUNE ANN MUNFORD

1. My name is June Ann Munford. I am over the age of 18, have personal knowledge of the facts set forth herein, and am competent to testify to the same.
2. I earned a Master of Library and Information Science (MLIS) from the University of Wisconsin-Milwaukee in 2009. I have over ten years of experience in the library/information science field. Beginning in 2004, I have served in various positions in the public library sector including Assistant Librarian, Youth Services Librarian and Library Director. I have attached my Curriculum Vitae as Appendix CV.
3. During my career in the library profession, I have been responsible for materials acquisition for multiple libraries. In that position, I have cataloged, purchased and processed incoming library works. That includes purchasing materials directly from vendors, recording publishing data from the material in question, creating detailed material records for library catalogs and physically preparing that material for circulation. In addition to my experience in acquisitions, I was also responsible for analyzing large collections of library materials, tailoring library records for optimal catalog

search performance and creating lending agreements between libraries during my time as a Library Director.

4. I am fully familiar with the catalog record creation process in the library sector. In preparing a material for public availability, a library catalog record describing that material would be created. These records are typically written in Machine Readable Catalog (herein referred to as “MARC”) code and contain information such as a physical description of the material, metadata from the material’s publisher, and date of library acquisition. In particular, the 008 field of the MARC record is reserved for denoting the date of creation of the library record itself. As this typically occurs during the process of preparing materials for public access, it is my experience that an item’s MARC record indicates the date of an item’s public availability.
5. Typically, in creating a MARC record, a librarian would gather various bits of metadata such as book title, publisher and subject headings among others and assign each value to a relevant numerical field. For example, a book’s physical description is tracked in field 300 while title/attribution is tracked in field 245. The 008 field of the MARC record is reserved for denoting the creation of the library record itself. As this is the only date reflecting the inclusion of said materials within the library’s collection, it is my experience

that an item's 008 field accurately indicates the date of an item's public availability.

6. I have reviewed Exhibit EX-1021, "Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White" by Vaissiere, L., Laurent, J., and Reinhardt, A. as published in *Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM*.

7. Attached hereto as Appendix VAISSIERE01 is a true and correct copy of the MARC record for *Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM* as held by the Library of Congress. I secured this record myself from the library's public catalog. The MARC record contained within Appendix VAISSIERE01 accurately describes the title, author, publisher, and ISBN number of *Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM*.

8. The 008 field of the MARC record in Appendix VAISSIERE01 indicates the date of record creation. The 008 field of Appendix VAISSIERE01 indicates the Library of Congress first acquired these proceedings as of October 31, 2003. Considering this information, it is my determination that *Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM* and therefore

"Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White" was made available to the public shortly after its initial acquisition as of October 31, 2003.

9. Attached hereto as Appendix VAISSIERE02 are photos of *Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM*. These photos were secured using the copy of *Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM* held by the Library of Congress. Page 1 of Appendix VAISSIERE02 contains a library stamp dated August 18, 2003.

10. Attached hereto as Appendix VAISSIERE03 are photos of "Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White" as contained within Appendix VAISSIERE02, the Library of Congress copy of *Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM*. In comparing Exhibit EX-1021 to Appendix VAISSIERE03, it is my determination that Exhibit EX-1021 is a true and correct copy of "Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White" by Vaissiere, L., Laurent, J., and Reinhardt, A.

11. Attached hereto as Appendix VAISSIERE04 is a true and correct copy of “Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White” as presented in *Proceedings of the 2002 SAE International Body Engineering Conference and Automotive & Transportation Technology Conference on CD-ROM (IBAT2002CD)*.

Appendix VAISSIERE04 is a high-quality reprint of “Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White” provided by SAE International. Based on reviewing the content of Appendices VAISSIERE02, VAISSIERE03 and VAISSIERE04, it is my determination that VAISSIERE04 is an identical reprinting of “Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White” and as such, my statements regarding the public availability of Appendix VAISSIERE02 also apply to Appendix VAISSIERE04. In comparing Exhibit EX-1021 to Appendix VAISSIERE04, it is my determination that Exhibit EX-1021 is a true and correct copy of "Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White" by Vaissiere, L., Laurent, J., and Reinhardt, A. as published in *Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM*.

12. I am familiar with the Internet Archive, a digital library formally certified by the State of California as a public library. Among other services that the Internet Archive makes available to the general public is the Wayback Machine, an online archive. The Internet Archive's Wayback Machine service archives webpages as of a certain capture date to track changes in the web over time. The Internet Archive has been in operation as a nonprofit library since 1996 and has hosted the Wayback Machine service since its inception in 2001. During my time as a librarian, I frequently used the Internet Archive's Wayback Machine for research and instruction purposes. This includes teaching instructional classes on using the Wayback Machine to library patrons and using the Wayback Machine to research reference inquiries that require hard-to-find online resources. I consider the Internet Archive's recordskeeping to be as rigorous and detailed as other formal library recordskeeping practices such as MARC records, OCLC records and Dublin Core.

13. Attached hereto as Appendix VAISSIERE05 is a screen capture of the Internet Archive Wayback Machine entry for <http://catalog.loc.gov/cgi-bin/Pwebrecon.cgi?DB=local&PAGE=First>. I secured these screen captures myself from <https://web.archive.org/web/20020914220308/http://catalog.loc.gov/cgi->

bin/Pwebrecon.cgi?DB=local&PAGE=First. This record was captured as of September 14, 2002.

14. Appendix VAISSIERE05 is an Internet Archive capture of a web page entitled "Library of Congress Online Catalog" as hosted on the Library of Congress. This web page is the searchable online library catalog of the Library of Congress as of September 14, 2002 and would include *Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM* in its search results once the CD-ROM was added to the collection in 2003. The descriptive indexing provided by MARC records allows interested members of the public to discover library materials by prompting the Library of Congress online catalog with advanced search queries. As of September 14, 2002, this library catalog allowed users to search the library catalog by title, author, subject, call number, ISBN, ISBN and other advanced search criteria. These search types correspond to specific entries within any given MARC record – for instance, Appendix VAISSIERE01's ISBN is noted in field 020 while the work's subjects are assigned to field 650.

15. I have reviewed "Hardening Technology of Steel by Die Quenching and Application to Body Parts" by Katsuji Nakajima as published in *Current Advances in Materials and Processes: Report of the ISIJ Meeting, 2004*.

16. Attached hereto as Appendix NAKAJIMA01 is a true and correct copy of the MARC record for *Current Advances in Materials and Processes: Report of the ISIJ Meeting* as held by the Library of Congress. I secured this record myself from the library's public catalog. The MARC record contained within Appendix NAKAJIMA01 accurately describes the title, author, publisher, and ISSN number of *Current Advances in Materials and Processes: Report of the ISIJ Meeting*. The 'Item Availability' field of this record visible on page 4 indicates this collection includes the 2004 edition of *Current Advances in Materials and Processes: Report of the ISIJ Meeting* containing "Hardening Technology of Steel by Die Quenching and Application to Body Parts".

17. Attached hereto as Appendix NAKAJIMA02 is a true and correct copy of "Hardening Technology of Steel by Die Quenching and Application to Body Parts" as published in *Current Advances in Materials and Processes: Report of the ISIJ Meeting* as held by the Library of Congress. These scans were secured from the library's collection. In comparing Appendix NAKAJIMA01 to Appendix NAKAJIMA02, it is my determination that Appendix NAKAJIMA02 is a true and correct copy of "Hardening Technology of Steel by Die Quenching and Application to Body Parts" by

Katsuji Nakajima as published in *Current Advances in Materials and Processes: Report of the ISIJ Meeting 2004*. Page 9 of this Appendix contains a citation to "Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White."

18. The 008 field of the MARC record in Appendix NAKAJIMA01 indicates the date of record creation. The 008 field of Appendix NAKAJIMA01 indicates the Library of Congress library first acquired this journal as of December 8, 1998 and held the journal in perpetuity until 2013. Considering this information, it is my determination that *Current Advances in Materials and Processes: Report of the ISIJ Meeting 2004* and therefore "Hardening Technology of Steel by Die Quenching and Application to Body Parts" was made available to the public shortly after its initial release in 2004. The inclusion of a citation to "Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White" within Nakajima's paper indicates "Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White" was publicly available as of the publication of the Nakajima paper in 2004.

19. I have been retained on behalf of the Petitioner to provide assistance in the above-illustrated matter in establishing the authenticity and public

availability of the documents discussed in this declaration. I am being compensated for my services in this matter at the rate of \$200.00 per hour plus reasonable expenses. My statements are objective, and my compensation does not depend on the outcome of this matter.

20. I declare under penalty of perjury that the foregoing is true and correct. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: 8/20/2024

A handwritten signature in black ink, appearing to read "June Ann Munford", with a stylized flourish at the end.

June Ann Munford

Appendix CV

June A. Munford
Curriculum Vitae

Education

University of Wisconsin-Milwaukee - MS, Library & Information Science, 2009
Milwaukee, WI

- Coursework included cataloging, metadata, data analysis, library systems, management strategies and collection development.
- Specialized in library advocacy, cataloging and public administration.

Grand Valley State University - BA, English Language & Literature, 2008
Allendale, MI

- Coursework included linguistics, documentation and literary analysis.
- Minor in political science with a focus in local-level economics and government.

Professional Experience

Researcher / Expert Witness, October 2017 – present
Freelance ● Pittsburgh, Pennsylvania & Grand Rapids, Michigan

- Material authentication and public accessibility determination. Declarations of authenticity and/or public accessibility provided upon research completion. Experienced with appeals and deposition process.
- Research provided on topics of public library operations, material publication history, digital database services and legacy web resources.
- Past clients include Alston & Bird, Arnold & Porter, Baker Botts, Fish & Richardson, Erise IP, Irell & Manella, O'Melveny & Myers, Perkins-Coie, Pillsbury Winthrop Shaw Pittman and Slayden Grubert Beard.

Library Director, February 2013 - March 2015
Dowagiac District Library ● Dowagiac, Michigan

- Executive administrator of the Dowagiac District Library. Located in

Southwest Michigan, this library has a service area of 13,000, an annual operating budget of over \$400,000 and total assets of approximately \$1,300,000.

- Developed careful budgeting guidelines to produce a 15% surplus during the 2013-2014 & 2014-2015 fiscal years while being audited.
- Using this budget surplus, oversaw significant library investments including the purchase of property for a future building site, demolition of existing buildings and building renovation projects on the current facility.
- Led the organization and digitization of the library's archival records.
- Served as the public representative for the library, developing business relationships with local school, museum and tribal government entities.
- Developed an objective-based analysis system for measuring library services - including a full collection analysis of the library's 50,000+ circulating items and their records.

November 2010 - January 2013

Librarian & Branch Manager, Anchorage Public Library ● Anchorage, Alaska

- Headed the 2013 Anchorage Reads community reading campaign including event planning, staging public performances and creating marketing materials for mass distribution.
- Co-led the social media department of the library's marketing team, drafting social media guidelines, creating original content and instituting long-term planning via content calendars.
- Developed business relationships with The Boys & Girls Club, Anchorage School District and the US Army to establish summer reading programs for children.

June 2004 - September 2005, September 2006 - October 2013

Library Assistant, Hart Area Public Library

Hart, MI

- Responsible for verifying imported MARC records and original MARC

cataloging for the local-level collection as well as the Michigan Electronic Library.

- Handled OCLC Worldcat interlibrary loan requests & fulfillment via ongoing communication with lending libraries.

Professional Involvement

Alaska Library Association - Anchorage Chapter

- Treasurer, 2012

Library Of Michigan

- Level VII Certification, 2008
- Level II Certification, 2013

Michigan Library Association Annual Conference 2014

- New Directors Conference Panel Member

Southwest Michigan Library Cooperative

- Represented the Dowagiac District Library, 2013-2015

Professional Development

Library Of Michigan Beginning Workshop, May 2008

Petoskey, MI

- Received training in cataloging, local history, collection management, children's literacy and reference service.

Public Library Association Intensive Library Management Training, October 2011

Nashville, TN

- Attended a five-day workshop focused on strategic planning, staff management, statistical analysis, collections and cataloging theory.

Alaska Library Association Annual Conference 2012 - Fairbanks, February 2012

Fairbanks, AK

- Attended seminars on EBSCO advanced search methods, budgeting, cataloging, database usage and marketing.

Depositions

2019 ● Fish & Richardson

Apple v. Qualcomm (IPR2018-001281, 39521-00421IP, IPR2018-01282 and 39521-00421IP2)

2019 ● Erise IP

Implicit, LLC v. Netscout Systems, Inc (Civil Action No. 2:18-cv-53-JRG)

2019 ● Perkins-Coie

Adobe Inc. v. RAH Color Technologies LLC (Cases IPR2019-00627, IPR2019-00628, IPR2019-00629 and IPR2019-00646)

2020 ● O'Melveny & Myers

Maxell, Ltd. v. Apple Inc. (Case No. 5:19-cv-00036-RWS)

2021 ● Pillsbury Winthrop Shaw Pittman LLP

Intel v. SRC (IPR2020-1449)

2022 ● Perkins-Coie

Realtek v. Future Link (IPR2021-01182)

2023 ● Fish & Richardson

Neuroderm Ltd. v. Abbvie, Inc (Case No. PGR2022-00040)

2023 ● Fish & Richardson

Nearmap US Inc. v. Pictometry International Corp. (IPR2022-00735)

2023 ● Fish & Richardson

Samsung Electronics v. MemoryWeb LLC (Case No. 39843-0136PS1)

2023 ● Pillsbury Winthrop Shaw Whitman LLP

Gravel Rating Systems v. Costco Wholesale Corp. (Civil Action No. 4:21-cv-149-ALM)

Limited Case and Clientele History

Alston & Bird

- Ericsson

v. Collision Communications (IPR2022-01233)

- Nokia

v. Neptune Subsea, Xtera (Case No. 1:17-cv-01876)

- Universal Electronics Inc

v. Roku Inc (IPR2022-00818)

Arnold & Porter

- Ivantis

v. Glaukos (Case No. 8:18-cv-00620)

- Samsung

v. Jawbone (Case No. 2:21-cv-00186)

Benesch Friedlander Coplan & Aronoff

- Voyis

v. Cathx (Case No. 5:21-cv-00077-RWS)

Erise I.P.

- Apple

- v. Ericsson Inc. (IPR2022-00715)

- v. Future Link Systems (IPRs 6317804, 6622108, 6807505, and 7917680)

- v. INVT (Case No. 20-1881)

- v. Navblazer LLC (IPR2020-01253)

- v. Qualcomm (IPR2018-001281, 39521-00421IP, IPR2018-01282, 39521-00421IP2)

- v. Quest Nettech Corp (Case No. 2:19-cv-00118-JRG)

- v. Telefonaktiebolaget LM Ericsson (IPR2022-00275)

- Fanduel

- v. CGT (Case No. 19-1393)

- Garmin

- v. Phillips North America LLC (Case No. 2:19-cv-6301-AB-KS)

- Netscout

- v. Longhorn HD LLC (Case No. 2:20-cv-00349)

- v. Implicit, LLC (Civil Action No. 2:18-cv-53-JRG)

- Sony Interactive Entertainment LLC

- v. Bot M8 LLC (IPR2020-01288)

- v. Infernal Technology LLC (Case No. 2:19-CV-00248-JRG)

- Unified Patents

v. GE Video Compression (Civil Action No. 2:19-cv-248)

Fish & Richardson

- Apple

- v. AliveCor (3:21-cv-03958)

- v. LBS Innovations (Case No. 2:19-cv-00119-JRG-RSP)

- v. Koss Corporation (IPR2021-00305)

- v. Masimo (IPR 50095-0012IP1, 50095-0012IP2, 50095-0013IP1, 50095-0013IP2, 50095-0006IP1, 50095-0135IP1)

- v. Neonode (Case No. 21-cv-08872-EMC)

- v. Qualcomm (IPR2018-001281, 39521-00421IP, IPR2018-01282, 39521-00421IP2)

- Dell

- v. Neo Wireless (IPR2022-00616)

- Dish Network

- v. Entropic Communications, LLC (Case No. 2:2023-CV-01043)

- v. Realtime Adaptive Streaming (Case No. 1:17-CV-02097-RBJ)

- v. TQ Delta LLC (Case No. 18-1798)

- Evapco Dry Cooling

- v. SPG Dry Cooling (IPR2021-00688)

- Genetec

- v. Sensormatic Electronics (Case No. 1:20-CV-00760)

- Huawei

- v. Bell Northern Research LLC (IPR2019-01174)
- Kianxis
 - v. Blue Yonder (Case No. 3:20-cv-03636)
- LG Electronics
 - v. Bell Northern Research LLC (Case No. 3:18-cv-2864-CAB-BLM)
- Metaswitch
 - v. Sonus Networks (IPR2018-01719)
- Microsoft
 - v. Throughputer Inc (IPR2022-00757)
- Mom Enterprises
 - v. Ddrops Company (Case No. 1:22-cv-00332)
- MLC Intellectual Property
 - v. MicronTech (Case No. 3:14-cv-03657-SI)
- Nearmap Inc
 - v. EagleView Technologies (IPR2022-01009)
- Neuroderm Ltd.
 - v. Abbvie, Inc (Case No. PGR2022-00040)
- Realtek Semiconductor

v. Future Link (IPR2021-01182)

- Quectel

v. Koninklijke Philips (Case No. 1:20-cv-01710)

- Samsung

v. Aire Technology (IPR2022-00877)

v. Bell Northern Research (Case No. 2:19-cv-00286-JRG)

v. Communication Technologies Inc (IPR2022-01221)

v. Jawbone Innovations (IPR2022-00865)

v. MemoryWeb LLC (IPR2022-00885)

v. Dodots Licensing Solutions (IPR2023-00701)

v. Telefonaktiebolaget LM Ericsson (IPR2021-00615)

- Texas Instruments

v. Vantage Micro LLC (IPR2020-01261)

- Xilinx

v. Sentient Sensors LCC (Case No. 1:22-cv-00173)

Irell & Manella

- Curium

O'Melveny & Myers

- Apple

v. Maxell (Case No. 5:19-cv-00036-RWS)

- Micron Technology Inc.
v. Besang Inc (IPR2023-00900)
- Samsung
v. Daedalus Prime LLC (1335 Investigation)

Perkins-Coie

- Heru Industries
v. The UAB Research Foundation (IPR2022-01148)
- Intel Corporation
v. BitMICRO (Case No. 5:23-cv-00625)
- Realtek Semiconductor
v. Future Link (IPR2021-01182)
- Twitter Inc
v. VOIP-Pal.com (Case No. 3:20-cv-02397-JD)
- TCL Industries
v. Koninklijke Philips NV (IPR2021-00495, IPR2021-00496
and IPR2021-00497)

Pillsbury Winthrop Shaw Pittman

- Intel
v. FG SRC LLC (Case No. 6:20-cv-00315)
- Gravel Rating Systems

- v. Costco (Case No. 4:21-cv-149)
- v. Lowe's Home Centers (Case No. 4:21-cv-150)
- v. T-Mobile USA (Case No. 4:21-cv-152)
- v. Kohl's Inc. (Case No. 4:21-cv-258)
- v. Under Armor (Case No. 4:21-cv-356)

Quinn Emanuel

- Wolfspeed
 - v. The Trustees of Purdue University (Case No. 1:2021-cv-00840)

Stern, Kessler, Goldstein & Fox

- Preliminary Research

Sheppard, Mullin, Richter & Hampton LLP

- Cadence Design Systems Inc.
 - v. Semiconductor Design Technologies (Case No. 3:23-cv-01001)

Appendix VAISSIERE01



CATALOG

LC Catalog Quick Search



LOGIN



SEARCH OPTIONS

Refine Your Search



1 of 1



BOOK

Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM

Full Record

MARC Tags

000 01655cam a2200337a 4500
 001 13390191
 005 20050315153947.0
 007 co |||||
 008 031031s2002 paau sb 000 0 eng d
 006 _ |a 7 |b cbc |c copycat |d 2 |e ncip |f 20 |g y-gencatlg
 925 0_ |a acquire |b 2 shelf copy |x policy default
 955 _ |a vb23 2003-10-31 Preprocessor |h vb23 2005-03-15 |e vb23 2005-03-15 to BCCD
 010 _ |a 2003557551
 035 _ |a (OCoLC)ocm50276941
 040 _ |a CLU |c CLU |d DLC
 042 _ |a lccopycat
 020 _ |a 0768010667
 050 00 |a TL240
 111 2_ |a International Body Engineering Conference and Exhibition |d (2002 : |c Paris, France)
 245 10 |a Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM |h [electronic resource] / |c IBEC 2002, International Body Engineering Conference and Exhibition, Automotive & Transportation Technology Congress.
 260 _ |a [Warrendale, Pa.] : |b Society of Automotive Engineers, |c c2002.
 300 _ |a 1 CD-ROM : |b col. : |c 4 3/4 in.
 538 _ |a System requirements for Macintosh: PowerPC processor; MAC OS 7.1.2 or later; 16 MB of application RAM; 4x CD-ROM drive; super VGA monitor.
 538 _ |a System requirements for Windows: Pentium processor; Windows 95,98,2000, or NT 4.0; 32 MB of RAM; 4x CD-ROM drive; super VGA monitor.
 500 _ |a Title from title screen.
 500 _ |a Includes illustrations.
 500 _ |a Conferences held July 9-11, 2002, at the Palais des congrès, Paris, France.
 504 _ |a Includes bibliographical references.
 500 _ |a *IBAT2002CD*--CD-ROM label.
 650 _0 |a Automobiles |x Design and construction |v Congresses.
 710 2_ |a Society of Automotive Engineers.

Request this Item

LC Find It

Item Availability



Book

PRINT RECORD

SAVE RECORD

EMAIL RECORD

CITE RECORD

MARCXML Record
 MODS Record

Report Record Errors
 Ask a Librarian
 Feedback

Top

Item Availability

CALL NUMBER TL240 [2005 00261]
 Copy 1

Request in See Reference Staff. By Appt in Jefferson Main RR (MRC)

Status Not Charged



 [Subscribe \(Patron Services\)](#) [Ask a Librarian](#) [Feedback](#) [Search/Browse Help](#)

[Speech Enabled](#) [Accessibility](#) [Legal](#) [Inspector General](#) [External Link Disclaimer](#) [USA.gov](#) 



CATALOG

LC Catalog Quick Search



LOGIN



SEARCH OPTIONS

← Refine Your Search



1 of 1



BOOK

Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM

Full Record

MARC Tags

Meeting name

International Body Engineering Conference and Exhibition (2002 : Paris, France)

Main title

Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM [electronic resource] / IBEC 2002, International Body Engineering Conference and Exhibition, Automotive & Transportation Technology Congress.

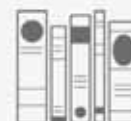
Published/Created

[Warrendale, Pa.] : Society of Automotive Engineers, c2002.

Request this Item

LC Find It

Item Availability



Book

PRINT RECORD

SAVE RECORD

EMAIL RECORD

CITE RECORD

MARCXML Record
MODS RecordReport Record Errors
Ask a Librarian
Feedback

LCCN Permalink https://lccn.loc.gov/2003557551

Description 1 CD-ROM : col. ; 4 3/4 in.

ISBN 0768010667

LC classification TL240

Related names Society of Automotive Engineers.

LC Subjects Automobiles--Design and construction--Congresses.

Browse by shelf order TL240

Notes

Title from title screen.

Includes illustrations.

Conferences held July 9-11, 2002, at the Palais des congrès, Paris, France.

"IBAT2002CD"--CD-ROM label.

Includes bibliographical references.

Computer file info

System requirements for Macintosh: PowerPC processor; MAC OS 7.1.2 or later; 16 MB of application RAM; 4x CD-ROM drive; super VGA monitor.

System requirements for Windows: Pentium processor; Windows 95,98,2000, or NT 4.0; 32 MB of RAM; 4x CD-ROM drive; super VGA monitor.

LCCN 2003557551

Other system no. (OCoLC)ocm50276941

Type of material Book

Item Availability

CALL NUMBER

TL240 [2005 00281]
Copy 1

Request in

See Reference Staff. By Appt in Jefferson Main RR (MRC)

Top

Status

Not Charged



 [Subscribe \(Patron Services\)](#) [Ask a Librarian](#) [Feedback](#) [Search/Browse Help](#)

[Speech Enabled](#) [Accessibility](#) [Legal](#) [Inspector General](#) [External Link Disclaimer](#) [USA.gov](#) 

Appendix VAISSIERE02

TX 5-787-675



47100007076754

MRC

TL 240

2005

00281

Copy 1

ELC 2002
INTERNATIONAL BODY
ENGINEERING CONFERENCE AND EXHIBITION

Palais des Congrès
1 July 2002 • Paris, France

✓
LIBRARY OF CONGRESS
AUG 18 2003
COPY _____
COPYRIGHT OFFICE



2003557551
C-1

IBEC
CD-ROM

Co-located with:



Automotive & Transportation
Technology Congress

Proceedings of the 2002 IBEC and ATT Conferences on CD-ROM

SAE technical papers contained on this CD-ROM feature the latest technological and interior automotive body engineering manufacturing. Coverage includes technologies, body design and exterior body materials, chassis, electronic environmental sustainability, fuel transportation, glass and glazing transfer and heat exchanges, manufacturing assembly, materials, powertrain,



ISBN 0-7680-1066-7



Copyright © 2002 Society of Automotive Engineers, Inc. All rights reserved.

IBAT2002CD

ISBN: 0-7680-1066-7

Minimum System Requirements Recommended by OMNIPRESS:

Macintosh®: PowerPC processor, Mac OS 7.1.2 or later, 16 MB of application RAM, 4x CD-ROM drive.

Windows®: Windows 95, 98, 2000 or NT 4.0, Pentium processor, 32 MB of RAM, 4x CD-ROM drive.

UNIX®: Sun SPARCstation, SunOS ver. 2.3, Open Windows 3.0 or Motif ver. 1.2.3, 32 MB machine.

HP Series 9000 - model 700, HP-UX 9.0.3, HP-VUE environment, 32 MB machine.

(For UNIX® Technical Support please contact Adobe at 1-800-685-3652)

Monitor: Super VGA (800 by 600 pixels) **Printer:** Laser, Ink Jet or Bubble Jet (avoid dot-matrix printers)

This CD-ROM requires the Adobe Acrobat® Reader 4.0 software included on this CD-ROM.



**Proceedings of the
2002 IBEC and ATT Conferences
on CD-ROM**

SAE
INTERNATIONAL®

©2002 Society of Automotive Engineers, Inc. All rights reserved. ISBN 0-7680-1088-7 • IBAT2002CD

*Proceedings of the 2002 IBEC
and ATT Conferences on CD-ROM*



**Palais des Congrès
9-11 July 2002 • Paris, France**



Co-located with:



**Automotive & Transportation
Technology Congress**

Installation Instructions

MACINTOSH

To ensure this product performs correctly, you must install the Acrobat® Reader version from this CD-ROM.

Installing Software

Double-click the "Omni EZ Installer™" icon and follow the instructions.

Running the CD-ROM

Double-click the "Begin.pdf" icon in the main window of the CD-ROM.

UNIX

Installing Software

See the system requirements and installation instructions in `\install\unix\instguid.txt`. Omnipress does not offer support for UNIX® (please contact Adobe Acrobat® Support).

Running the CD-ROM

Launch the "Begin.pdf" at the root level of the CD-ROM.

WINDOWS

Acrobat Reader 4.0 is not compatible with the Windows 3.1 operating system.

Installing Software

This CD-ROM features Autorun software to simplify the install process. If the installer does not run after placing the CD-ROM in your computer:

- In the Taskbar, click Start > Run
- Type `d:\install` (assuming "d" is the letter of your CD-ROM drive)

Running the CD-ROM

In the Taskbar, click Start > Programs > SAE International > 2002 Future Car Congress

omnipress
omnipro-cd™

CD-ROM Help: To better acquaint yourself with this product, we suggest that you spend a few minutes with the **CD-ROM Help** file located on the main menu. This section is very helpful and will facilitate easier, more productive use of this CD-ROM.

Technical Support: contact Adobe at 1-800-685-3652 or visit Adobe's Acrobat Reader support website: <http://www.adobe.com/support/products/acroreader.html>

General Support or Product Information: contact Omnipress at 1-608-246-2600 (Mon - Fri 8 am - 5 pm CST) or e-mail support at digital@omnipress.com. Omnipress does not offer support for UNIX®.

©2002 OMNIPRESS® Macintosh, QuickTime and the QuickTime logo are registered trademarks of Apple Computer Inc. Windows® is a registered trademark of Microsoft Corporation. ©1987-99, Adobe Systems Inc. All rights reserved. Adobe, Acrobat and the Acrobat logo are trademarks of Adobe Systems, Inc., which may be registered in certain jurisdictions. Some portions copyrighted and reprinted with permission from Adobe Systems, Inc.

Appendix VAISSIERE03

2002-01-2048

Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White

L. Vaissiere
RENAULT S.A.

J. P. Laurent
USINOR - CRPC

A. Reinhardt
PSA Peugeot Citroën

Copyright © 2002 Society of Automotive Engineers, Inc.

ABSTRACT

The automotive industry have to face with its will to increase the safety of the passengers and the necessity to reduce the pollutant emissions. Besides, the customers expect more and more high vehicle quality and especially as far as corrosion is concerned.

The development of the pre-coated boron steel associated with the hot stamping allows PSA Peugeot Citroën and RENAULT to lighten their parts significantly and fulfill the automotive corrosion requirements.

The benefit in crash resistance has been obtained by the increase of the mechanical properties after heat treatment. After a complete austenitisation in a 930°C furnace, the blanks are stamped and quenched in one step in a water cooled tool. This process allows to obtain :

YS > 950 MPa

TS > 1300 MPa.

INTRODUCTION

The reinforcement of regulations in terms of pollution (CAFE 2008 CO₂ emission under 140 g/km) and the increase of equipments induce that the automotive industry has a critical need for weight reduction solutions for car bodies. Moreover, the crash resistance objectives are more and more severe to improve the car safety and lead the manufacturers to reinforce the bodies in white. Then, the lengthening of anti-corrosion guarantees requires a two sides pre-coated steel supply.

This challenge is achieved through the use of steels having the highest possible mechanical properties, meaning, however, a decrease of formability.

In order to solve this problem, it was necessary to make a breakthrough with respect to the continuous process of increasing mechanical characteristics. For this, the forming and properties-of-use functions have been considered separately in the development of the USIBOR steel. The as-delivered USIBOR steel allows easy forming and, after heat treatment, presents high mechanical characteristics and corrosion resistance compatible with the new guarantees given by the manufacturers to their customers.

In order to meet these requirements, a working group was created between USINOR, PSA Peugeot Citroën and RENAULT with the objective to develop a pre-coated version of the USIBOR steel.

PRE-COATED USIBOR 1500

1/ POSITION IN THE RANGE

Pre-coated USIBOR 1500 has been developed to reply to the weight reduction needs for structural and reinforcement parts of automobiles (fig. 1), and the lengthening of the anti-corrosion guarantees.

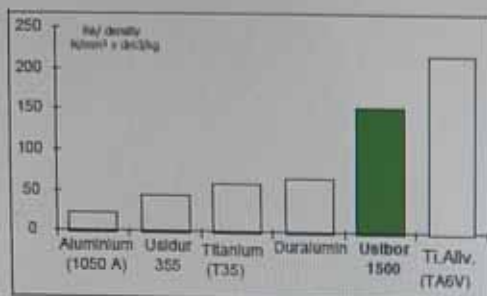


Figure 1: Weight reduction potential of USIBOR 1500 compared to other materials according to their yield strength.

This internationally patented steel, with its high hot forming possibilities, make it possible, after heat treatment, to obtain very high mechanical characteristics, with exceptional impact resistance.

The heat treatment is carried out after forming in order to obtain a high tensile strength level.

Mechanical characteristics, before and after heat treatment are shown in figure 2.

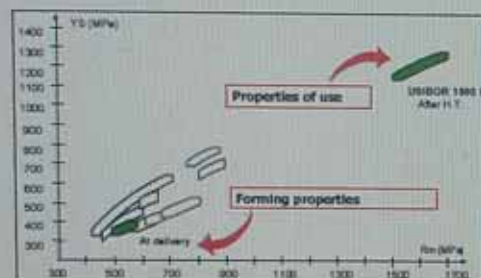


Figure 2: Mechanical characteristics, before and after heat treatment.

2/ METALLURGICAL PROCESS

2-1 Chemical analysis and coating

USIBOR 1500 is a carbon/manganese steel micro-alloyed with boron.

	C	Mn	Si	S	Cr	Al	B	Ti
Mini	200	1100	150		150	20	2	20
Maxi	250	1350	350	8	300	60	4	50

Chemical analysis in thousandths of a %.

In order to protect the metal from oxidation and decarburization during heat treatment, and to increase corrosion resistance after painting, an aluminium based pre-coating is applied with a hot dipped process, the thickness of which is usually between 23µm and 32µm per face.

2-2 Effects of additive elements and rolling

The addition of carbon, manganese, and chrome give good quenchability and the slight addition of boron increases this latter considerably. The boron, in effect, enables the ferritic zone to be shifted towards low cooling speeds thus ensuring good quenchability of parts during heat treatment (critical quenching speed : 27°C/s).

The titanium acts as a nitrogen scavenger thus protecting the boron. Sulphides are globularised with a SiCa treatment.

The thermo-mechanical process applied during the manufacture of hot and cold re-rolled products, enables a homogeneous structure, guaranteeing good formability and reproducible mechanical characteristics, to be obtained before and after heat treatment.

2-3 Microstructures of steel and layer at delivery



Figure 3: Typical HSM ferrite-pearlite microstructure.

The homogeneous distribution of pearlite and an equiaxed grained, ferritic matrix may be noted.



Figure 4: Typical microstructure of coating section by BSE on an SEM.

The coating is composed of an alloyed layer in contact with the substrate on which a layer, composed principally of aluminium, develops.

3/ INFLUENCE OF THE HEAT TREATMENT

3-1 Typical mechanical properties

Blanks are heated to around 900°C for a few minutes.

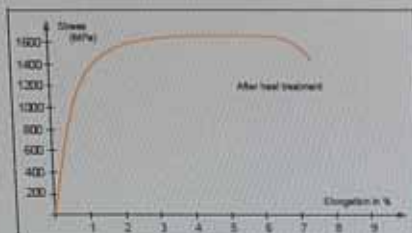


Figure 5 : Typical tensile curve after heat treatment. Thickness 1mm.

After heat treatment, USIBOR 1500 still shows a high capacity for consolidation. The typical tensile results on as-delivered metal and on quenched test pieces are shown below :

	YS (MPa)	TS (MPa)	E% (20x80)
At delivery	400	600	20
After hot forming	1060	1500	5

The ratio YS/TS is between 0,6 and 0,7 at delivery depending on size and between 0,65 and 0,75 after quenching in the die.

3-2 Microstructures of steel and Al-Si coating

Heating the pre-coated USIBOR 1500 at the required temperature creates an alloying reaction by iron diffusion from the steel to the coating. The result is the formation of a multiphase Fe-Al-Si layer. The two main consequences is an increasing of the layer hardness (figure 6) and the layer thickness around 20 µm.

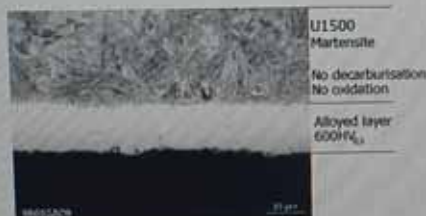


Figure 6 : Typical microstructure of coating section by optical microscope with 4% Nital etch.

Figure 6 shows the totally martensitic structure without the presence of surface decarburization or oxidation. It may be noted that the very hard alloyed layer, is strongly adhered to the substrate.

One of the advantages of the coating is to be an obstacle to the carbon diffusion and so, allows an easy control of the furnace atmosphere.

4/ CHARACTERISTICS OF USE

4-1 Heat treatment.

4-1-1 Jominy curve

Up to 7 mm in depth, maximum hardness is retained, guaranteeing quenching throughout the metal, whatever the thickness supplied.



Figure 7 : Jominy Curve.

4-1-2 Austenitisation

The point A_{c3} is at 850°C, for a heating speed of 5°C/s. The structure of a tensile test sample, austenitised for 5 min at 850°C and water quenched, is totally martensitic. At 840°C some ferrite islands persist. Considering the homogeneity of the initial structure, these islands are evenly distributed.

The point A_{c1} is at 750°C, M_s is at 400°C.

For austenitisation at 900°C, the linear dilatation of the metal is 1,13% at this temperature.

4-1-3 Recommendations

The following recommendations enable the complete alloying of the coating ensuring good corrosion resistance.

For 1,2 mm thick blanks, heated in an electric or gas furnace. The furnace dwell time (from door opening to door opening) must be greater than the following :

Temperature	880°C	900°C	950°C
Mini time	5 min	4 min	3 min

These times must be adapted to the substrate thickness.

4-1-4 CCT Diagram

The CCT diagram was made under the following conditions :

Austenitisation : at 900°C for 5 min

Temperature increase rate: 15°C/s

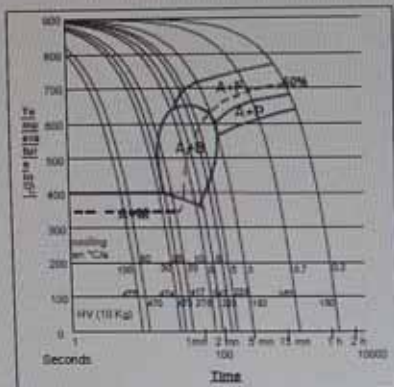


Figure 8 : CCT curve for USIBOR 1500.

The critical quenching speed enabling a completely martensitic structure, under these conditions, is 27°C/s.

4-1-5 The influence of annealing

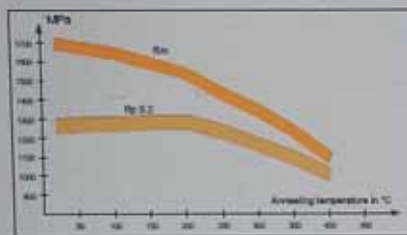


Figure 9 : Influence of annealing temperature.

The water quenching of the test pieces was carried out after austenitisation at 950°C for 5 min. The dwell time for the different coatings was one hour. Elongation at rupture varied little with annealing temperature and was between 5 and 7% (for ISO 20x80 test pieces 1 mm thick).

It is interesting to note that heat treatment due to paint baking (bake hardening) brings about an increase in yield strength of 100 MPa.

4-2 Weldability

4-2-1 Spot welding

The mean carbon equivalent is 0.50%.

$$CE = (\%C) + (\%Mn + \%Si)/6 + (\%Cr + \%Mo + \%V)/5 + (\%Cu + \%Ni)/15$$

When quenched strip is spot welded, the weldability range, determined according to standard NFA 87-001, is higher than 2kA whether by homogeneous welding or on an XES G10/10 (HDG DDQ, 140g/m² BS). The cross tensile strength is conform to standards.

Electrode test life give excellent results, being greater than 5000 spots compared to 700 spots typically for galvanised strip. Even in a triple thickness configuration, electrode life is 2 to 3 times longer compared to galvanised YES.

4-2-2 MAG Weldability

MAG welding gives no particular difficulties. Concerning mechanical resistance, it is recommended to use wire with C>0.1%.

4-3 Impact resistance

Most present applications concern anti-intrusion parts (passenger compartment or engine), for example door reinforcements and bumper beams.

These trials are carried out using a catapult (Fig. 10) with a test piece as shown in figure 11.

The 300kg impactor is propelled at 29km/h corresponding to an energy level of 10 kJ.

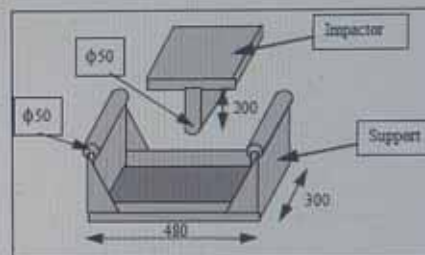


Figure 10 : Bending impact test assembly.

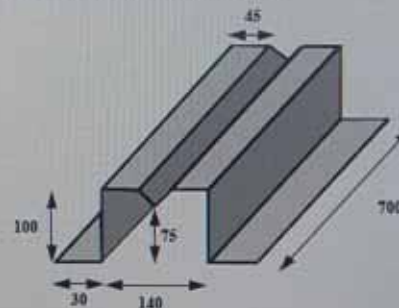


Figure 11 : Schema of the test piece for the three-point bending impact test.



Figure 12 : Photo of a typical test piece after a dynamic, three-points bending impact test.

In terms of ultimate force before structural collapse, USIBOR 1500 permits thickness reduction, and thus considerable weight saving, compared to the use of HLE steels. What is more, the behaviour is reproducible in terms of force peak, absorbed energy and rupture mode.

Even for high speed crashes, all the fractured areas present a ductile aspect.

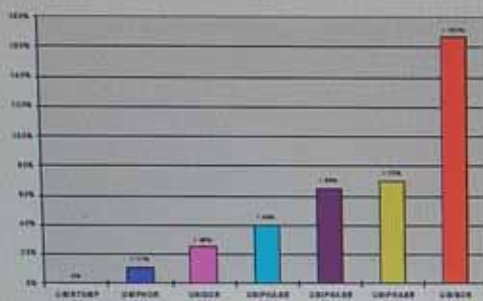


Figure 13 : Ultimate force, 3 points bending.

4-4 Aptitude for coating of die quenched parts and blanks.

4-4-1 The corrosion resistance of non-painted parts with no temporary protection.

Given the iron content of the coating after alloying and if the part is not painted, red rust may appear (RR), if the part is exposed to a very humid atmosphere. However, if watermarks appear on un-coated strip, this is not the case with USIBOR. The first traces of RR appear after 10 cycles in a humidity cabinet (DIN 50 017 cycles FKW).

For 3 months' exposure to marine atmosphere in an open hall, there was no appearance of RR.

The loss of mass, after 1000h exposure to salt spray was less than 100g/m² whereas for a galvanised steel, it was 140 g/m² and more than 1200 g/m² for an un-coated reference steel.

The presence of an alloyed coating renders the application of temporary protection on parts stored under normal conditions, unnecessary.

4-4-2 Aptitude to surface treatment (ST) and to cataphoresis.

The phosphatisation bath used is of the Henkel Granodine 958 (Trication) type.

The surface is not phosphated but remains unchanged during its passage through the bath. It does not pollute the bath with dissolved Al.



Figure 14 : SEM image of surface roughness after complete alloying

The high roughness level of the alloyed layer results in the cataphoresis having exceptional adherence. Covering is total, from 8µm of paint thickness.

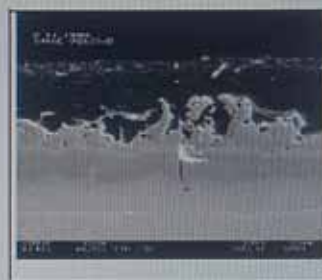


Figure 15 : Section of alloyed and cataphoresis layer by SEM in BSE mode

4-4-3 Corrosion resistance of parts painted by cataphoresis.

The product used for E-coat is of the type, PPG 742/762.

After Renault 3C type corrosion test (9 weeks), average delamination was 2 mm. The depth attained was less than 80µm compared to the reference steel with a depth of 150 and 250µm.

There was also a good response to the VICT test (VOLVO/PSA lasting 12 weeks) with very limited delamination, ~0.5 mm for an admissible maximum of 3 mm. Better protection may be noted on the edges, compared to the reference steel but less than those seen on galvanised steel.

Salt spray tests show that, after 1000h exposure, the peeling is still less than 3 mm.

Scab-Tests (3, weekly NaCl sprayings) carried out at Fos/Mer in a marine and industrial atmosphere show that, after 6 months' exposure, the cataphoresis' peeling is still less than 2 mm with depths attained less than 25µm (Fig. 16). The same tests on a reference steel and a galvanised steel show delamination of from 5 to 7 mm and from 2 to 5 mm respectively with depths of from 100 to 200 µm and from 25 à 70µm.

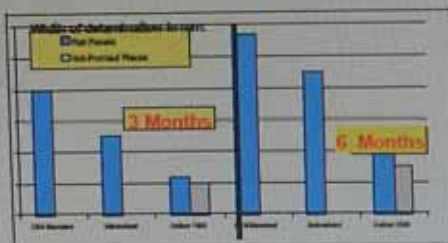


Figure 16 : Measurements of delamination width after 3 and 6 months' Scab-testing carried out at Fos/Mer.



Figure 17 : Photo of a hot-formed part after 6 months' Scab-testing carried out at Fos/Mer.

The galvanic corrosion behaviour was also evaluated through accelerated corrosion testing on spot welded test pieces bringing galvanized metal into contact with USIBOR. Results show that the risk of galvanic corrosion between the zinc and the alloyed layer of USIBOR were negligible, if not zero.

The behaviour of parts is equally excellent regarding the wet adherence in polluted water at 40°C considering the fact that after 21 days the adherence of the E-coat is remarkable.

Finally, stone chipping resistance was studied on parts, upon which a complete set of paint layers was applied on surface treated and E-coated surfaces. Results were identical to those for galvanized steel.

Then, whatever the test carried out on the painted part, the inner surface corrosion resistance is excellent. For edges, complementary protection (wax, mastic etc.) is necessary, applied as necessary, depending on the particular parts concerned.

The good capacity for corrosion resistance of the material is due to the thickness increasing of the layer after heat treatment. The corrosion studies on different coating thickness lead to the conclusion that the minimum thickness to answer the corrosion requirements of RENAULT and PSA Peugeot Citroën is 23 µm before heat treatment.

HOT STAMPING PROCESS

The hot stamping process is composed by different steps : a blanking press, a furnace, a roboted arm to transfer the hot blanks in the press and a tool with a water cooling system to stamp and quench in the same step.

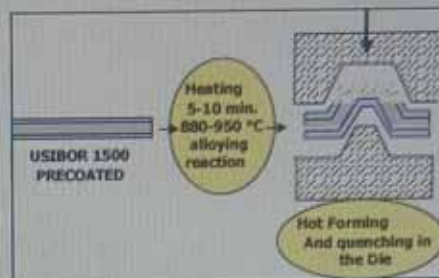


Figure 18 : Schema of the process principle for hot forming.

1) THE FURNACE

The blank is heated at 930°C for several minutes. At such temperature the steel is very ductile and is easily formed into complex shapes without springback.

The heating time depends on the thickness of the blanks and has to ensure the good alloying of the Al-Si coating. Even if the coating is an obstacle to the diffusion of carbon, it is necessary to control the furnace atmosphere to limit the decarburization on the trimming edge.

Besides, the coating avoids the appearance of an oxide layer on the parts and so allows to eliminate the descaling operation in the process. This result is very important for the automotive industry which is more and more concerned by the environment protection.



Figure 19 : blank just before the tool closing.

2) THE BLANK TRANSFER

The transfer operation must be realized as quickly as possible to assure the required mechanical properties on the part according to the CCT diagram. If the blank temperature falls below 780°C, the microstructure will present bainitic or ferritic areas.

3) THE PRESS AND TOOL

The hot blank is placed by the robotized arm in the tool which is water cooled to room temperature. The tools remain closed for approximately 15 seconds by the hydraulic press. Then, the part is extracted from the tool at a temperature around 80°C to guarantee a good geometry after the final air cooling. So, the production rate allows to realize 2 or 3 stamps per minute.

The pre-coated USIBOR 1500, optimized for the stability of its quenchability, is transformed, at the end of forming, into pure martensite thus giving very high mechanical characteristics to then finished part: YS~1000MPa, TS~1500MPa.

The chemical composition and microstructure of USIBOR 1500 are optimized to obtain a homogeneous microstructure for a wide range of cooling speeds and so, very regular mechanical characteristics.

3) THE CUTTING AND PIERCING

The cutting and piercing tools are used with conventional mechanical press. However, the high hardness of the steel and the coating after heat treatment, leads to use specific gap and adapted material for cutting dies.

APPLICATION IN THE CITROËN C5 SUBFRAME

According to the reinforcement of crash resistance regulation and more severe EuroNcap specifications, intrusions have to be limited in the passenger compartment in high speed frontal crash (64 km/h and 40% overlap).

USIBOR1500 has been chosen by the C5 project team to improve the crash resistance of A frames without increasing the weight of the body in white. Thanks to the high level of yield strength after hot stamping (about 950 MPa), more load can come through the C5 A frame without plastic deformations during high speed frontal crash.

Citroën C5 A frame reinforcement is 1,17 mm thick and 1000 mm length; Two A frame reinforcements are stamped in one stamp from a single blank; right and left parts are cut after hot stamping.



Figure 20a: Blank just before stamping



Figure 20b: Blank just after quenching

The use of a coating is necessary in this area due to the situation of the part in the body in white. Indeed, this area is hardly requested by the water flow from the roof inside the frame. Thanks to the AISi pre-coated boron steel, corrosion protection is increased and in accordance with PSA Peugeot Citroën specifications.

About welding operations, the main concern was linked to the spread of the coating thickness on the stamped part. The evolution of this thickness (about 15 microns) is linked to the initial variation of coating thickness (about 9 microns) on the blanks and to the evolution of process parameters (such as the austenisation time). Assembly trials were carried out to verify, for the maximum acceptable range of thickness, the steadiness of the industrial assembly process. The quality of the welding electric points was checked and are in accordance with our specifications.

The use of a precoated USIBOR1500 hot stamped A frame reinforcement in the subframe means high geometric tolerances on the parts in accordance with PSA specifications. For example, +/- 0,5 mm are reached on the shape and on the trimmings of the part.



Figure 21 : C5 A frame reinforcement

Then, the development of precoated hot stamped A frame reinforcements permits to fulfill EuroNcap four stars level and corrosion protection. It allows also to reduce weight of about 1,4 kg on the C5 body in white compared with a conventional 300 MPa high strength steel. Besides, it's a first world application in the subframe for very high production rate of stamped parts.

APPLICATION IN THE RENAULT LAGUNA II FRONT BUMPER BEAM

The main function of the front bumper beam is to

absorb impact and/or protect the vehicle against intrusion in case of several crash scenari. For the LAGUNA II, RENAULT adds another functional criteria concerning the new corrosion guarantee. Besides, the front bumper beam support the recovery eye fixing.

For urban crash at 15 km/h, the front bumper beam has to limit the intrusion in the vehicle in order to minimize the cost of repairing and must assure the good rails members behaviour in high speed frontal crashes (64 km/h - 40% overlap).

To design this part, RENAULT has chosen to use the couple USIBOR 1500 / hot stamping to combine the use of an UHSS, i.e. maximum weight reduction, and a complex geometry, i.e. length 1400 mm and stamping depth 70 mm.

In comparison with the classic HSLA solution, the high yield strength (≥ 1000 MPa after heat treatment) allows the project team to divide the thickness of the part approximately by two. The front bumper beam is 2 mm thick.

The blank is heated at 930°C during several minutes. Cutting and piercing operations are realized after hot stamping. Different controls have been made on parts after hot stamping, to check the metallurgical and geometric quality : minimum coating thickness to ensure a good corrosion behaviour, mechanical properties reproducibility, maximum thinning of the steel.



Figure 22 : LAGUNA II front bumper beam before and after cutting

To meet RENAULT corrosion requirements, the E-coat has to lead to a thick cover layer on the edges. The result is a 10 μ m minimum thickness layer compared to 1 to 3 μ m with a standard E-coat.

Even if the average elongation is around 5 to 6 % on part, all the crash resistance tests are positive according to the RENAULT specification and notably, for the urban crash where the important stiffness of the part limits significantly the crash intrusion.



Figure 23 : Front bumper beam of the LAGUNA II after urban crash

Different laboratory accelerated corrosion tests show a very good behaviour of the front bumper beam. Thanks to the use of the couple pre-coated steel and specific E-coat, there are no red rust and no perforation after an equivalent of « 12 years ».

This technical solution is considered as a success :

- 1- The LAGUNA II has a very good crash behaviour in each scenari with a significantly weight reduction of the front bumper beam : first vehicle to obtain ★★★★★ EuroNcap.
- 2- The corrosion behaviour of this part is excellent (12 years without red rust and perforation)
- 3- RENAULT takes part in environment protection with the use of an unleaded E-coat and the Al-Si pre-coated which allows the acid descaling cancellation.



figure 24 : EuroNcap front crash of the laguna II

CONCLUSION

The main advantages of USIBOR 1500 are to combine an easy hot formability without springback and a high level of mechanical properties after quenching (YS > 950 MPa, TS > 1300 MPa and E% > 4,5 %).

The corrosion behaviour of the pre-coating allows to use this steel on the body in white even with the new corrosion criterias. Besides, it allows to cancel the descaling operation after heat treatment (no oxide layer) and it avoids the decarburization.

With the use of pre-coated boron steel and hot stamping, PSA PEUGEOT CITROEN and RENAULT lighten their bodies in white and increase the protection of the passengers.

REFERENCES

1. X. BANO, JP. LAURENT, «Heat treated boron steels in the automotive industry», 39TH Mechanical Working and Steel Processing Conference Proceedings, Volume XXXV, Indianapolis, IN 1997, p673-677.

CONTACT

L. VAISSIERE, RENAULT S.A.,
Email : loic.vaissiere@renault.com,

A. REINHARDT, PSA Peugeot Citroën,
Email : reinhard@mpsa.com,

F. RONIN, USINOR AUTO,
Email : francois.ronin@usinorauto.com.

Appendix VAISSIERE04

**SAE TECHNICAL
PAPER SERIES**

2002-01-2048

Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White

L. Vaissiere
RENAULT S.A.

J. P. Laurent
USINOR - CRPC

A. Reinhardt
PSA Peugeot Citroën

**Reprinted From: Proceedings of the 2002 SAE International Body Engineering Conference
and Automotive & Transportation Technology Conference on CD-ROM
(IBAT2002CD)**

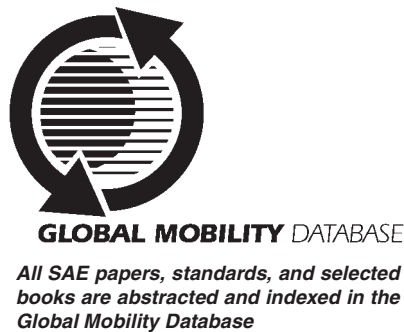
SAE *The Engineering Society
For Advancing Mobility
Land Sea Air and Space®*
INTERNATIONAL

**International Body Engineering Conference & Exhibition and
Automotive & Transportation Technology Conference
Paris, France
July 9–11, 2002**

The appearance of this ISSN code at the bottom of this page indicates SAE's consent that copies of the paper may be made for personal or internal use of specific clients. This consent is given on the condition, however, that the copier pay a per article copy fee through the Copyright Clearance Center, Inc. Operations Center, 222 Rosewood Drive, Danvers, MA 01923 for copying beyond that permitted by Sections 107 or 108 of the U.S. Copyright Law. This consent does not extend to other kinds of copying such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale.

Quantity reprint rates can be obtained from the Customer Sales and Satisfaction Department.

To request permission to reprint a technical paper or permission to use copyrighted SAE publications in other works, contact the SAE Publications Group.



No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

ISSN 0148-7191

Copyright © 2002 Society of Automotive Engineers, Inc.

Positions and opinions advanced in this paper are those of the author(s) and not necessarily those of SAE. The author is solely responsible for the content of the paper. A process is available by which discussions will be printed with the paper if it is published in SAE Transactions. For permission to publish this paper in full or in part, contact the SAE Publications Group.

Persons wishing to submit papers to be considered for presentation or publication through SAE should send the manuscript or a 300 word abstract of a proposed manuscript to: Secretary, Engineering Meetings Board, SAE.

Printed in USA

2002-01-2048

Development of Pre-Coated Boron Steel for Applications on PSA Peugeot Citroën and RENAULT Bodies in White

L. Vaissiere
RENAULT S.A.

J. P. Laurent
USINOR - CRPC

A. Reinhardt
PSA Peugeot Citroën

Copyright © 2002 Society of Automotive Engineers, Inc.

ABSTRACT

The automotive industry have to face with its will to increase the safety of the passengers and the necessity to reduce the pollutant emissions. Besides, the customers expect more and more high vehicle quality and especially as far as corrosion is concerned.

The development of the pre-coated boron steel associated with the hot stamping allows PSA Peugeot Citroën and RENAULT to lighten their parts significantly and fulfill the automotive corrosion requirements.

The benefit in crash resistance has been obtained by the increase of the mechanical properties after heat treatment. After a complete austenitisation in a 930°C furnace, the blanks are stamped and quenched in one step in a water cooled tool. This process allows to obtain :

$YS > 950 \text{ MPa}$

$TS > 1300 \text{ MPa}.$

INTRODUCTION

The reinforcement of regulations in terms of pollution (CAFE 2008 CO₂ emission under 140 g/km) and the increase of equipments induce that the automotive industry has a critical need for weight reduction solutions for car bodies. Moreover, the crash resistance objectives are more and more severe to improve the car safety and lead the manufacturers to reinforce the bodies in white. Then, the lengthening of anti-corrosion guarantees requires a two sides pre-coated steel supply.

This challenge is achieved through the use of steels having the highest possible mechanical properties, meaning, however, a decrease of formability.

In order to solve this problem, it was necessary to make a breakthrough with respect to the continuous process of increasing mechanical characteristics. For this, the forming and properties-of-use functions have been considered separately in the development of the USIBOR steel. The as-delivered USIBOR steel allows easy forming and, after heat treatment, presents high mechanical characteristics and corrosion resistance compatible with the new guarantees given by the manufacturers to their customers.

In order to meet these requirements, a working group was created between USINOR, PSA Peugeot Citroën and RENAULT with the objective to develop a pre-coated version of the USIBOR steel.

PRE-COATED USIBOR 1500

1/ POSITION IN THE RANGE

Pre-coated USIBOR 1500 has been developed to reply to the weight reduction needs for structural and reinforcement parts of automobiles (fig. 1), and the lengthening of the anti-corrosion guarantees.

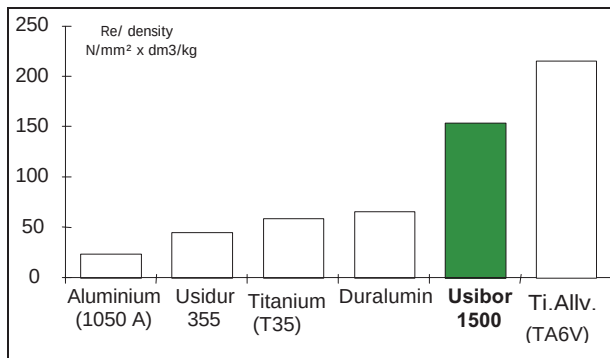


Figure 1 : Weight reduction potential of USIBOR 1500 compared to other materials according to their yield strength.

This internationally patented steel, with its high hot forming possibilities, make it possible, after heat treatment, to obtain very high mechanical characteristics, with exceptional impact resistance.

The heat treatment is carried out after forming in order to obtain a high tensile strength level.

Mechanical characteristics, before and after heat treatment are shown in figure 2.

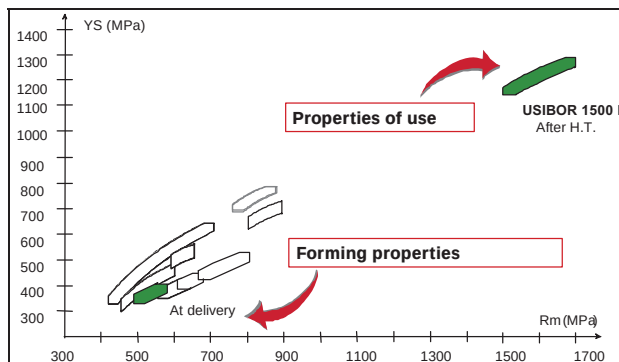


Figure 2 : Mechanical characteristics, before and after heat treatment.

2/ METALLURGICAL PROCESS

2-1 Chemical analysis and coating.

USIBOR 1500 is a carbon/manganese steel micro-alloyed with boron.

	C	Mn	Si	S	Cr	Al	B	Ti
Mini	200	1100	150		150	20	2	20
Maxi	250	1350	350	8	300	60	4	50

Chemical analysis in thousandths of a %.

In order to protect the metal from oxidation and decarburization during heat treatment, and to increase corrosion resistance after painting, an aluminium based pre-coating is applied with a hot dipped process, the thickness of which is usually between 23µm and 32µm per face.

2-2 Effects of additive elements and rolling.

The addition of carbon, manganese, and chrome give good quenchability and the slight addition of boron increases this latter considerably. The boron, in effect, enables the ferritic zone to be shifted towards low cooling speeds thus ensuring good quenchability of parts during heat treatment (critical quenching speed : 27°C/s).

The titanium acts as a nitrogen scavenger thus protecting the boron. Sulphides are globularised with a SiCa treatment.

The thermo-mechanical process applied during the manufacture of hot and cold re-rolled products, enables a homogeneous structure, guaranteeing good formability and reproducible mechanical characteristics, to be obtained before and after heat treatment.

2-3 Microstructures of steel and layer at delivery

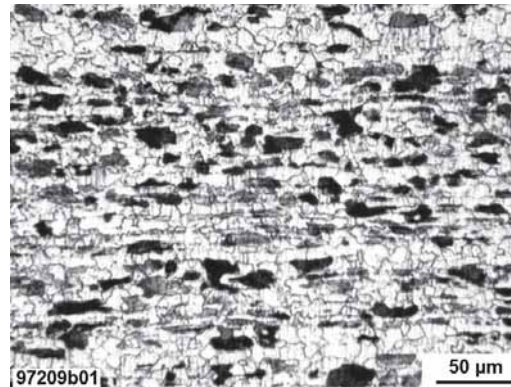


Figure 3 : Typical HSM ferrite-pearlite microstructure.

The homogeneous distribution of pearlite and an equiaxed grained, ferritic matrix may be noted.

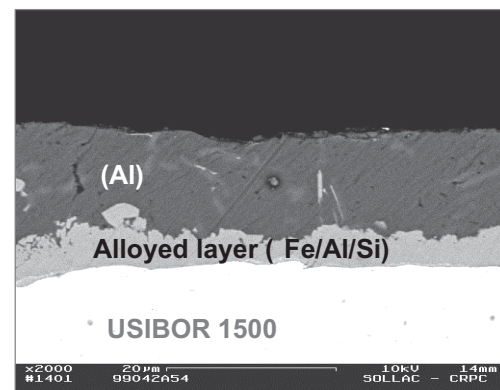


Figure 4 : Typical microstructure of coating section by BSE on an SEM.

The coating is composed of an alloyed layer in contact with the substrate on which a layer, composed principally of aluminium, develops.

3/ INFLUENCE OF THE HEAT TREATMENT

3-1 Typical mechanical properties

Blanks are heated to around 900°C for a few minutes.

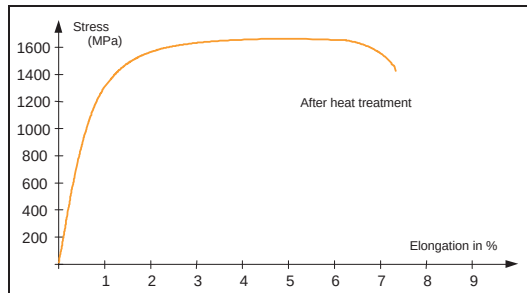


Figure 5 : Typical tensile curve after heat treatment. Thickness 1mm.

After heat treatment, USIBOR 1500 still shows a high capacity for consolidation. The typical tensile results on as-delivered metal and on quenched test pieces are shown below :

	YS (MPa)	TS (MPa)	E% (20x80)
At delivery	400	600	20
After hot forming	1060	1500	5

The ratio YS/TS is between 0,6 and 0,7 at delivery depending on size and between 0,65 and 0,75 after quenching in the die.

3-2 Microstructures of steel and Al-Si coating

Heating the pre-coated USIBOR 1500 at the required temperature creates an alloying reaction by iron diffusion from the steel to the coating. The result is the formation of a multiphase Fe-Al-Si layer. The two main consequences is an increasing of the layer hardness (figure 6) and the layer thickness around 20 μm .

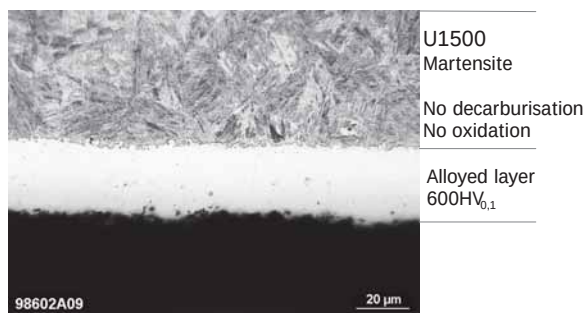


Figure 6 : Typical microstructure of coating section by optical microscope with 4% Nital etch.

Figure 6 shows the totally martensitic structure without the presence, of surface decarburization or oxidation. It may be noted that the very hard alloyed layer, is strongly adhered to the substrate.

One of the advantages of the coating is to be an obstacle to the carbon diffusion and so, allows an easy control of the furnace atmosphere.

4/ CHARACTERISTICS OF USE

4-1 Heat treatment.

4-1-1 Jominy curve

Up to 7 mm in depth, maximum hardness is retained, guaranteeing quenching throughout the metal, whatever the thickness supplied.



Figure 7 : Jominy Curve.

4-1-2 Austenitisation

The point A_{c3} is at 850°C, for a heating speed of 5°C/s. The structure of a tensile test sample, austenitised for 5 min at 850°C and water quenched, is totally martensitic. At 840°C some ferrite islands persist. Considering the homogeneity of the initial structure, these islands are evenly distributed.

The point A_{c1} is at 750°C, M_s is at 400°C.

For austenitisation at 900°C, the linear dilatation of the metal is 1,13% at this temperature.

4-1-3 Recommendations

The following recommendations enable the complete alloying of the coating ensuring good corrosion resistance.

For 1,2 mm thick blanks, heated in an electric or gas furnace. The furnace dwell time (from door opening to door opening) must be greater than the following :

Temperature	880°C	900°C	950°C
Mini time	5 min	4 min	3 min

These times must be adapted to the substrate thickness.

4-1-4 CCT Diagram

The CCT diagram was made under the following conditions :

Austenitisation : at 900°C for 5 min

Temperature increase rate: 15°C/s

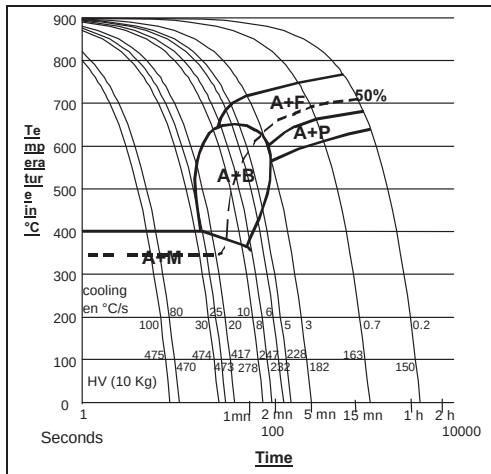


Figure 8 : CCT curve for USIBOR 1500.

The critical quenching speed enabling a completely martensitic structure, under these conditions, is 27°C/s.

4-1-5 The influence of annealing

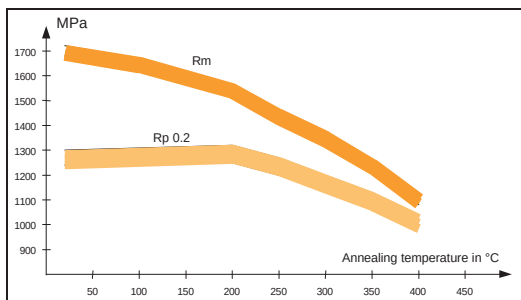


Figure 9 : Influence of annealing temperature.

The water quenching of the test pieces was carried out after austenitisation at 950°C for 5 min. The dwell time for the different coatings was one hour. Elongation at rupture varied little with annealing temperature and was between 5 and 7% (for ISO 20x80 test pieces 1 mm thick).

It is interesting to note that heat treatment due to paint baking (bake hardening) brings about an increase in yield strength of 100 MPa.

4-2 Weldability

4-2-1 Spot welding.

The mean carbon equivalent is 0.50%.

$$CE = (\%C) + (\%Mn + \%Si)/6 + (\%Cr + \%Mo + \%V)/5 + (\%Cu + \%Ni)/15$$

When quenched strip is spot welded, the weldability range, determined according to standard NFA 87-001, is higher than 2kA whether by homogeneous welding or on an XES G10/10 (HDG DDQ, 140g/m² BS). The cross tensile strength is conform to standards.

Electrode test life give excellent results, being greater than 5000 spots compared to 700 spots typically for galvanised strip. Even in a triple thickness configuration, electrode life is 2 to 3 times longer compared to galvanised XES.

4-2-2 MAG Weldability

MAG welding gives no particular difficulties. Concerning mechanical resistance, it is recommended to use wire with C>0.1%.

4-3 Impact resistance.

Most present applications concern anti-intrusion parts (passenger compartment or engine), for example door reinforcements and bumper beams.

These trials are carried out using a catapult (Fig. 10) with a test piece as shown in figure 11.

The 300kg impactor is propelled at 29km/h corresponding to an energy level of 10 kJ.

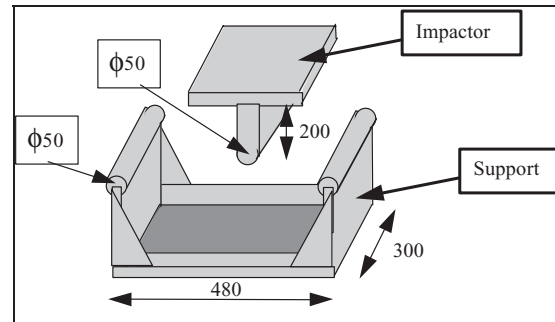


Figure 10 : Bending impact test assembly.

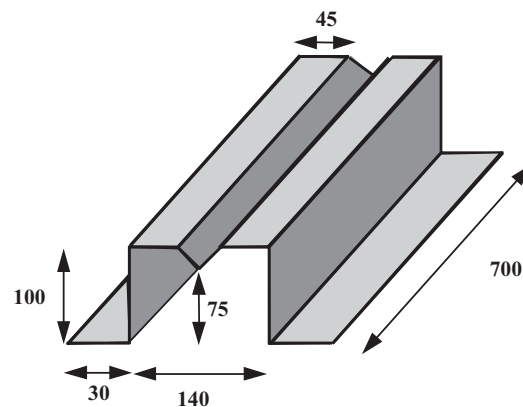


Figure 11 : Schema of the test piece for the three-point bending impact test.



Figure 12 : Photo of a typical test piece after a dynamic, three-points bending impact test.

In terms of ultimate force before structural collapse, USIBOR 1500 permits thickness reduction, and thus considerable weight saving, compared to the use of HLE steels. What is more, the behaviour is reproducible in terms of force peak, absorbed energy and rupture mode.

Even for high speed crashes, all the fractured areas present a ductile aspect.

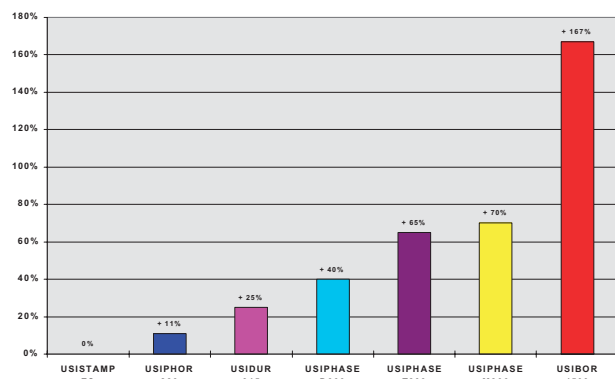


Figure 13 : Ultimate force, 3 points bending.

4-4 Aptitude for coating of die quenched parts and blanks.

4-4-1 The corrosion resistance of non-painted parts with no temporary protection.

Given the iron content of the coating after alloying and if the part is not painted, red rust may appear (RR), if the part is exposed to a very humid atmosphere. However, if watermarks appear on un-coated strip, this is not the case with USIBOR. The first traces of RR appear after 10 cycles in a humidity cabinet (DIN 50 017 cycles FKW).

For 3 months' exposure to marine atmosphere in an open hall, there was no appearance of RR.

The loss of mass, after 1000h exposure to salt spray was less than 100g/m² whereas for a galvanised steel, it was 140 g/m² and more than 1200 g/m² for an un-coated reference steel.

The presence of an alloyed coating renders the application of temporary protection on parts stored under normal conditions, unnecessary.

4-4-2 Aptitude to surface treatment (ST) and to cataphoresis.

The phosphatisation bath used is of the Henkel Granodine 958 (Trication) type.

The surface is not phosphated but remains unchanged during its passage through the bath. It does not pollute the bath with dissolved Al.

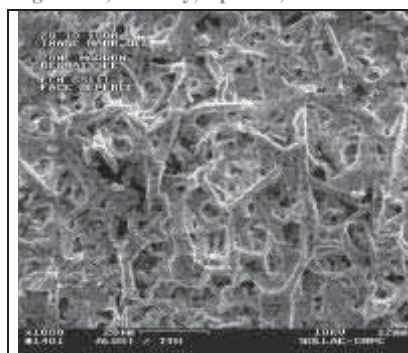


Figure 14 : SEM image of surface roughness after complete alloying

The high roughness level of the alloyed layer results in the cataphoresis having exceptional adherence. Covering is total, from 8µm of paint thickness.

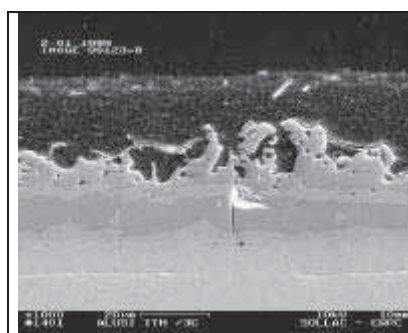


Figure 15 : Section of alloyed and cataphoresis layer by SEM in BSE mode

4-4-3 Corrosion resistance of parts painted by cataphoresis .

The product used for E-coat is of the type, PPG 742/762.

After Renault 3C type corrosion test (9 weeks), average delamination was 2 mm. The depth attained was less than 80µm compared to the reference steel with a depth of 150 and 250µm.

There was also a good response to the VICT test (VOLVO/PSA lasting 12 weeks) with very limited delamination, ~0.5 mm for an admissible maximum of 3 mm. Better protection may be noted on the edges, compared to the reference steel but less than those seen on galvanised steel.

Salt spray tests show that, after 1000h exposure, the peeling is still less than 3 mm.

Scab-Tests (3, weekly NaCl sprayings) carried out at Fos/Mer in a marine and industrial atmosphere show that, after 6 months' exposure, the cataphoresis' peeling is still less than 2 mm with depths attained less than 25µm (Fig. 16). The same tests on a reference steel and a galvanised steel show delamination of from 5 to 7 mm and from 2 to 5 mm respectively with depths of from 100 to 200 µm and from 25 à 70µm.

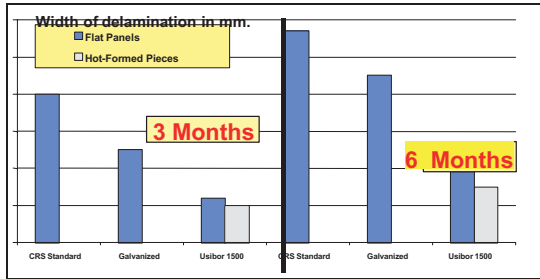


Figure 16 : Measurements of delamination width after 3 and 6 months' Scab-testing carried out at Fos/Mer.



Figure 17 : Photo of a hot-formed part after 6 months' Scab-testing carried out at Fos/Mer.

The galvanic corrosion behaviour was also evaluated through accelerated corrosion testing on spot welded test pieces bringing galvanized metal into contact with USIBOR. Results show that the risk of galvanic corrosion between the zinc and the alloyed layer of USIBOR were negligible, if not zero.

The behaviour of parts is equally excellent regarding the wet adherence in polluted water at 40°C considering the fact that after 21 days the adherence of the E-coat is remarkable.

Finally, stone chipping resistance was studied on parts, upon which a complete set of paint layers was applied on surface treated and E-coated surfaces. Results were identical to those for galvanized steel.

Then, whatever the test carried out on the painted part, the inner surface corrosion resistance is excellent. For edges, complementary protection (wax, mastic etc.) is necessary, applied as necessary, depending on the particular parts concerned.

The good capacity for corrosion resistance of the material is due to the thickness increasing of the layer after heat treatment. The corrosion studies on different coating thickness lead to the conclusion that the minimum thickness to answer the corrosion requirements of RENAULT and PSA Peugeot Citroën is 23 µm before heat treatment.

HOT STAMPING PROCESS

The hot stamping process is composed by different steps : a blanking press, a furnace, a roboted arm to transfer the hot blanks in the press and a tool with a water cooling system to stamp and quench in the same step.

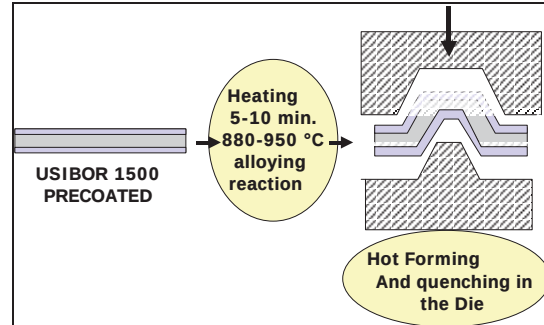


Figure 18 : Schema of the process principle for hot forming.

1) THE FURNACE

The blank is heated at 930°C for several minutes. At such temperature the steel is very ductile and is easily formed into complex shapes without springback.

The heating time depends on the thickness of the blanks and has to ensure the good alloying of the Al-Si coating. Even if the coating is an obstacle to the diffusion of carbon, it is necessary to control the furnace atmosphere to limit the decarburization on the trimming edge.

Besides, the coating avoids the appearance of an oxide layer on the parts and so allows to eliminate the descaling operation in the process. This result is very important for the automotive industry which is more and more concerned by the environment protection.

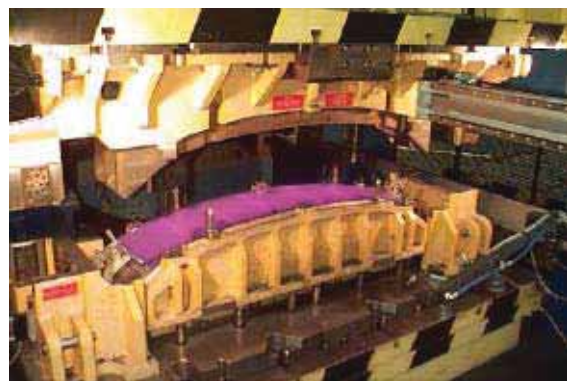


Figure 19 : blank just before the tool closing.

2) THE BLANK TRANSFER

The transfer operation must be realized as quickly as possible to assure the required mechanical properties on the part according to the CCT diagram. If the blank temperature falls below 780°C, the microstructure will present bainitic or ferritic areas.

The hot blank is placed by the robotized arm in the tool which is water cooled to room temperature. The tools remain closed for approximately 15 seconds by the hydraulic press. Then, the part is extracted from the tool at a temperature around 80°C to guarantee a good geometry after the final air cooling. So, the production rate allows to realize 2 or 3 stamps per minute.

The pre-coated USIBOR 1500, optimized for the stability of its quenchability, is transformed, at the end of forming, into pure martensite thus giving very high mechanical characteristics to then finished part : YS~1000MPa, TS~1500MPa.

The chemical composition and microstructure of USIBOR 1500 are optimized to obtain a homogeneous microstructure for a wide range of cooling speeds and so, very regular mechanical characteristics.

3) THE CUTTING AND PIERCING

The cutting and piercing tools are used with conventional mechanical press. However, the high hardness of the steel and the coating after heat treatment, leads to use specific gap and adapted material for cutting dies.

APPLICATION IN THE CITROËN C5 SUBFRAME

According to the reinforcement of crash resistance regulation and more severe EuroNcap specifications, intrusions have to be limited in the passenger compartment in high speed frontal crash (64 km/h and 40% overlap).

USIBOR1500 has been chosen by the C5 project team to improve the crash resistance of A frames without increasing the weight of the body in white. Thanks to the high level of yield strength after hot stamping (about 950 MPa), more load can come through the C5 A frame without plastic deformations during high speed frontal crash.

Citroën C5 A frame reinforcement is 1,17 mm thick and 1000 mm length; Two A frame reinforcements are stamped in one stamp from a single blank; right and left parts are cut after hot stamping.



figure 20a: Blank just before stamping

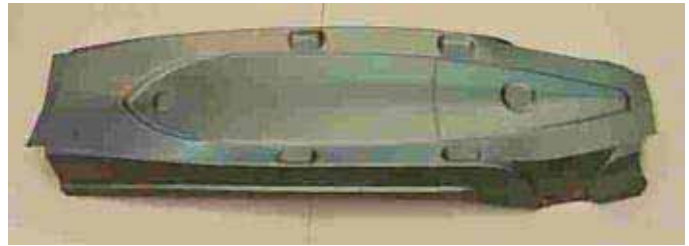


Figure 20b: Blank just after quenching

The use of a coating is necessary in this area due to the situation of the part in the body in white. Indeed, this area is hardly requested by the water flow from the roof inside the frame. Thanks to the AISi pre coated boron steel, corrosion protection is increased and in accordance with PSA Peugeot Citroën specifications.

About welding operations, the main concern was linked to the spread of the coating thickness on the stamped part. The evolution of this thickness (about 15 microns) is linked to the initial variation of coating thickness (about 9 microns) on the blanks and to the evolution of process parameters (such as the austenisation time). Assembly trials were carried out to verify, for the maximum acceptable range of thickness, the steadiness of the industrial assembly process. The quality of the welding electric points was checked and are in accordance with our specifications.

The use of a precoated USIBOR1500 hot stamped A frame reinforcement in the subframe means high geometric tolerances on the parts in accordance with PSA specifications. For example, +/- 0,5 mm are reached on the shape and on the trimmings of the part.



Figure 21 : C5 A frame reinforcement

Then, the development of precoated hot stamped A frame reinforcements permits to fulfill EuroNcap four stars level and corrosion protection. It allows also to reduce weight of about 1,4 kg on the C5 body in white compared with a conventional 300 MPa high strength steel. Besides, it's a first world application in the subframe for very high production rate of stamped parts.

APPLICATION IN THE RENAULT LAGUNA II FRONT BUMPER BEAM

absorb impact and/or protect the vehicle against intrusion in case of several crash scenarios. For the LAGUNA II, RENAULT adds another functional criteria concerning the new corrosion guarantee. Besides, the front bumper beam supports the recovery eye fixing.

For urban crash at 15 km/h, the front bumper beam has to limit the intrusion in the vehicle in order to minimize the cost of repairing and must assure the good rails members behaviour in high speed frontal crashes (64 km/h - 40% overlap).

To design this part, RENAULT has chosen to use the couple USIBOR 1500 / hot stamping to combine the use of an UHSS, i.e. maximum weight reduction, and a complex geometry, i.e. length 1400 mm and stamping depth 70 mm.

In comparison with the classic HSLA solution, the high yield strength (≥ 1000 MPa after heat treatment) allows the project team to divide the thickness of the part approximately by two. The front bumper beam is 2 mm thick.

The blank is heated at 930°C during several minutes. Cutting and piercing operations are realized after hot stamping. Different controls have been made on parts after hot stamping, to check the metallurgical and geometric quality: minimum coating thickness to ensure a good corrosion behaviour, mechanical properties reproducibility, maximum thinning of the steel.



Figure 22 : LAGUNA II front bumper beam before and after cutting

To meet RENAULT corrosion requirements, the E-coat has to lead to a thick cover layer on the edges. The result is a 10 μm minimum thickness layer compared to 1 to 3 μm with a standard E-coat.

Even if the average elongation is around 5 to 6 % on part, all the crash resistance tests are positive according to the RENAULT specification and notably, for the urban crash where the important stiffness of the part limits significantly the crash intrusion.



figure 23 : Front bumper beam of the LAGUNA II after urban crash

Different laboratory accelerated corrosion tests show a very good behaviour of the front bumper beam. Thanks to the use of the couple pre-coated steel and specific E-coat, there are no red rust and no perforation after an equivalent of « 12 years ».

This technical solution is considered as a success :

- 1- The LAGUNA II has a very good crash behaviour in each scenario with a significantly weight reduction of the front bumper beam : first vehicle to obtain ★★★★★ EuroNcap.
- 2- The corrosion behaviour of this part is excellent (12 years without red rust and perforation)
- 3- RENAULT takes part in environment protection with the use of an unleaded E-coat and the Al-Si pre-coated which allows the acid descaling cancellation.



figure 24 : EuroNcap front crash of the LAGUNA II

CONCLUSION

The main advantages of USIBOR 1500 are to combine an easy hot formability without springback and a high level of mechanical properties after quenching ($Y_S > 950$ MPa, $T_S > 1300$ MPa and $E\% > 4,5$ %).

The corrosion behaviour of the pre-coating allows to use this steel on the body in white even with the new corrosion criterias. Besides, it allows to cancel the descaling operation after heat treatment (no oxide layer) and it avoids the decarburization.

With the use of pre-coated boron steel and hot stamping, PSA PEUGEOT CITROEN and RENAULT lighten their bodies in white and increase the protection of the passengers.

REFERENCES

1. X. BANO, JP. LAURENT, «Heat treated boron steels in the automotive industry», 39TH Mechanical Working and Steel Processing Conference Proceedings, Volume XXXV, Indianapolis, IN 1997, p673-677.

CONTACT

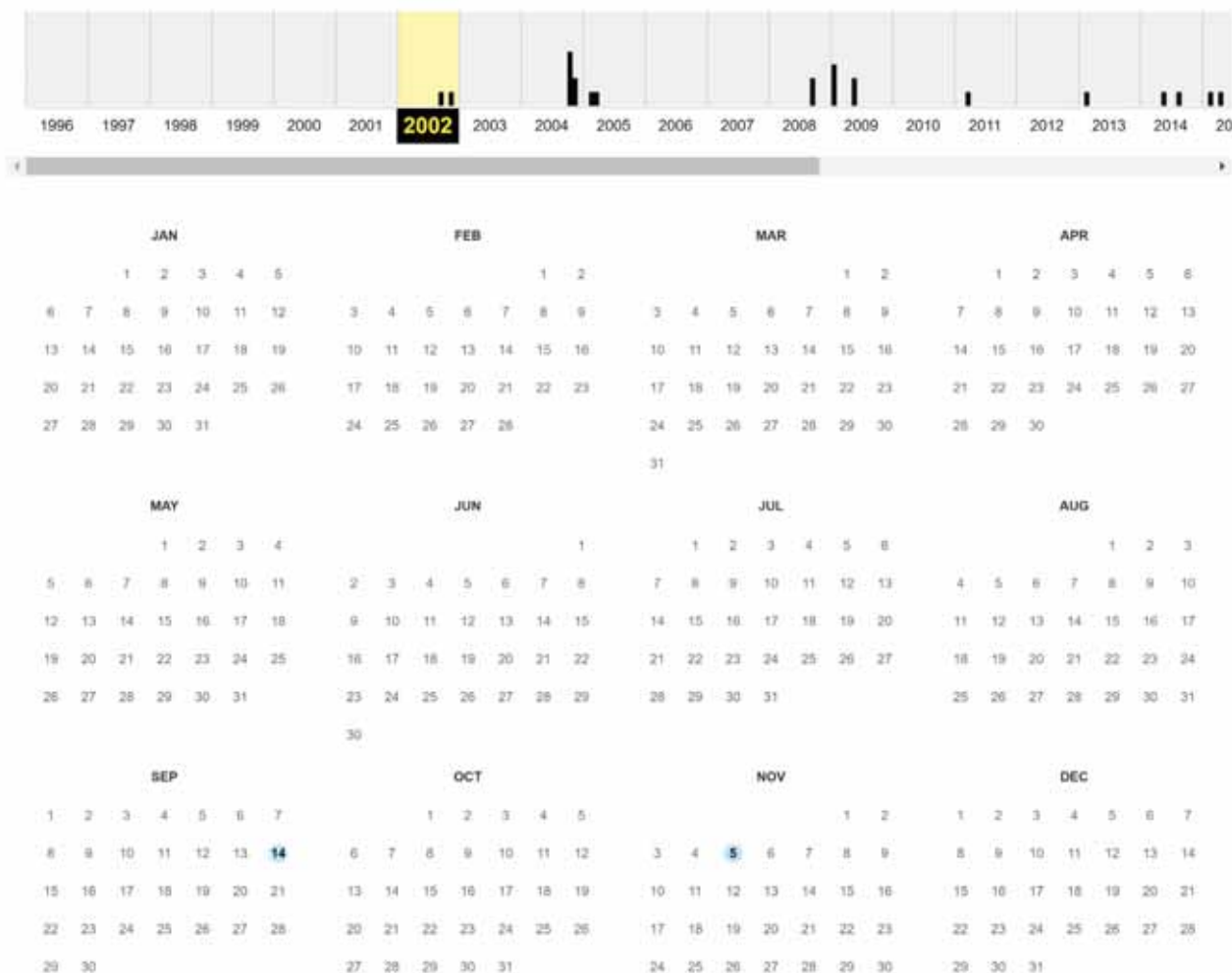
L. VAISSIERE, RENAULT S.A.,
Email : loic.vaissiere@renault.com,

A. REINHARDT, PSA Peugeot Citroën,
Email : reinhard@mpsa.com,

F. RONIN, USINOR AUTO,
Email : francois.ronin@usinorauto.com,

Appendix VAISSIERE05

Saved 179 times between September 14, 2002 and July 29, 2024.



Note

This calendar view maps the number of times <http://catalog.loc.gov/cgi-bin/Pwebrecon.cgi?DB=local&PAGE=First> was crawled by the Wayback Machine, *not* how many times the site was actually updated. More info in the [FAQ](#).





http://catalog.loc.gov/cgi-bin/Pwebrecon.cgi?DB=local&PAGE=First

179 captures
14 Sep 2002 - 29 Jul 2004Go AUG SEP NOV
14
2001 2002 2004 About this capture

The Library of Congress

>> Go to Library of Congress Authorities



LIBRARY OF CONGRESS ONLINE CATALOG


[Help](#) [Search](#) [Search History](#) [Headings List](#) [Titles List](#) [Request an Item](#) [Account Status](#) [Other Databases](#) [Start Over](#)

DATABASE: Library of Congress Online Catalog

Basic Search [Guided Search](#)

Search Text:

Search Type:

[*] indicates
search limits
availableScroll down for
Search Hints

Title *

Author/Creator Browse

Subject Browse

Call Number Browse

LCCN-ISBN-ISSN *

Keyword *

Command Keyword *

25 records per page

Begin Search

Reset

Set Search Limits

Basic Search Tips

Search Type	Brief Help (select a search type for detailed Help)	Help on Limits
Title	- Enter all or initial part of title, starting with the first word: king and i - Drop initial articles (a, das, the) and punctuation (" , & !) in any language. - Truncation is automatic.	Search Limits Available!
Author/Creator Browse	- For <u>personal names</u>, enter surname first: shakespeare william - For <u>group names</u>, enter in direct order: army war college - Truncation is automatic.	Search Limits Not Available!
Subject Browse	- Enter standard subject heading, name, or genre term: solar energy - Start with the left-most word: vietnamese conflict 1961 1975 - Omit most punctuation: united states army history (especially double-hyphens in subject subdivisions) - Truncation is automatic.	Search Limits Not Available!
Call Number Browse	- Enter all or the initial part of a call number: t128.4 (include period) - Enter spacing and punctuation accurately: p85.m23 r6 (include period/spaces) - Truncation is automatic.	Search Limits Not Available!
LCCN-ISBN-ISBN	- For <u>LCCNs</u>, omit hyphen/add leading zeros: 89-456 is entered 89000456 - For <u>ISSNs</u>, include hyphen/use " ": 1094-1304 is entered "1094-1304" - For <u>ISBNs</u>, omit hyphens/spaces: 0-553-37783-3 is entered 0553377833	Search Limits Available!
Command Keyword	- " " for exact phrases: "tax reform" - Boolean AND, OR, NOT: (mars OR venus) AND mission - Index codes refine searches: KSFG western -> finds western as subject form/genre term - ? truncates: polic? -> finds police, policing, policy, etc. EXAMPLE: (wood? OR forest) AND "resource manage?"	Search Limits Available!
Keyword	- " " surround exact phrases: "war of the worlds" - + marks essential terms: +hurricanes +gulf - ! eliminates terms: pets !cats - ? truncates: entrepr? -> finds entrepreneur, entrepreneurial, etc. EXAMPLE: soldiers +"afr? american?" +"civil war" !fiction	Search Limits Available!

[Help](#) - [Search](#) - [History](#) - [Headings](#) - [Titles](#) - [Request](#) - [Account](#) - [Databases](#) - [Exit](#)


The Library of Congress
URL: <http://www.loc.gov/>
Mailing Address:
101 Independence Ave. S.E.
Washington, DC 20540

Library of Congress Online Catalog
URL: <http://catalog.loc.gov/>
Library of Congress Authorities
URL: <http://authorities.loc.gov/>

Questions, comments, error reports: [Contact Us](#)

Appendix NAKAJIMA01



CATALOG

LC Catalog Quick Search



SEARCH OPTIONS ▾

LOGIN ▾



← Refine Your Search



1 of 1



PERIODICAL OR NEWSPAPER

Zairyō to purosusu : Nihon Tekkō Kyōkai kōen ronbunshū = Current advances ...

Full Record

MARC Tags

000 02513cas a2200577 a 4500
 001 11757579
 005 20200904071200.0
 008 981208c19uu9999ja uu 0 0jpn
 010 — |a 00207808
 022 — |a 0914-6628 |l 0914-6628
 035 — |a (OCoLC)ocm43264948
 040 — |a DLC |b eng |c DLC |d OCLCQ |d DLC |d OCLCQ |d OCLCF |d OCLCO |d DLC
 041 0_ |a jpn |b eng
 042 — |a pcc
 050 00 |a TS300 |b .Z35
 066 — |c \$1
 245 00 |6 880-01 |a Zairyō to purosusu : |b Nihon Tekkō Kyōkai kōen ronbunshū = Current advances in materials and processes : report of the ISIJ Meeting.
 246 17 |a CAMP-ISIJ
 246 30 |6 880-02 |a Nihon Tekkō Kyōkai kōen ronbunshū
 246 31 |a Current advances in materials and processes
 260 — |6 880-03 |a Tōkyō : |b Dō Kyōkai
 300 — |a v. : |b ill. ; |c 30 cm.
 546 — |a In Japanese; summaries and table of contents also in English.
 588 — |a Description based on: Vol. 10, no. 1 (1997); title from cover.
 588 — |a Latest issue consulted: Vol. 10, no. 2 (1997).
 592 — |a ACQN: aq 99002478
 650 _0 |a Iron |v Periodicals.
 650 _0 |a Iron |x Metallurgy |v Periodicals.
 650 _0 |a Steel |v Periodicals.
 650 _0 |a Steel |x Metallurgy |v Periodicals.
 650 _0 |a Materials science |v Periodicals.
 650 _7 |a Iron. |2 fast |0 (OCoLC)fst00979089
 650 _7 |a Iron |x Metallurgy. |2 fast |0 (OCoLC)fst00979114
 650 _7 |a Materials science. |2 fast |0 (OCoLC)fst01011957
 650 _7 |a Steel. |2 fast |0 (OCoLC)fst01132472
 650 _7 |a Steel |x Metallurgy. |2 fast |0 (OCoLC)fst01132524
 655 _7 |a Periodicals. |2 fast |0 (OCoLC)fst01411641
 710 2_ |6 880-04 |a Nihon Tekkō Kyōkai.
 776 08 |6 880-05 |i CD-ROM version: |t Zairyō to purosusu |x 1882-8922 |w (DLC) 2009273334 |w (OCoLC)437259132
 850 — |a DLC
 880 00 |6 245-01/\$1 |a 材料とプロセス : |b 日本鉄鋼協会講演論文集 = Current advances in materials and processes : report of the ISIJ Meeting.
 880 30 |6 246-02/\$1 |a 日本鉄鋼協会講演論文集
 880 — |6 260-03/\$1 |a 東京 : |b 同協会
 880 2_ |6 710-04/\$1 |a 日本鉄鋼協会.
 880 06 |6 776-05/\$1 |i CD-ROM version: |t 材料とプロセス |x 1882-8922 |w (DLC) 2009273334 |w (OCoLC)437259132
 906 — |a 7 |b cbc |c serials |d 2 |e ncip |f 20 |g n-odcserc
 925 0_ |a Acquire |b 1 shelf copy |x policy default
 955 — |a dd48 01-13-00; dd94 5-20-00; to RCCD 5-26-00; yf04 to Asian Div 04-04-01
 984 — |a adsf |d 2007-05-23

Periodical or
Newspaper

PRINT RECORD

SAVE RECORD

EMAIL RECORD

CITE RECORD

MARCXML Record
MODS RecordReport Record Errors
Ask a Librarian
Feedback

↑ Top

991 — |b c-Asian |w ACQUIRE
992 — |b JAPANESE SECT |w ACQUIRE

[Request this Item](#)

[LC Find It](#)

[↓ Item Availability](#)

Item Availability

CALL NUMBER	TS300 .Z35 Japan Set 1 Unbound issues have location number 18650.
Request in	Asian Reading Room (Jefferson, LJ150)
Status	c.1 v. 26, no. 1 2013 Mar. In Process 05-10-2013
Latest receipts	v. 26, no. 1 (2013 Mar.) v. 20, no. 3 (2007 Mar.) v. 20, no. 2 (2007 Mar.) v. 20, no. 1 (2007 Mar.)
Older receipts	v.10-v.19 (1997-2006)
Supplements	v.179 (2020) "Shunki Kōen Taikai puroguramu"



[Subscribe \(Patron Services\)](#) [Ask a Librarian](#) [Feedback](#) [Search/Browse Help](#)

[Speech Enabled](#) [Accessibility](#) [Legal](#) [Inspector General](#) [External Link Disclaimer](#) [USA.gov](#)



CATALOG

LC Catalog Quick Search



SEARCH OPTIONS ▾

LOGIN ▾



← Refine Your Search



1 of 1



PERIODICAL OR NEWSPAPER

Zairyō to purosusu : Nihon Tekkō Kyōkai kōen ronbunshū = Current advances ...

Full Record

MARC Tags

Main title

Zairyō to purosusu : Nihon Tekkō Kyōkai kōen ronbunshū = Current advances in materials and processes : report of the ISIJ Meeting.

材料とプロセス : 日本鉄鋼協会講演論文集 = Current advances in materials and processes : report of the ISIJ Meeting.

Published/Created

Tōkyō : Dō Kyōkai

東京 : 同協会

Request this Item

LC Find It

Item Availability

Periodical or
Newspaper

PRINT RECORD

SAVE RECORD

EMAIL RECORD

CITE RECORD

MARCXML Record
MODS RecordReport Record Errors
Ask a Librarian
Feedback

↑ Top

LCCN Permalink https://lccn.loc.gov/00207808

Description v. : ill. ; 30 cm.

ISSN 0914-6628

Linking ISSN 0914-6628

LC classification TS300 .Z35

Portion of title Nihon Tekkō Kyōkai kōen ronbunshū
日本鉄鋼協会講演論文集

Parallel title Current advances in materials and processes

Running title CAMP-ISIJ

Related names Nihon Tekkō Kyōkai.
日本鉄鋼協会.LC Subjects Iron--Periodicals.
Iron--Metallurgy--Periodicals.
Steel--Periodicals.
Steel--Metallurgy--Periodicals.
Materials science--Periodicals.Other Subjects Iron.
Iron--Metallurgy.
Materials science.
Steel.
Steel--Metallurgy.

Form/Genre Periodicals.

Browse by shelf order TS300

Notes In Japanese; summaries and table of contents also in English.

Additional formats CD-ROM version: Zairyō to purosusu 1882-8922 (DLC) 2009273334 (OCoLC)437259132
CD-ROM version: 材料とプロセス 1882-8922 (DLC) 2009273334 (OCoLC)437259132

LCCN 00207808

Language code	jpn eng
Other system no.	(OCoLC)ocm43264948
Type of material	Periodical or Newspaper
Source of description	Description based on: Vol. 10, no. 1 (1997); title from cover. Latest issue consulted: Vol. 10, no. 2 (1997).

Item Availability

CALL NUMBER	TS300 .Z35 Japan Set 1 Unbound issues have location number 18650.
Request in	Asian Reading Room (Jefferson, LJ150)
Status	c.1 v. 26, no. 1 2013 Mar. In Process 05-10-2013
Latest receipts	v. 26, no. 1 (2013 Mar.) v. 20, no. 3 (2007 Mar.) v. 20, no. 2 (2007 Mar.) v. 20, no. 1 (2007 Mar.)
Older receipts	v.10-v.19 (1997-2006)
Supplements	v.179 (2020) "Shunki Kōen Taikai puroguramu"



[Subscribe \(Patron Services\)](#)
[Ask a Librarian](#)
[Feedback](#)
[Search/Browse Help](#)

[Speech Enabled](#)
[Accessibility](#)
[Legal](#)
[Inspector General](#)
[External Link Disclaimer](#)
[USA.gov](#)

Appendix NAKAJIMA02

材料とプロセス

Volume 17, Number 6 2004

1087-1495

181650

日本鉄鋼協会講演論文集

材料とプロセス

第148回秋季講演大会

材料の組織と特性、評価・分析・解析

Current Advances in Materials and Processes

Report of the ISIJ Meeting

The Timetable of the 148th ISIJ Meeting

Date		Time		Topic		Speaker	
Day	Time	Topic	Speaker	Day	Time	Topic	Speaker
Monday	8:30-12:00	Registration and Welcome Reception		Tuesday	8:30-12:00	Registration and Welcome Reception	
	13:00-17:00	Registration and Welcome Reception			13:00-17:00	Registration and Welcome Reception	
	18:00-21:00	Registration and Welcome Reception			18:00-21:00	Registration and Welcome Reception	
	22:00-24:00	Registration and Welcome Reception			22:00-24:00	Registration and Welcome Reception	
Tuesday	8:30-12:00	Registration and Welcome Reception		Wednesday	8:30-12:00	Registration and Welcome Reception	
	13:00-17:00	Registration and Welcome Reception			13:00-17:00	Registration and Welcome Reception	
	18:00-21:00	Registration and Welcome Reception			18:00-21:00	Registration and Welcome Reception	
	22:00-24:00	Registration and Welcome Reception			22:00-24:00	Registration and Welcome Reception	
Wednesday	8:30-12:00	Registration and Welcome Reception		Thursday	8:30-12:00	Registration and Welcome Reception	
	13:00-17:00	Registration and Welcome Reception			13:00-17:00	Registration and Welcome Reception	
	18:00-21:00	Registration and Welcome Reception			18:00-21:00	Registration and Welcome Reception	
	22:00-24:00	Registration and Welcome Reception			22:00-24:00	Registration and Welcome Reception	
Thursday	8:30-12:00	Registration and Welcome Reception		Friday	8:30-12:00	Registration and Welcome Reception	
	13:00-17:00	Registration and Welcome Reception			13:00-17:00	Registration and Welcome Reception	
	18:00-21:00	Registration and Welcome Reception			18:00-21:00	Registration and Welcome Reception	
	22:00-24:00	Registration and Welcome Reception			22:00-24:00	Registration and Welcome Reception	
Friday	8:30-12:00	Registration and Welcome Reception		Saturday	8:30-12:00	Registration and Welcome Reception	
	13:00-17:00	Registration and Welcome Reception			13:00-17:00	Registration and Welcome Reception	
	18:00-21:00	Registration and Welcome Reception			18:00-21:00	Registration and Welcome Reception	
	22:00-24:00	Registration and Welcome Reception			22:00-24:00	Registration and Welcome Reception	

Program of the 148th ISIJ Meeting (September 28-30, 2004)

Lecture No.	Title	Speaker	Page
High Temperature Processes			
1	Physical property data of molten slags and fluxes	N. Jellinek	342
2	Viscosity of CaO-SiO ₂ -Al ₂ O ₃ -FeO slags	T. Miki	345
3	Evolution of viscosity of molten slag based on Al ₂ O ₃ -Gibbs model	T. Miki	345
4	Discussion on the surface tension of molten slag mixtures and molten slag	T. Miki	349
5	Applications of square wave pulse heating method to thermal properties measurement of CaO-SiO ₂ system slags	K. Shiohara	353
6	ISI Research Promotion Grant/Fundation research for refractory molten of molten slag slags	M. Saito	357
7	Measurement of thermal conductivity for molten slag at high temperatures by means of a novel laser flash technique	H. Shiohara	361
Fundamental research and technological development for the intermetallic process with high productivity and suitable properties using iron ores having low quality (Final report of the research project on "porous iron-matrix texture steel")			
8	Effect of molten iron content and wettability on gasification property of iron ore	T. Ohtsuka	362
9	Simulation for gasification of iron ore by using DDM	T. Ohtsuka	366
10	Effect of Al ₂ O ₃ and MgO addition on molting behavior of sintering	J. Kato	370
11	Properties of iron ore required for sinter mixtures using a large amount of limestone, ores	F. Tsubouchi	374
12	Feasibility of iron ore required for sinter mixtures using a large amount of limestone, ores	T. Ohtsuka	375
13	The sintering behavior of iron ore required for sinter mixtures using a large amount of limestone, ores	E. Kato	382
14	Influence of slag composition and pore blockage accompanied with iron ore reduction on reducibility of iron ore	C. Kato	386
15	Structure of the columnar ferrite phase (SPC-NO)	H. Ohtsuka	390
16	Strength and stiffness analysis of sinter ore with consideration of its texture	K. Higashimura	394
17	Evolution of local strain distribution in iron ore by EBSD	T. Aizawa	398
18	Discussion of mechanism: sintering process for iron ore sintering	T. Aizawa	402
Cookmaking technology to support low RAR, high productivity blast furnace operation			
19	Optimization of blast furnace gas properties for blast furnace in future	T. Aizawa	406
20	Mechanical strength of coke for ironmaking	M. Saito	410
21	Evolution of coke strength by sintering measurement	K. Ueda	414
22	Breakage behavior of coke during devolatilization and effect of coke pore structure on coke strength and CSR	K. Maruyama	418
23	Effect of coke pore structure on coke reactivity and strength before/after CO ₂ reaction	T. Aizawa	422
24	Texture and distribution of ash in the reactivity of coke during the low reducing agent rate	T. Aizawa	426
25	Gasification reactivity of ash in the reactivity of coke during the low reducing agent rate	T. Aizawa	430
26	Production technology of high strength and high reactivity coke	T. Aizawa	434
Innovative development of refining processes in steelmaking by heterogeneous fluxes			
27	Improvement of pre-treatment process of pig iron and efficiency for dephosphorization in Nippon Steel	K. Miyamoto	442
28	The reaction of solid phase with molten slag in hot metal dephosphorization	K. Miyamoto	446
29	Effects of temperature and flux composition on rate of hot metal dephosphorization	K. Miyamoto	448
30	Novel refining process using capillary phenomena of molten CaO	J. Kato	452
31	Hot metal dephosphorization behavior by sintered dephosphorization agent containing Al ₂ O ₃	M. Saito	455
32	Solid-state reaction kinetics of the system CaO-FeO	H. Ohtsuka	458
33	Mechanism of hot metal dephosphorization in ferroalloy by BOP slag	T. Aizawa	462
34	Prediction of steelmaking slag volume with heterogeneous fluxes	M. Saito	466
Instrumentation, Control and System Engineering			
Recent researches and developments for internal and sub-surface defect inspection			
35	High-speed 3D ultrasonic inspection	T. Tani	530
36	Signal processing techniques for high-precision ultrasonic flaw detection	K. Nishida	534
37	Ultrasonic processing analysis in consideration of grain boundary scattering by the explicit finite element method	T. Tani	538
38	Scattering analysis for quantitative evaluation of ultrasonic noise	K. Nishida	542
39	Responses of Doherty-type probe to flaws in the conductive material	T. Tani	546
40	Lock-in magnetic-optical imaging and analysis for detecting surface and internal flaws of steel	S. Aoki	548
41	Modeling of detecting signal and magnetic noise on magnetized eddy current testing of rolling thin steel plate	M. Hashimoto	552
Processing for Quality Products			
Structure and property controlled by casting process and/or forging process			
42	Microstructure control and utilization of forging for grain refinement in steel	K. Taniuchi	572
43	Metallographic technology in intermetallic forging for automotive parts	L. Nishida	576

材料とプロセス

Volume 17, Number 5 2004

929-1085

ISSN 0914-6628

日本鉄鋼協会講演論文集

材料とプロセス

第148回秋季講演大会

計測・制御・システム工学、創形創質工学

Current Advances in Materials and Processes

Report of the ISIJ Meeting

2004
Volume 17
Number

5



社 団
法 人

日 本 鉄 鋼 協 会

The Iron and steel Institute of Japan

熱間シェールリング形状計測装置の開発

Development of Measuring Instrument for Hot Shell Ring Shape

株式会社 神戸製鋼所 ○西本 陽 和生 泰弘

1. はじめに

原子力/化学プラント圧力容器に用いられるシェールリング (Fig.1) の鍛造仕上がり寸法は、鍛造中の各パスにおけるプレス圧下量の決定が大きく影響する。しかし、現状では測定による時間コストを避けるため鍛造中の外径/内径/厚さなどの測定はできず、プレス圧下量は、経験と勘に頼らざるを得ない状況である。そこで圧下量をより正確化し、寸法精度向上、鍛造時間の短縮を目的とし、鍛造工程中的シェールリング形状を高速度・高精度に測定する装置を開発した。本計測装置により、シェールリング外径/内径等の形状を測定精度 $\pm 10\text{mm}$ 、測定時間4秒で同時に測定できる。

2. 計測装置の概要

鍛造中の熱間シェールリング (外径4~6m) から約15m離れた場所から、ステレオ法¹⁾により形状計測する。計測装置外観をFig.2に、計測画面をFig.3に示す。カメラ2台によるステレオ法では、撮影時に発生しやすいためカメラ取り付け位置ずれによる計測精度低下が大きい。カメラ取り付け位置ずれの影響を受けにくいカメラ1台による移動ステレオ方式を採用している。メザータセルカメラの採用、サブピクセル補正処理、レンズ歪みを考慮した光学式キャリブレーション法により、鍛造工程中のシェールリング外径/内径等の形状測定と同時に、高速・高精度に測定できる。本装置は、カメラ感度、レンズ絞り、光学フィルター等の適正化により、熱間 (500℃以上) でも測定可能である。

3. 実験および考察

長さ既知(4~6m)の冷間物体を測定して測定精度 $\pm 5\text{mm}$ を確認した。また、実ワークである鍛造時の熱間シェールリングの外径を、従来法 (作業者が熱間シェールリングに近づき、レーザー距離計にて外径を測定する方法) と比較した結果をFig.4に示す。従来法との差量が約 $\pm 10\text{mm}$ で良好な結果となった。

4. まとめ

鍛造工程中の熱間シェールリングの外径/内径等の形状を、測定精度 $\pm 10\text{mm}$ 、測定時間4秒で計測する装置を開発した。本装置は前圧プレス工場にて稼働中である。本装置導入により、形状計測値に基づくプレス圧下量の定量化、鍛造時間の短縮、寸法精度向上による機械加工時間の短縮などが期待できる。さらに、作業負担もなっている船体作業の軽減も可能となる。

参考文献

- 1) 松山他: コンピュータビジョン株式会社新技術コミュニケーションズ(1998)

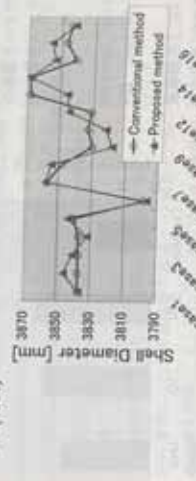


Fig.4. The comparison of two measuring methods



Fig.1. Shell ring under forging



Fig.2. Photo of instrument



Fig.3. Image of Console measurement



片のタリアラランクスを変化させた時の冷却速度を測定したものであり、特に 500℃以下では冷却速度に大きな違いがあることが確認される。
これらの原因により、ダイクエンチにおいては水投入のような均一な硬さ分布は期待できない。Fig.10 は、向中央部・側部中央部・板厚中央部と板厚減少率を示す例であり、各部位の硬さは Hv20~40 のバラツキがあり、金型温度が最も高温となり、かつ配管減少率が大きく金型との接触が制限される印及びひびは、その他の部位よりも低い値を示している。連続降流の中で、金型温度を極力低くかつ均一な温度分布に制御することが今後の課題となる。

4. 3 ショットブラスト工程

ダイクエンチのプロセスでは、プラントの加熱は保護雰囲気下で行われるが、加熱工程からプレス成形完了までは大気中にさらされるため、酸化スケールの発生は避けられない。この酸化スケールは、化成処理工程・造粒工程・スボット溶接工程に悪影響を及ぼすため除去が必要となる。

酸化スケールの除去は、その簡便性からショットブラストを使用しており、投射速度・グリット径を固定するに酸化スケールの除去率は投射時間に比例することになる。酸化スケールの除去率を調査の間、電圧抵抗値で代用し、投射時間との相関を調査した結果を Fig.11 に示す。ダイクエンチ直後の電圧抵抗値は 20~80mΩ 程度であるが、投射時間 25 秒で数 mΩ に低下しその後投射時間を長くしても大きな変化は見られない。一方でパネルの面精度もショットブラスト工程で変化する。Fig.12 に示すように、パネルの形状によりその絶対値は変化するものの、投射時間が長くなるにつれてほぼ直線的に歪量が増加するため、投射時間をあまり長くすると相手パネルとの合わせ精度が確保できなくなる。このように酸化スケールの除去率とパネル精度は相反する特性となるため、酸化スケールの除去率は化成処理・脱炭素性・耐食性・スボット溶接性を確認したうえで、管理線の上限を設定している。

ショットブラスト直後の化成処理の評価結果を Fig.12 に、脱炭素性の評価結果を Fig.13 に示す。ショットブラスト前は化成処理により針状のボイトが形成され、基盤目録では脱炭素の測定をするが、ショットブラスト後は脱炭素の測定が難しくボイトが形成され、基盤目録においても 440MPa 以上でない。また、SST 試験においても 440MPa 以上イテンと同等の耐食性が確認されており、実用上十分な特性を有している。

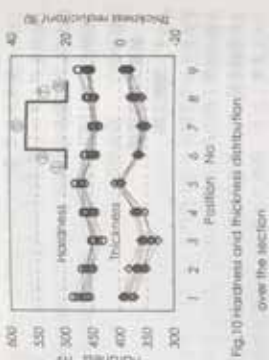


Fig.10 Hardness and thickness distribution over the section

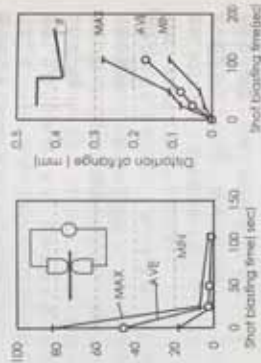


Fig.11 Relation between electrical resistance and shot blasting time



Fig.12 Micrograph of phosphated surface



Fig.14 Result of paint adhesion test

5. ボデー部品への適用例

欧州では 1990 年ごろから、リアインパクトビームを対象としてダイクエンチの実用化が始まった。従来から部品で構成されていたボディ製のリアインパクトビームをダイクエンチで一体成形したものであり、この技術の採用により降圧工程の省略のみならず、設計の自由度が大幅に向上した。最近の研究安全に関する規制強化に伴い、その適用部品は増加傾向にあり、現在 4 社がダイクエンチ製のボディ部品を生産・供給している。Table3 に欧州での適用部品を示す。また A・B ピラーリンフォースメント、B ピラーリンフォースメント等の車両骨格部品にまで採用が広がっている。

国内では 2001 年よりリアインパクトビーム¹²⁾で採用が始まり、現在では欧州の例と同様に、ルーフィングフォース・B ピラーリンフォース・A ピラーリンフォースに採用され、年間生産量は 450 万本に達している。それらの例を Fig.15 に示す。欧州と同様に国内も安全規制が強化される方向にあり、バンパー・ビーム及び他の車体骨格部品への採用も期待できる。

6. おわりに

本稿ではダイクエンチの概要とその適用例について紹介した。この成形技術は歴史が長く、まだ解決すべき技術課題が多く残されており、材料分野では更なる高強度化・耐食性の向上が、生産技術分野では効率の良い加熱法・冷却法・成形制御による成形サイクルの短縮・信頼性の高い加工法¹³⁾及び成形解析技術¹⁴⁾等が求められている。

最近では耐食性に優れたアルミニウム合金¹⁵⁾が開発されており、諸問題も徐々に解決されつつある。今後も材料メーカーとの連携・成形技術の改善を通して、車両の衝突安全確保・軽量化に寄与していきたい。

Table3 Body parts commercialized in Europe

Door beam
Bumper beam
A-Pillar reinforcement
B-Pillar reinforcement
Roof reinforcement

Roof reinforcement

Door beams

A-Pillar reinforcement

Fig.15 Body parts produced by die quench

参考文献

- (1) 中興物産、製鉄部、ダイクエンチ法によるインパクトビームの開発、鋼材研、Vol.43, No.12, (2002), p.31-34
- (2) A.D. Pines and R. Colwell, Laser Gating of Body Structural Parts with High Strength Hot Formed Steel
- (3) 大谷、ダイクエンチ法における加熱・冷却制御の最適化シミュレーション
- (4) 第 14 回鋼材加工技術開発シンポジウム、(2002), p.449-450
- (5) L. Vaisier, P. Lantier, and A. Bichard, Development of pre-coated Bump Steel for Applications on PSA Peugeot Citroën and Renault in White, IEEC Conf., 2002-01-2046 (2002)